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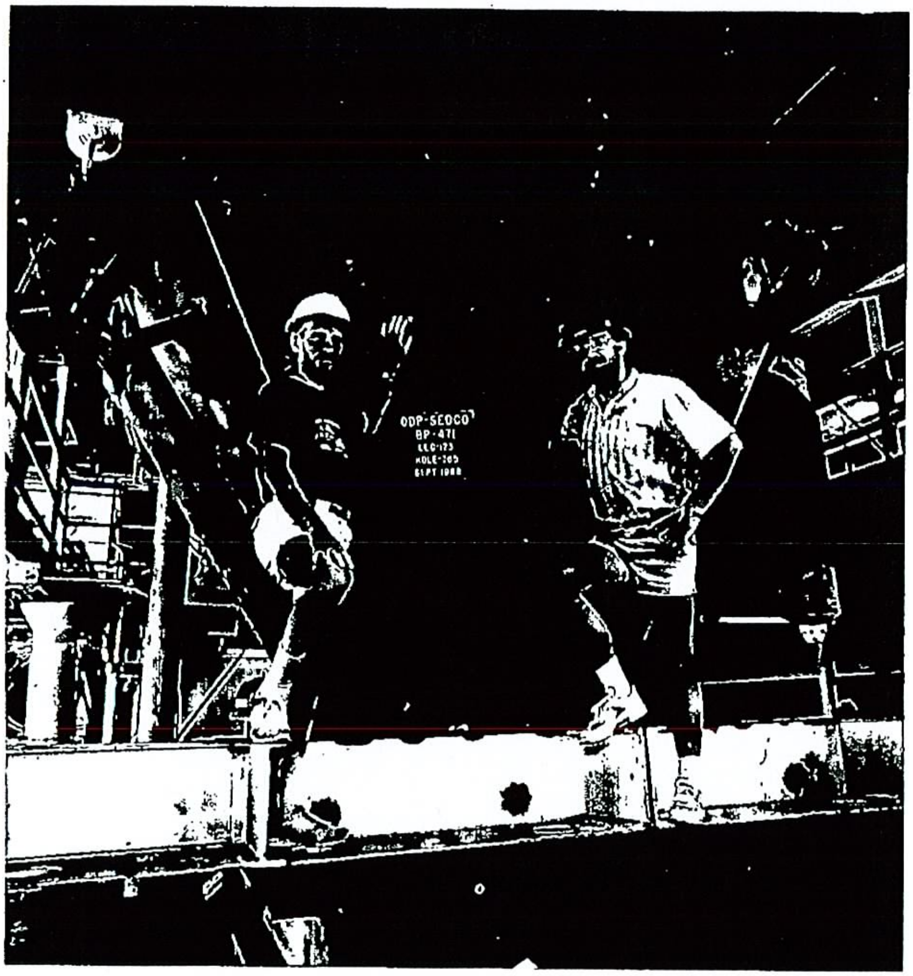

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JOIDES AND JOIDES JOURNAL

In 1964 the need was recognized in the oceanographic community for scientific planning of a program to obtain deep cores from the ocean bottom. Four of the major oceanographic institutions that had strong interests in the fields of marine geology and geophysics formed the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES). This group, Lamont-Doherty Geological Observatory of Columbia University, the Rosenstiel School of Marine and Atmospheric Science of the University of Miami, the Scripps Institution of Oceanography of the University of California at San Diego, and Woods Hole Oceanographic Institution, expressed an interest in undertaking scientific planning and guidance of the drilling program. It was the purpose of this group to foster programs to investigate the sediments and rocks beneath the deep oceans by drilling and coring.

Through discussions sponsored by the JOIDES organization, with support from the National Science Foundation, the Lamont-Doherty Geological Observatory operated a successful drilling program in the summer of 1965 on the Blake Plateau region off Jacksonville, Florida, using the drilling vessel CALDRILL I.

With this success in hand, planning began for a more sophisticated deep sea effort. This resulted in the award of a contract by the National Science Foundation to the University of California for an eighteen month drilling program in the Atlantic and Pacific Oceans termed the "Deep Sea Drilling Project." Operations at sea for Phase I of this project began in August 1968. The project continued through Phases II and III, which in addition to the Atlantic and Pacific Oceans, included drilling in the Indian Ocean as well as in the southern oceans surrounding Antarctica and in the Arctic area.

During this time the membership of the original JOIDES group has enlarged several times. In 1968 the University of Washington became a member. In 1973 the P. P. Shirshov Institute of Oceanology, Moscow, became the first non-United States member of JOIDES. The USSR agreement

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FOCUS

As this is being written, two events that have just taken place are of great importance to the future of ocean drilling. One is that a new Memorandum of Understanding has been signed between NSF and Canada on behalf of the Canadian-Australian Consortium. Welcome Australia!

The second is that ODP Leg 124E is underway from Manila. Because major technological advances will be required in order to address important new scientific drilling objectives over the next several years, PCOM has decided to invest about one month per year to prepare for that drilling, mainly by testing new equipment at sea.

The first of these engineering legs, 124E, has as its main purpose the testing of a mining coring system on the drill ship. A rig with 2000 m of small diameter drill string has been installed. The high-speed, narrow kerf, low-bit-weight diamond coring system that drills small hole diameters using low flow rates is anticipated to yield more stable hole conditions than is possible now in certain formations. Higher percentages of recovery and higher rates of penetration are also probable. Similar systems have been very successful in mining exploration and in drilling in the North Sea.

The JOIDES interest in this system is for future drilling of brittle, zero-age crust at ridge crests, interbedded hard and soft rocks, mainly chert and chalk, at many Paleogene and Mesozoic sites, and such unconsolidated sediments as turbidite sands and reef rubble. The 2.4-inch (6.0 cm) core diameter is comparable to standard DSDP and ODP cores. A very major disadvantage, however, is that the 4-inch-diameter hole is too small for advanced logging tools and many special experiments. Options may be to ream the hole larger for the present ODP logging tools, use a restricted suite of existing slim-line tools, or develop new slim-line tools.

The scientific legs of 1989 will be in the Western Pacific, near the Mariana, Bonin, and Japanese islands, and in 1989 will end with a second engineering leg, 129E. Although its objectives will depend mainly on the results of 124E, there probably will be further tests of the diamond coring system, with 4000 m capabilities, at sites with chert-chalk intervals, reefal limestones, and bare rock in the Pacific rises, guyots, and back-arc basins.

The synopsis in this JOIDES Journal of the PCOM Annual Meeting in Miami shows that the Science Plan approved for drilling in FY90 carries the vessel from Japan by way of the southwestern Pacific to Lau and Tonga. A third engineering leg, 134E, would transit to the extreme eastern Equatorial Pacific, and be used to prepare Hole 504B for deepening, either by fishing out the junk left there or deviating the hole past it. Guidebases will be set during 134E for later bare-rock drilling on the East Pacific Rise.

Many of the objectives of COSOD I and COSOD II can only be attained with the development of new technology. I've taken my prerogative of using this page to focus on the use of vessel time to assist in the development.

Ralph Moberly
Planning Committee Chairman

JOIDES RESOLUTION OPERATIONS SCHEDULE

LEGS 125 - 129

LEG	AREA	DEPARTURE		ARRIVAL		IN PORT	DAYS AT SEA
		LOCATION	DATE	LOCATION	DATE		
125	Bon/Mar	Guam	02/20/89	Tokyo	04/18/89	04/18 - 04/22	57
126	Bon 2	Tokyo	04/23/89	Tokyo	06/19/89	06/19 - 06/23	57
127	Japan Sea I	Tokyo	06/24/89	Hakodate	08/20/89	08/20 - 08/24	57
128	Japan Sea II	Hakodate	08/25/89	?	10/05/89		41
	Dry Dock					10/05 - 10/18	
129	Nankai	?	10/19/89	?	12/18/89	12/18 - 12/22	59
129E	Engineering II	?	12/23/89	?	01/21/90	?	30

revised 12/21/88

LEGS 122 & 123: EXMOUTH PLATEAU AND ARGO ABYSSAL PLAIN

INTRODUCTION

Leg 122 sailed from Singapore 2 July 1988 and returned to Singapore 28 August 1988. Co-chiefs were Drs. Bilal Haq (NSF) and Ulrich von Rad (Bundesanstalt für Geowissenschaften und Rohstoffe, FRG). Leg 123 sailed from Singapore 9 September 1988, returning on 1 November. Co-chiefs for Leg 123 were Drs. Felix Gradstein (Bedford Institute, Canada) and John Ludden (University of Montreal, Canada). Dr. Suzanne O'Connell was ODP Staff Scientist for both legs. A comprehensive report on preliminary scientific and operational results is available from the Ocean Drilling Program Publications Distribution Specialist, Texas A&M University Research Park, 1000 Discovery Drive, College Station, TX 77840.

Drilling a complete Exmouth-Argo transect during Legs 122 and 123 was a major, integrated scientific venture, where extensive interaction between both scientific parties was critical to the success of the cruises. Four sites (759, 760, 761, 764) on the Wombat Plateau and two sites (762, 763) on the western part of the Exmouth Plateau were drilled during Leg 122. Two sites were drilled during Leg 123: Site 765 on the southernmost Argo Abyssal Plain, and Site 766 on the western Exmouth Plateau. Major objectives addressed at these sites have been discussed in the June 1988 JOIDES Journal (Vol. XIV, No. 2). Site summaries for Leg 122 appeared in the October 1988 Journal (Vol. XIV, No. 3). Site summaries for Leg 123 are included in this volume.

The composite section recovered at the four sites drilled on Wombat Plateau comprises: a paralic to marginal-marine lower Carnian-Norian section of an early rift environment with the oldest nannoflora yet discovered; an almost complete marine Rhaetian carbonate platform sequence; a condensed hemipelagic mid-Cretaceous section and possibly complete Cretaceous-Tertiary boundary; an expanded Paleocene eupelagic marine sequence; and a middle Eocene-Quaternary eupelagic marine sequence. Liassic to earliest Cretaceous sediments are missing. New constraints on the ages of seismic reflectors on the Wombat Plateau from these drilling results indicate that major rifting and block-faulting in the region occurred in the Early-Middle Jurassic (pre-Callovian). This corresponds with the timing of the block-faulting event on the central Exmouth Plateau.

The composite section recovered at the two sites drilled on the Exmouth Plateau during Leg 122 (762 & 763) includes a thick prograding distal-shelf margin sequence of Berriasian-Valanginian age (Barrow Group equivalent) that will be important for understanding depositional processes of clastic wedges for comparison with modern clastic depositional systems. Dating of the unconformity overlying this sequence narrows the age of the break-up of the western and southern margins of the Exmouth Plateau to Hauterivian-Barremian. Overlying this unconformity, hemipelagic sediment of the Albian-Cenomanian characterizes the "juvenile ocean" stage in the evolution of this margin, and the change to purely pelagic sedimentation in the Turonian represents the beginning of the "mature ocean" margin stage. Sea-level fluctuations deciphered at Exmouth and Wombat Plateau sites from sequence stratigraphic analyses correspond well with the global eustatic cycle chart.

The section recovered at Site 765 on the Argo Abyssal Plain consists of a 931-m-thick Berriasian-Pleistocene sedimentary section overlying 271 m of aphyric to sparsely phyric basaltic basement. The upper half of the sedimentary section is dominated by calcareous turbidites, while the lower half is dominated by hemipelagic clays and claystones.

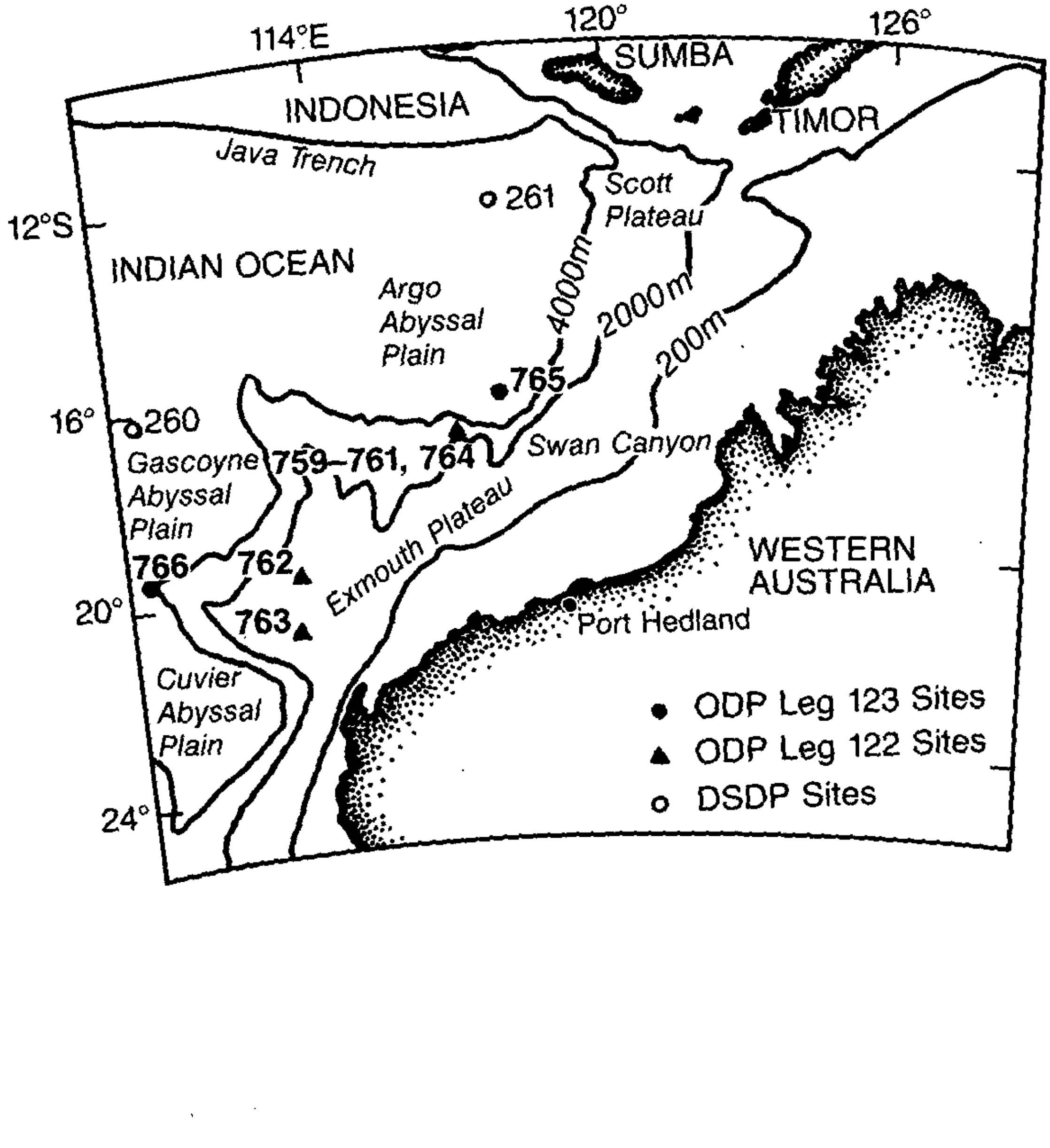

Figure 1. Geography of northwestern Australia and locations of ODP Sites drilled on Leg 122 and Leg 123. Location of DSDP Site 261 is shown also.

The most surprising stratigraphic information from Site 765 was the lack of any Jurassic sediments. Detailed radiolarian, nannofossil and dinoflagellate stratigraphy of the red-brown claystones recovered at the base of the sedimentary section dates the basement as late Berriasian to earliest Valanginian (approximately 140 Ma). This is at least 20 my younger than predicted for Site 765. Detailed first order bio-, litho-, and seismo-stratigraphic correlation of Site 765 to DSDP Site 261 (Fig. 1) where so-called Jurassic basal sediments calibrated Jurassic opening of the Indian Ocean, indicates that both sites may be of Early Cretaceous age. The Cretaceous opening of the Indian Ocean has important consequences for plate tectonic evolution in the Southern Hemisphere, and the demise of the Tethys.

The section recovered at Site 766 on the western Exmouth Plateau consists of a 467-m-thick late Valanginian/Pleistocene sedimentary section overlying 60 m of interlayered intrusives and siltstones. Geochemical data indicate that the intrusions are iron-rich tholeiites, comparable to the basalts drilled at Site 765. The green sands and siltstones at the base of Site 766 do not show continuity with the upper Barrow Delta sediments on the Exmouth Plateau, and indicate a local source, perhaps on the edge of the plateau. Paleomagnetic data from both the sediments and basalts of Sites 765 and 766 suggest that the paleolatitude of northwestern Australia was at about 30-35°S, or 10° farther north in Cretaceous time than previously assumed.

LEG 122 HIGHLIGHTS

Leg 122 results contribute new data that bear on the tectonic, sedimentary, and paleoenvironmental evolution of passive continental margins typified by the Exmouth Plateau. Highlights of these results at the time of the conclusion of the cruise follow.

➡An unconformity between late Carnian and Norian is documented on the Wombat Plateau, marking an earlier episode of block-faulting and constraining the timing of the reactivation of the northern Exmouth Plateau hinge Zone.

➡Validating seismic horizons on the Wombat Plateau by constraining the ages of prominent reflectors demonstrates that the major rifting and block-faulting in the region occurred in the Early to Middle Jurassic (pre-Callovian). The steep north and south escarpments of the plateau developed at this time, culminating in the formation of the Wombat half-graben to the south, rift-flank tilting of the Wombat horst and initiation of the formation of the Argo Abyssal Plain to the north. Pre-rift strata were tilted gently to the north and may have been subaerially exposed and eroded by wave action. Further tilting at a later time slowly developed a more accentuated northward slope as the now-coupled Argo Abyssal Plain sank. The unexpected complete absence of Jurassic sediments on the Wombat Plateau is also a testament to this major rift stage and its aftermath. Seismic and industry well site data suggest that on the central Exmouth Plateau the block-faulting event can also be dated as Early to Middle Jurassic, and is marked by an unconformity between the Triassic Mungaroo Sandstone equivalent strata and the thin Oxfordian-Kimmeridgian Dingo Claystone equivalent sediments.

➡Biostratigraphical dating constrains the major erosional unconformity representing the break-up of the western and southern margins of the Exmouth as between Valanginian and early Aptian.

➡The middle Eocene unconformity at Site 763 that eroded down into Maestrichtian sediments most likely occurred because the site was a structural high, and endured greater erosion relative to Site 762.

➡The first known occurrence of carbonate on the Exmouth Plateau derived from the Tethys Ocean in the early to middle Carnian, when purely marginal marine clastics graded into interbedded carbonates and deltfacies. A sequence (>900 m) of Triassic sediments was recovered of which 30% are carbonates and the remainder are low-energy paralic to fluvio-deltaic facies. Active delta-lobe migrations modify the stacking patterns in the latter facies. In the Rhaetian, the Wombat Plateau developed a carbonate platform setting. The recovery of an almost complete marine Rhaetian succession is the exception outside western Europe, with which it shows remarkable similarities.

➨Dinoflagellate assemblages in the thick, prograding distal-shelf margin sequence of the Berriasian-Valanginian, which otherwise lack microfossils will be helpful in constraining the ages of various prograding subunits.

➨The hemipelagic sediments of the Albian-Cenomanian characterize the "juvenile ocean" stage in the evolution of the margin, and the change to purely pelagic sedimentation in the Turonian represents the beginning of the "mature ocean" margin stage.

➨Where tectonic events can be isolated, sea level fluctuations can be deciphered from sequence stratigraphic anaysis of seismic, litho- and biofacies, and well-log data. These considerations document important sequence boundaries on the Wombat Plateau between the middle and late Carnian, at the Norian/Rhaetian boundary, and in the latest Rhaetian, whose timing and relative magnitude conform well with eustatic cycle charts. In addition, the sequence boundary and systems tracts recognized in the central Exmouth Barrow Group equivalent strata also correspond well to the global cycle chart. These preliminary results are of considerable importance in providing a test of the validity of the eustatic model.

➨Discovery of diverse Carnian to Rhaetian calcareous nannofossils on the Wombat Plateau represents the oldest known occurrence of this fossil group, which will help elucidate their early evolutionary history and may improve biostratigraphic subdivision of the late Triassic. The recovery of an expanded Paleocene sequence at Site 761 with well preserved foraminifers, nanno-fossils, and radiolarians will aid in resolving magnetobiochronologic issues for this rarely cored interval. It also offers the opportunity to establish a Paleocene zonation for the Radiolaria for the first time. Stable-isotopic analyses of the Paleocene section and across the apparently complete K/T boundary interval will also provide previously scarce data for this important interval.

➨Rock-Eval pyrolysis of the sediments on central Exmouth Plateau indicates the organic matter to be land-derived. Organic-carbon values are low (1% or less) in the cored intervals, but increase to 15% in the thin black shale layers at the Cenomanian/Turonian boundary. Hydrocarbon gases show peak concentrations in the Upper Cretaceous chalk. The deep-sourced gases bypass the Lower Cretaceous clastic sequence of the Barrow equivalent strata through faults, into the Upper Cretaceous chalk which acts as a barrier to farther upward migration of gases, resulting in pore waters charged with dissolved methane.

LEG 123 HIGHLIGHTS

The first of a series of geochemical reference sites was drilled at Site 765. Bulk geochemical analysis will be used to evaluate recycling of oceanic crust and sediment in subduction zones. Knowledge of the composition of the crust being subducted will be used to constrain models of magma genesis in volcanic arcs and also to constrain global mass balance calculations related to sediment recycling in the mantle.

➨The revised timing of the initial rifting of the early Indian Ocean at Site 765 requires reappraisal of the rift to drift history of the northwestern Australian margin. Assuming a comparable age for Sites 765 and DSDP Site 261, and a slightly (5-10 my) younger opening age for the Gascoyne and Cuvier abyssal plains, any north-south spreading in the Argo must have involved rapid ridge jumps to result in the predominant east-west spreading direction in the Gascoyne Abyssal Plain.

➡Few oceanic sites, and none in the Southern Hemisphere, exist that directly relate the M-series geomagnetic reversals in the sediments with multiple biostratigraphy. Sites 765 and 766 yield a detailed reversal scale for M13 and M0, Valanginian to Aptian, which, together with the detailed nannofossil record and potential radiometric dates on the fresh basaltic basement and volcanic ash in the sediments, will strengthen understanding of the Mesozoic time scale.

➡Turbidite sedimentation dominated the sedimentary history of Site 765. The lowermost sediments of this site are reddish brown calcareous claystones derived from the old continental margin. These are overlain by red and green claystones with subordinate radiolarite layers, and are succeeded by Upper Cretaceous and lower Paleogene clays with subordinate carbonate turbidites. Nearby Swan Canyon was probably cut into the margin at the end of Oligocene time (approx. 25 Ma), and became an active conduit for turbidites in the Miocene.

➡270 m of basalt lava flows and pillow lavas was cored in Hole 765D. Despite their Early Cretaceous age, these lavas preserve fresh glass and are in perfect condition for laboratory studies to delineate Indian Ocean mantle reservoirs. They are fractionated relative to modern mid-Indian Ocean ridge basalts. However, their higher CaO and lower Na_2O, Zr and Nb may reflect higher percentages of mantle melting.

➡For the first time in the history of ODP and DSDP a comprehensive suite of bulk sediment and clay fraction XRF analyses were completed on board. These analyses were complemented by a full suite of geochemical logs for K, U, Th, Ca, Si and Al run in basement and in sediments through the steel casing in Hole 765D. The bulk elemental sediment composition is variable on the scale of a meter. However, most of the variability is a result of simple mixing between three end members: biogenic calcium carbonate, biogenic silica, and an alumino-silicate component. Most of the geochemical variation can be explained in terms of mixing of a single terrigenous component and volcanigenic clays.

➡Pore waters in the lower sediments at Site 765 display unusually low salinity and sharp chloride gradients. These are related to fresh water addition. No other pelagic basins are known to have such low-salinity pore waters, and their source remains problematic.

➡The deep hole at 765 provided an ideal location for detailed well logging and experimental geophysics projects. In addition to over 1100 m of geochemical data (see above), 750 m of lithoporosity data and sonic velocity data were recorded. These log patterns have been used to refine our understanding of the turbidite sequence, particularly in the thick Miocene sediment unit that flowed out of submarine canyons on the Exmouth Plateau.

➡The orientations of stress-induced breakouts suggests that this section of the Indian Plate is undergoing north-south compression.

➡The green sands and siltstones at the base of Site 766 do not show continuity with the upper Barrow Delta sediments on the Exmouth Plateau, and indicate a local source, perhaps on the edge of the Plateau.

➡Cretaceous microflora and microfauna from Sites 765 and 766 are comparable to those typically found in the mid-latitudes of the Northern Hemisphere. Nonetheless, some microflossil groups show local taxa, not known elsewhere, which suggest relative isolation of the early Indian Ocean water masses from global circulation patterns.

ODP Leg 123 was the last leg of highly successful drilling operations with JOIDES RESOLUTION in the Indian Ocean. Site 765 is now the deepest cased site in the oceans and, with its reentry cone on the seafloor, is in perfect shape for future ocean drilling or related scientific investigations.

LEG 123: ARGO ABYSSAL PLAIN AND EXMOUTH PLATEAU ESCARPMENT SITE REPORTS

Site Summary, Site 765

Latitude:	15° 58.541'S
Longitude:	117° 34.495'E
Water Depth:	5721.4 m

Major objectives for this site (See Figure 1, Legs 122 & 123 Preliminary Report, this issue) on the Argo Abyssal Plain were to: (1) elucidate the paleoceanography, sedimentology, and magmatic processes related to rifting of the early Indian Ocean; (2) constrain the rift to drift tectonic history of one of the Earth's oldest oceanic basins; (3) improve the late Mesozoic time scale, particularly with respect to the Southern Hemisphere; and (4) provide a geochemical reference section of old oceanic crust, incorporating the bulk composition of the sediments and basement, for use in geochemical and petrological global mass-balance models.

Holes 765A, 765B and 765C cored Cenozoic and Cretaceous fine-grained abyssal sediments. Oceanic basement was reached at 931 mbsf in Hole 765C. Average sediment recovery was 68%. Hole 765D is located approximately 30 m from the other holes, and was drilled and cased through 924 m of sediments into volcanic basement. The hole was then continuously cored a further 259 m into remarkably fresh basalt. Average core recovery in Hole 765D was 31%. Both Holes 765C and D were logged with sonic, lithodensity and geochemical tools. In general, the upper half of the seidmentary section recovered at Site 765 is dominated by calcareous turbidites, funneled down canyons that cut the edge of the deep continental margin plateaus, while the lower half is dominated by hemipelagic clays and claystone.

➡Unit I (0-189.1 mbsf) is late Pliocene to Pleistocene, consisting of clayey calcareous turbidites, massive slumps and debris flows, and siliceous ooze.

➡Unit II (189.1-474.1 mbsf) is of Miocene age and consists of calcareous turbidites with minor clay and a massive debris flow containing basaltic pebbles.

➡Unit III (474.1-591.7 mbsf) is Turonian to early Miocene with stratigraphic hiatuses. Varicolored zeolitic clay, redeposited calcareous sediments and dark claystones were recovered.

➡Unit IV (591.7-724.1 mbsf) is Aptian-Cenomanian siliciclastic and mixed lithology turbidites, nannochalk, calcareous claystone and zeolitic clay.

➡Unit V (724.1-859.2 mbsf) consists of varicolored and dark gray radiolarian and rhodochrosite claystone of Barremian-Aptian age.

➡Unit VI (859.2-892.9 mbsf) is late Valanginian-Hauterivian and is predominantly nannofossil chalk with varied minor lithologies.

➡Unit VII (892.9-931.2 mbsf) consists of Berriasian-Valanginian brown-red silty claystone and reddish brown to greenish claystone; the basal contact between claystone and basalt is marked by a few cm of basalt hyaloclastic altered to celadonite floating in a matrix of red claystone and white sparry calcite cement. Altered volcanic ash layers occur higher up in Units VI and VII.

Geochemical variations, determined by using major and trace elements, are significant and can be related to dilution of clay related elements by $CaCO_3$ and SiO_2. Nonetheless, a "bulk" geochemical composition of the sediments can be calculated and individual turbidites may be geochemically fingerprinted. the principal clay minerals in the sediments represent volcanic alteration products, with the onset of rapid sedimentation in the early Miocene showing a wide variety of volcanic minerals from different source regions along the margin. All sediments display evidence of deposition below the carbonate compensation depth (CCD), although the (approx. 4 km-deep) seafloor may have been above the CCD in late Valanginian-Hauterivian time, when nannofossil chalk was laid down; the same relationships exist in the Atlantic Ocean. Organic carbon content is low, as expected in abyssal sediments, with, as consistent with global trends, a rapid excursion to higher values near the Aptian/Albian boundary. Mesozoic microfossil assemblages are typical for middle latitudes and, except for radiolarians, are not endemic.

Holes 765C and 765D penetrated 28 m and 271 m, respectively, into volcanic basement. Twenty-two volcanic units were distinguished based on lithological and geochemical variations. The main lithologies recovered were pillow basalt (54%), massive basalt (28%), diabase (4%), autoclastic breccia (6%), and tectonically brecciated pillow basalt (8%).

Despite being one of the oldest sections of oceanic basement cored (lowermost Cretaceous), rock preservation is excellent. Fresh glass is present in pillow margins and within hyaloclastite breccia. Low temperature alteration has affected the entire volcanic section, which is veined with calcite, celadonite, smectite, Fe-oxyhydroxides, and rare zeolites; there is no lithological indication of gradation at the base of the hole into higher temperature assemblages. In spite of the low temperature alteration and asssociated geochemical fronts parallel to the veins, much of the basaltic section is only slightly altered.

Although geochemical data indicate that the lavas are typical but somewhat evolved mid-ocean ridge basalt (MORB) tholeiites, the phenocryst assemblage is atypical for MORB. The lavas are dominantly aphyric or sparsely phyric with rare samples having up to 10% phenocrysts. Plagioclase is the dominant phenocryst with clinopyroxene being the only mafic phenocryst in many lavas. Olivine, when observed, is highly altered and appears xenocrystic. In the upper 50 m of basalt, numerous xenocrysts of calcic plagioclase and clinopyroxene occur.

Hole 765D was cased in order to provide a stable site for coring, logging and a series of geophysical experiments. Lithoporosity, sonic and geochemical logs were run in the hole without any operational problems; the chemical log was run through the casing in the sedimentary section, as was the sonic log, to investigate the integrity of the cement behind the casing. High sonic velocities show broad correlations with massive flow intervals and the diabase. Potassium anomalies can be correlated with brecciated zones containing smectite and celadonite. Vertical seismic profiling was attempted in basement, but met with little success.

<u>Site Summary, Site 766</u>

Latitude:	19° 55.985'S
Longitude:	110° 27.130'E
Water Depth:	3997.5 m

The initial drilling program proposed for this site at the foot of the Exmouth Plateau Escarpment called for Advance Piston Corer/Extended Core Barrel (APC/XCB) coring to refusal, Rotary Core Barrel (RCB) coring to what was interpreted as basement intermediate between continental and oceanic rocks, and physical and geochemical well logging. However, owing to time restrictions, a reduced program, eliminating the APC/XCB coring was carried out.

The principal objective for this site was to understand the tectonic, sedimentary, and magmatic evolution of the outermost edge of a passive margin. As a result of the extensive sediment cover at most passive margins, it is rarely possible to core the transition zone from continental to oceanic basement; the sediment starved nature of the northwestern Australian margin makes this objective attainable at Site 766. Specific questions posed at Site 766 were: (1) What is the nature of "basement" transitional to continental and oceanic crust in a rifted passive margin? (2) What are the ages of the onset of rifting between Australia and India, and of earliest seafloor spreading in the Gascoyne and Cuvier abyssal plains? (3) How does the lithologic and seismostratigraphic sequence along the continental-margin-to-deep-ocean transect from Sites 762 and 763, drilled by ODP Leg 122 on the adjacent Exmouth Plateau, compare to that of ODP Site 766?

Total penetration was 527 mbsf and average core recovery was 66%, with the best recovery in the critical lower section. The base of the sedimentary section was placed at 466.7 mbsf, after which coring retrieved only igneous rock. However, the first igneous rocks were encountered at 458 mbsf. These rocks are interpreted as intrusive sheets (small sills) of igneous material, which are interlayered with green-gray siltstones; below 466.7 mbsf two or more large igneous intrusions were encountered and cored a total of 60 m.

Site 766 is within 10 km of magnetic anomaly M10, the 130 Ma isochron mapped along the Exmouth margin. The published oceanic spreading rate of 3.2 cm/yr predicts the onset of sea-floor spreading at 134 Ma in the M11 isochron of late Valanginian age. As a result, basal sediments and volcanics at Site 766 should also be of late Valanginian age. This age is exactly as determined by radiolarian/nannofossil-dinoflagellate stratigraphy for the oldest sediments at Site 766. The basement must therefore have been rifted, buried by sediments, and intruded by tholeiitic magmas immediately prior to the formation of true oceanic crust at the continent/ocean boundary. Whether Triassic crust is preserved at Site 766, or the hypabyssal intrusives grade downward into larger intrusive bodies, remains unsolved.

➡Unit I (seafloor-8.0 mbsf) is lower Pleistocene pink nannofossil ooze.

➡Unit II (8.0-82.8 mbsf) is Paleocene through lower Eocene and middle Pliocene in age and consists of pale brown to white nannofossil ooze.

➡Unit III (82.8-114.8 mbsf) is Campanian through lower Paleocene pink to pale brown nannofossil ooze, with graded beds.

➡Unit IV (114.8-136.5 mbsf) consists of Turonian through lower Campanian zeolitic calcareous ooze and clay, banded in brownish colors.

➡Unit V (136.5-191.0 mbsf) is Albian through Cenomanian in age and consists of brown to tan bioturbated chalk with zeolite and clay.

➡Unit VI (191.0-239.4 mbsf) is Aptian-lower Albian. The unit is tan to light green nannofossil chalk, zeolitic and clayey in the upper portion, siliceous in the lower half.

➡Unit VII (239.4-304.2 mbsf) is dark greenish gray to black claystone of upper Hauterivian through Barremian age.

➡Unit VII (304.2-458.0 mbsf) is uppermost Valanginian through Hauterivian greenish gray to black sandstone and bioturbated siltstone, with glauconite, quartz, bioclasts, and altered volcaniclastics.

The first igneous rock, interpreted as an intrusive sheet, was encountered at 458 mbsf. This was followed by an 8-m interlayered sequence of 1- to 1.5-m-thick intrusions and dark green to dark gray siltstone. Coring from 467.7 to 527 mbsf recovered a thick diabase intrusion; recovery in the intrusion was 100%. Only one definitive contact was preserved in the sequence, inclined 30° and chilled against sediments which have been baked to within 5-10 cm from the contact. No hyaloclastite breccia was drilled, and all the igneous bodies display a symmetric, gradiational increase in grain size from base to center and top to center, indicating that these are intrusions. The base of the large diabase was not encountered; 60 m of cores were recovered. The diabase contains gabbroic segregations which are inclined at 60-80° relative to the drill core. In addition, cooling fractures are oriented in the same plane as the gabbroic segregation in all but the last two cores; both of these lines of evidence indicate that this intrusion may be flat in the lowermost cores (i.e., a sill) and grade upward into a dike with a dip of up to 60°. Geochemical data the intrusions are iron-rich tholeiites of MORB affinity. Some differences are observed between the different intrusions, which can be explained by fractional crystallization, indicating that the intrusions may be cogenetic. The intrusions are slightly to moderately altered by low temperature processes. The veins and vessicles are filled with calcite, smectite and zeolite; pyrite occurs with smectite and zeolite.

Three petrophysical logging runs were completed at Site 766. The drill pipe was set at 260 mbsf (below the upper sequence of pelagic clays and oozes). Seismostratigraphic and porosity logs were run below this depth; both logging tools could not be lowered below a ledge immediately above the volcanics (approx. 445 mbsf). The Lower Cretaceous sands and siltstones were successfully logged between 445 and 245 mbsf.
The geochemical log, run through the pipe, was completed with drill pipe within 10 m of the base of the hole (approx. 515 mbsf). This log clearly delineates the sediment/intrusion contacts between 450 and 470 mbsf. Noteworthy on the logs are (1) an increase of thorium at 14 mbsf that appears to be associated with the hiatus between Eocene and Pliocene; (2) a similar enrichment in a 3-m zone above the K/T boundary, which suggests a hiatus, as observed also on the plot of the Site 766 burial history; (3) anoxic bottom conditions in the Hauterivian as deduced from the thorium/uranium ration, which agress with the observation of many pyrite concretions in the sediment; and (4) petrophysical trends in the Hauterivian to Aptian section, which may identify proposed sea-level fluctuations.

COLOR CORE PHOTOS AVAILABLE ON SLIDES OR VIDEO DISK

The entire collection of color core photographs from the Deep Sea Drilling Project (DSDP) and the Ocean Drilling Project (ODP) is now available to the scientific community. The photos show cores recovered from holes drilled at more than 750 sites in the world's oceans. The collection includes over 23,000 photographs and comes in two formats: 35-mm slides or 12-inch video disk. The 35-mm slides are boxed and consecutively numbered. Both the slides and video disk come with an introduction booklet giving details on their use and an index. To view the video disk, the user must have access to a NTSC standard disk player with random access capabilities and a video monitor (an example of such a player is the Sony video disk player #20002-2).

This collection will be particulary useful to those scientists working on samples from either DSDP or ODP. Those considering placing requests for DSDP or ODP samples will find the photographs make it easier to select the particular interval from which they want their samples taken.

The cost of the slide collection is US$4,500. The video disk costs US$50. These prices are in effect until July 1, 1989. Please call thereafter for a new quote.

To place an order, or for additional information, call or write to: Publications Distribution, Ocean Drilling Program, Texas A&M University, 1000 Discovery Drive, College Station, Texas 77840, U.S.A., Tel: (409) 845-2016.

LEG 124: SE ASIA BASINS SITE REPORTS

INTRODUCTION

Leg 124 documented the ages, stress directions, and geologic histories of the Celebes and Sulu seas, as proposed. All major objectives were met. The Celebes Sea is middle Eocene in age, and formed in a setting removed from continental or island arc sources. Its origin could have been either the Philippine Sea basin or, more likely, a plate that formed north of a spreading center with the present Australia-India plate. Preliminary, very tentative magnetic inclination observations suggest early, rapid northward movement of the plate. During the middle Miocene it received large amounts of continentally derived clastic debris, and in late Miocene/Pleistocene, abundant volcanic ash. The Eocene CCD lay between sites 767 and 770, or just below 4500 m.

The Sulu Sea is late early Miocene in age, and formed in an intra-arc or back-arc setting. Early outpourings of rhyolitic pyroclastics were followed by clay-rich deposition, including a late middle Miocene accumulation of continentally derived turbidites, similar to that seen in the Celebes Sea. Pleistocene volcanic ash dates the initiation of volcanoes, probably on the Sulu Ridge. A similar age of clay-rich sediments, late early Miocene and younger, overlie coarse andesitic tuffs and lapillistones on the southeast flank of the Cagayan Ridge, indicating a probable time correlation between the formation of the Sulu Sea and the cessation of volcanism on Cagayan Ridge. This is also about the time that the Cagayan Ridge collided with Palawan and Dangerous Grounds, a continental fragment of the China margin. Both the Celebes and Sulu seas show a clear synchroneity of terrigenous turbidites in the latest middle Miocene; this timing agrees with that of collisional processes observed along the margins of the basins, both in Borneo and in the Philippines.
Stress orientations directed northeast in the Sulu and Celebes seas argue for control of the regional stress pattern by collision of these basins and ridges with the Philippine mobile belt, and for lack of effect of the Sulu Trench. Increased Ca and Mg in the pore waters of lower sections of all sites argue strongly for a mechanism of basalt diagenesis different from the generally accepted views at present. A new magnetic reversal event has been documented within the Matuyama epoch at 1.11 Ma, the Sulu subchron.

Leg 124 departed from Singapore 6 November 1988 and arrived in Manila on 4 January 1989. The following site summaries were sent by JOIDES RESOLUTION Co-Chiefs Drs. Eli Silver (UCSC) and Claude Rangin (UPMC). Dr. Marta von Breymann was the ODP/TAMU Staff Scientist for Leg 124.

<u>Site Summary, Site 767</u>

Latitude:	04° 47.5'N
Longitude:	123° 30.2'E
Water Depth:	4916 m

Site 767 (proposed site CS-1) was designed to (1) determine the age and nature of the oceanic basement of the Celebes Sea basin, (2) to provide a stratigraphic history of the basin for use in deciphering its tectonic history, and (3) to determine the regional stress. The site was selected to lie at SP 140 on seismic line SO49-2, collected on the <u>R/V Sonne</u> by the Bundesanstalt für Geowissenschaften und Rohstoffe. It is located approximately 100 km west of the Cotabato trench off the southwest margin of Mindanao. The first two objectives were satisfied by the drilling, but the third was not due to failure to penetrate beyond 0.15 m into basement.

Hole 767A retrieved a mudline core 4.5 m long, after which a jet-in test was performed and temperature readings attempted. The temperature recording was unsatisfactory at this location. Hole 767B was APC-cored to 91 mbsf, followed by XCB coring to 739 mbsf. At that point the drill pipe had sticking problems and the hole was prepared for logging. Hole 767B was logged using the seismic stratigraphy package and the geochemistry tool string. Both runs were successful, after an initial attempt without the side-entry sub failed. Hole 767C was washed to 680 mbsf and RCB-cored to 786.6 mbsf. The last core recovered basalt in the core catcher, after which the drill string became stuck. After many attempts to pull out, it was decided to blast free, a process that took a day to complete successfully.

Site 767 records several major events in the history of the Celebes Sea. The basement is basalt, overlain by middle Eocene red clays. The basal red clays indicate an open ocean environment. This part of the section corresponds well with that observed at DSDP Site 291 in the southern Philippine Sea just to the east of the Philippine Islands.

➡Unit 1 (0-56.8 mbsf) consists of Pleistocene to Holocene hemipelagic volcanogenic clayey silt with interbeds of volcanic ash. The silt component is primarily volcanic ash, with glass, pumaceous glass, rock fragments, feldspar and hornblende. The low biogenic carbonate content is consistent with deposition below the CCD. Rare calcareous turbidite layers contain assemblages of foraminifers that have been redeposited from shallower depths.

➡Unit II (56.8-406.5 mbsf) is late Miocene to Pleistocene and consists of volcanogenic clayey silt/siltstone grading downward into volcanogenic silty claystone, with interbeds of volcanic ash/tuff, carbonate silt/siltstone and carbonate sand/sandstone.

➡Unit III (406.5-698.9 mbsf) is early-to-late Miocene and is characterized by the presence of quartz-rich sandstone, siltstone and associated claystone, all interpreted as turbidite deposits of continental provenance, interbedded with subordinate bioturbated hemipelagic claystone.

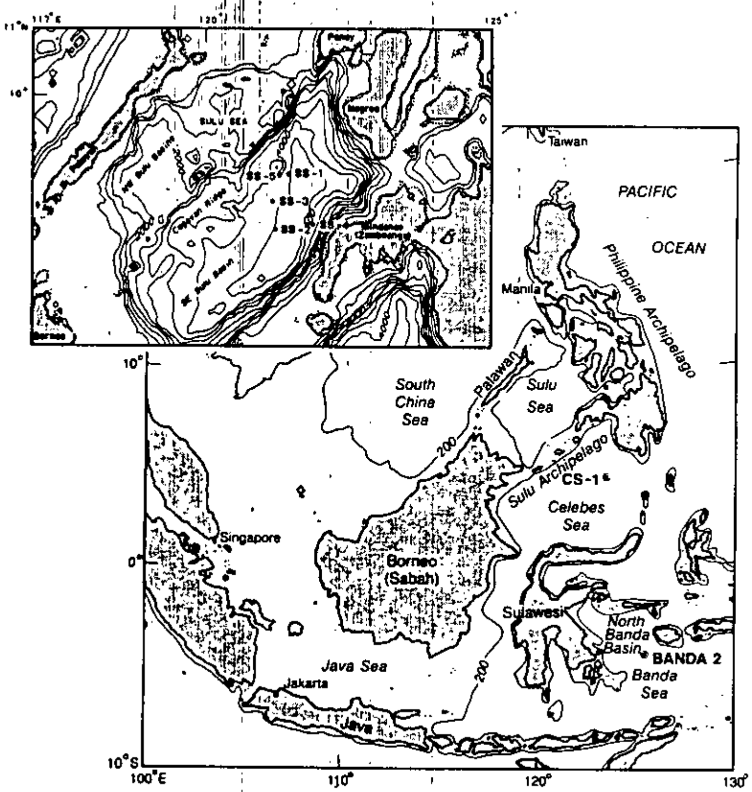

Figure 1. Location map of the Southeast Asia marginal basins showing the sites proposed for drilling on ODP Leg 124. Insert shows proposed site locations in the Sulu Sea (bathymetric contour interval = 500 m).

➡Unit IV (698.9-786.6 mbsf) is middle Eocene to early Miocene and is composed mainly of dark grayish brown to reddish brown claystone. Clay minerals are the principal component, with rare silt-sized particles of quartz, feldspar and opaque minerals (sulfides, oxides and copper). The carbonate content is very low (0.2%) throughout the unit. Agglutinated foraminifers are moderately common and radiolarians and fish teeth and bones are minor components.

Paleomagnetic studies of the oriented APC cores showed a very clear magnetic stratigraphy in the upper 100 m of the site. Changes in declination document the Bruhnes/Matuyama boundary, both boundaries of the Jarmillo event within the Matuyama, and an unidentified, short event below the Jaramillo, which may indicate a regional excursion or a local sedimentary slump.

<u>Site Summary, Site 768</u>

Latitude:	08°00.04'N
Longitude:	121° 13.18'E
Water Depth:	4395.5 m

Site 768 (proposed site SS-2) is located in the southeastern part of the Sulu Sea. The purpose of drilling this site was to determine the age and stratigraphic history of the Sulu Sea. It has been interpreted in various ways, including a trapped marginal basin of Eocene age, or a backarc basin of Oligocene to Miocene age. Its origin has profound implications for the development of the broad collision zone from Borneo to the Philippines, and the stratigraphic history of the basin was expected to record the collisional history, as well as the paleoceanography of the region.

Hole 768A was spudded at 0445 on 28 November. A mudline core was successfully retrieved, and a jet-in test was followed by a temperature run. The temperature reading was suspect and the tool was not used again at this site. Hole 768B was then continuously APC cored to 210 mbsf; recovery was 100% in this interval. Coring continued with XCB to 364 mbsf. Hole 768C was RCB-cored to a total depth of 1268 mbsf. Of this, 1046 m were in sediments and 222 m were in basement. Seismic stratigraphy and lithodensity Schlumberger logs were run, plus two borehole televiewer (BHTV) runs. The first BHTV attempt hit a bridge 65 m below the bottom of the pipe. The second run logged all of the basement and the lower part of the tuffs. A geochemical log was attempted, but the tool failed at 955 mbsf. Two medical emergencies interrupted operations at this site. Both came at times when pipe was being pulled out of the hole, which minimized the time lost, but an attempted packer run was canceled.

➡Unit I (0-123.0 mbsf) is Holocene to latest Pliocene and consists of thin to thick-bedded marl, with varying proportions of nannofossils and foraminifera and sparse thin beds of volcanic ashes. The carbonate content of the sediment averages 40%. Deposition must have occurred above the CCD which currently is deeper than the water depth at Site 768, but a turbidite origin for part of these sediments was interpreted. Below 110 mbsf, the calcareous microfossils show increasing signs of dissolution. The ashes show an increasing crystal content and decreasing glass and lithic content downhole.

➡Unit II (123.0-652.4 mbsf) is composed mainly of late Pliocene to middle Miocene alternating beds of clay, clayey silt, silt and some sand, arranged in fining-upward sequences. Ash layers were identified in the upper part of the unit down to 250 mbsf, but their alteration increases dramatically at 150 mbsf. The low carbonate content (<1%), and the association of quartz and metamorphic grains within the silts and sands, suggest deposition of continentally derived turbidites below the CCD. The low abundance of benthic forams and the absence of shelf-dwelling organisms suggest a source for these turbidites that is deeper than neritic.

➡Unit III (652.4-808.6 mbsf) is early to middle Miocene in age. The upper part includes mainly turbidites, while the base is represented by hemipelagic sediments. The structures and composition of clastic sequences indicate deposition by turbidity currents and related mass wasting processes (thick sand beds) beneath the CCD and with a continental origin. Tuff beds made of pyroclastic material and mixed with terrigenous clastics are interbedded in the sequence and are interpreted as gravity flows displaced from active volcanic centers. The lower part includes claystones with minor turbidites overlying dark reddish brown claystones. The unit base contains a moderately well preserved assemblage of radiolarians of upper lower Miocene age (Calocycletta costata zone). The boundary between the upper and lower parts of Unit III apparently correspond to an hiatus (NN8 to NN5).

➡Unit IV (806.6-1003.6 mbsf) is early Miocene in age and consists almost exclusively of coarse and fine vitric tuff and lapillistone. Claystones are interbedded with tuffs only at the top and base of the unit. The pyroclastics include devitrified glass shards and pumice with some rock fragments, and various minerals. These very thick fining-upward sequences of tuffs with reverse grading at their bases are interpreted as mass flows of pyroclastic material. Radiolarians at the top of the unit define the boundary between C. costata and Stichocoris wolffii zones.

➡Unit V (1003.6-1046.6 mbsf) consists of an alternation of dark brown claystone and greenish gray tuff. The contact between these lithologies is gradational. The tuff beds may be the product of either pyroclastic flows or turbidites, while the claystone represents background hemipelagic sedimentation. Rare, broken radiolarians found at the base of this unit are consistent with the S. wolffii zone.

A total of 221.8 m of basement, between 1046.7 and 1268.5 mbsf, was cored with an average recovery of 39.4%. The sequence has been divided into eight units, six of which occur as lavas and two as sills. The lavas are very uniform petrographically and mostly comprise very vessicular olivine-phyric basalts with a greater or lesser percentage of olivine. None of the actual contacts between the units are seen and the subdivision of the lava sequence has been based on their occurrence as either pillowed and brecciated basalts or lava flows. The sills are identified by their thickness, massiveness and phaneritic grain size, and have the composition of olivine dolerites. The two separate sills have different mineralogy, petrography, vessicularity and vein filling.

Paleomagneitc results at Site 768 were outstanding, with an excellent reversal stratigraphy through the Gilbert (5 Ma), and possible reversals 5D and 5E in the tuffs of Unit IV. The new excursion at 1.1 Ma, now called the Sulu excursion, was definitely recorded.

Logging was successful, including seismic stratigraphy and lithodensity logs, plus a very good BHTV log in the basement and the tuffs. The logs matched the results of physical properties quite well, including a major velocity increase between the pillow basalts and the sill, which was recognized as acoustic basement on the seismic line. Borehole breakouts were prominent in the basement, both the sill and the pillows, and in the upper 60 m of the tuffs. Basement breakouts trended approximately 300°, indicating a maximum horizontal stress direction of 030°.

Both the inorganic and organic geochemists have identified very important anomalies. Calcium and magnesium increase with depth in the lower part of the hole, in amounts exceeding that which can be ascribed to seawater contamination, very similar to observations at Site 767. A good coincidence between the maturity of the organic material and the generation of thermogenic hydrocarbons was observed. The organic-lean pyroclastic sequence shows high gas concentrations, suggesting downward migration of light hydrocarbons.

The drilling results for Site 768 demonstrate a backarc spreading origin for the Sulu Sea in early Neogene time; an origin by trapping in the Paleogene can be ruled out. The complex depositional history of the continentally derived turbidites and brown clays, as well as the stratigraphic hiatus recorded in the sequence, provide a complete record of Neogene subduction and collisions surrounding the Sulu Sea.

Site Summary, Site 769

Latitude:	08° 47.12'N
Longitude:	121° 17.68'E
Water Depth:	3644 m

Site 769 (proposed site SS-5) is on the southwest flank of the Cagayan Ridge. The objective of the site was to determine the Neogene paleoceanographic history of the enclosed Sulu Sea basin, at a site that was thought to lie above the CCD, protected from turbidite deposition. A secondary objective was to determine the nature of the Cagayan Ridge basement and to relate the basement and stratigraphic information to the results of Site 768 within the Sulu Sea.

Hole 769A was spudded 4 Dec. 1988; seven APC cores were recovered from Hole 769A, then Hole 769B re-cored the same interval with a 3-m vertical offset in order to obtain duplicate cores and to avoid gaps in the uppermost part of the record. Hole 769B was APC/XCB cored to 290.2 mbsf, at which point volcanic tuff was encountered, and thereafter RCB-cored. Hole 769C began at depth 261.1 mbsf for recoring of the lower 30 m of sediment, thought to be very important for dating, and continued to a total depth (TD) of 376.9 mbsf. Because of the shallow penetration depth, excellent core recovery and malfunctioning of the geochemical logging tool, logging was deemed unnecessary at this site.

➡Unit I (0-102.1 mbsf) is late Pliocene to Holocene with a dominant lithology of thin to thick-bedded nannofossil marl with foraminifers, interpreted as a mixture of pelagic biogenic carbonate sediment and hemipelagic clay. Minor thin beds of volcanic ash and turbidites of foraminiferal ooze also occur within the unit. Slump structures appear to increase with depth within the section.

➡Unit II (102.1-278.5 mbsf) is late middle Miocene to late Pliocene and consists of two subunits distinguished by color change from gray-green clay, minor marl, calcareous clay and silty clay (IIA) to a brown massive clay(IIB).

➡Unit III (278.5-376.9 mbsf) is massive, unstratified dark green coarse lapillistone of andesitic to basaltic composition, with no intermixed or interbedded sedimentary material.

The paleomagnetics are good from the surface to the Gilbert Epoch and show a remarkably continuous record from the Gilbert through Chron 11. The major increase in carbonate content of the cores in both Sites 768 and 769 near the end of the Pliocene indicates a rapid drop in the CCD. The low carbonate and high CCD in the late Miocene and early Pliocene can be the result of closing off of the basin due to collisions. The eruption of the tuffs and lapillistones corresponds closely in time with the opening of the Sulu Sea, in the late early Miocene. Pyroclastics at Site 768 are about the same age as the tuffs at Site 769, but gross compositions are different.

Site Summary, Site 770

Latitude:	05° 08.7'N
Longitude:	123° 40.1'E
Water Depth:	4516.2 m

Three holes were drilled at Site 770 (proposed sire CS-1A). Hole 770A did not spud in properly, and so was abandoned after two cores. Hole 770B was drilled to 474 mbsf, including 50 m of basement. It had to be abandoned to remove 7 km of polypropylene rope that was wrapped around the drill pipe. Hole 770B was spot cored every 50 m to 340 mbsf, then cored continuously to total depth. Hole 770C was drilled to basement, then cored to 529 mbsf, for 106 m of basement. We achieved excellent results in three Schlumberger logging runs and a BHTV run. The hole was reentered for a packer experiment, but the site was abandoned because of bridging at 56 mbsf. The objectives of

Site 770 were to obtain basement and logs within basement at a location close to Site 767, which had to be abandoned just after hitting basement.

➡Unit I (0-296 mbsf) is middle Miocene to Holocene with dominant lithologies composed of volcanogenic silty clay and clay with sparse thin beds of marl and volcanic ash.

➡Unit II (296-421 mbsf) is late middle Eocene to middle Miocene, consisting of claystone and calcareous claystone, with sparse interbeds of silty to sandy claystone and porcellanite clay mixed with sediment.

Site 770 has about half the sediment thickness of Site 767, yet the basal ages are identical. The difference reflects the higher elevation of Site 770, protecting it from turbidite influx, and allowing it to be just above the CCD in the lowest part. Basement was recovered from the interval 421-529 mbsf. Six lava units can be identified using their mineralogy, texture and structure: B1, B2 are pillow basalt sequences; B3 is a pillow breccia; B4-B6 are brecciated, massive amygdaloidal lavas.

Stress orientation data were obtained with the BHTV logs. Preliminary interpretation of hole ellipticity and breakout data indicate a maximum horizontal stress direction of 050°, slightly more easterly than results from Site 768. As at Site 769, a downhole increase in Ca and Mg values indicates a source in diagenesis of the basalts.

Site Summary, Site 771

Latitude:	08° 40.69'N
Longitude:	120° 40.78'E
Water Depth:	2859 m

Site 771 (proposed site SS-5A) on the Cagayan Ridge was drilled to a subbottom depth of 304.1 mbsf. The objectives at this site were to test the age of cessation of volcanism found at Site 769, to determine whether the coarse tuffs and lapillistones at Site 769 were a widespread or a local phenomenon, and to obtain better biostratigraphic correlation between different siliceous and calcareous microfaunas and floras at a site above the CCD. Two lithologic units are distinguished at Site 771: nannofossil marl and clay, overlying massive lapillistone, tuff and basalt flows.

➡Unit I (100-233.9 mbsf) is middle Miocene to late Pliocene, consisting of nannofossil clay and marl with rare, thin carbonate turbidites. The material also contains minor ailt-sized volcanic detritus. Dispersed volcanic ash is found in the lower 30 m, and its concentration increases in the lower 2 m.

➡Unit II (233.9-304.1 mbsf) is late early to early middle Miocene and is composed of volcaniclastic strata underlain and capped by basaltic lava flows. Thin-bedded coarse to fine tuffs occur below the upper basalt, but the dominant volcaniclastic rock is massive and structureless lapillistone.

The intercallation of flows and pyroclastic deposits suggests close proximity to a volcanic vent(s). The hemipelagic marlstone just above the upper basalt is evidence for submarine eruption of the lavas. The boundary between Units I and II represents a rapid transition from volcaniclastic to hemipelagic sedimentation in early middle Miocene. A major increase in carbonate content in cores from Sites 768, 769 and 771 near the end of the Pliocene indicates a rapid drop in the CCD. The low carbonate and high CCD in the late middle Miocene and early Pliocene can be the result of the closing off of the basin due to collisions. The drop of the CCD in the Pliocene-Pleistocene may indicate variations in depth of the sills present either between Mindoro and North Palawan, or along the Sulu archipelago, where a recent volcanic arc is built. Additionally, this corresponds to a global deepening of the CCD recognized in all the major oceans at this time.

Eruption of tuffs and lapillistones correponds closely in time with the opening of the Sulu Sea, as shown by formation of the crust at Site 768 in the early middle Miocene.

LEGS 125 AND 126: BONIN-MARIANA ARC-TRENCH SYSTEM

ODP Legs 125 and 126 in the Bonin-Mariana region have been designed to study three themes important to arc-trench systems: (1) the origin and evolution of the forearc terranes; (2) the process and products of arc rifting; and (3) dewatering of the subducted lithosphere. Leg 125 is currently scheduled to sail from Guam on 20 February 1989, and end on 18 April 1989, in Tokyo. Leg 126 will sail from Tokyo 23 April 1989, returning to Tokyo 19 June 1989.

Leg 125 Co-chiefs are Dr. Patricia Fryer (U. Hawaii) and Dr. Julian Pearce (U. Newcastle-Upon-Tyne, UK). Dr. Laura Stokking is Staff Scientist for Leg 125. Leg 126 Co-chiefs are Dr. Brian Taylor (U. Hawaii) and Dr. Kantaro Fujioka (U. Tokyo, Japan). Leg 126 Staff Scientist is Dr. Tom Janicek. A complete scientific prospectus for Legs 125/126 published as one report (ODP Scientific Prospectus Nos. 25 and 26) is available from ODP/TAMU.

BACKGROUND AND TECTONIC SETTING

The present-day tectonic configuration of the Bonin-Mariana region (Figure 1) comprises, from east to west: the trench, the forearc terrane, made up of an inner trench wall that in the Bonin system has a 30-km-wide along-strike terrace or ridge, an outer-arc high, a forearc basin, and a frontal-arc high; the active Izu-Bonin and Mariana island arcs; the actively spreading Mariana backarc basin, the West Mariana Ridge, a remnant arc; the Parece-Vela and Shikoku marginal basins; and the Palau-Kyushu Ridge, the westernmost remnant arc. Subduction of Pacific oceanic lithosphere is currently taking place at absolute velocities of between 8 and 10 cm per year to the northwest; the subduction angle is about 12° at shallow depths, steepening in some places to nearly vertical below about 80 km.
The evolution of these arc and basin systems is thought to have begun in early-middle Eocene with westward subduction of Pacific lithosphere beneath the West Philippine plate (Karig, 1975). Subduction continued through the early Oligocene, forming an intraoceanic volcanic arc atop a 200-km-wide forearc composed of volcanic rocks of tholeiitic to boninitic affinities (Natland and Tarney, 1981). In the Mariana area this arc formed on or near the edge of the West Philippine Basin, whereas in the Bonin area it formed on the edge of the Amani-Oki-Daito province, a series of island arcs and intervening basins of Santonian to Paleocene age. Middle Oligocene rifting split the arc, and late Oligocene to early Miocene backarc spreading in the Parece Vela and Shikoku basins isolated a remnant arc (the Palau-Kyushu Ridge) from an active Bonin-Mariana arc (Kobayashi and Nakada, 1979). The initiation of this backarc spreading event was not synchronous along the length of the Oligocene arc. Spreading began at about 31 Ma in what became the central Parece Vela Basin and propagated both north and south, giving the basin its arcuate shape. A second spreading episode began by 25 Ma in what became the northernmost Shikoku Basin and propagated south (Kobayashi and Nakada, 1979). By 23 Ma the two systems had joined at what is now approximately 25°N, and both basins shared a common spreading axis until spreading ceased at 17-15 Ma.

A repitition of this cycle of events began in late Miocene when the southern part of the arc split again. Subsequently, 6-8 m.y. of spreading in the Mariana backarc basin isolated the active Mariana arc from, and increased its curvature with respect to, a remnant arc, the West Mariana Ridge (Karig et al., 1978; Hussong and Uyeda, 1981). Spreading in the Mariana backarc basin may now be propagating to the north, "unzipping" the Mariana arc from the West Mariana Ridge (Stern et al., 1984). The Bonin arc is still in the early rifting stage of backarc formation, undergoing extension along most of its length (Honza and Tamaki, 1985). The major zone of rifting lies west of the active volcanic chain, but some volcanoes

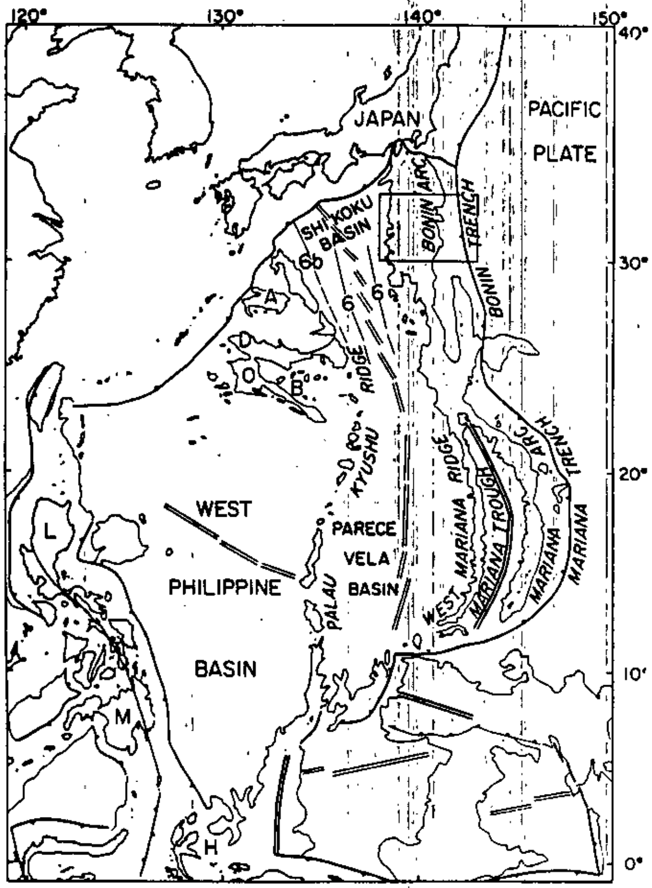

Figure 1. Active plate boundaries and relict spreading centers in the Philippine Sea region. Barbed lines locate subduction zones, medium double lines locate active spreading centers, and thin double lines locate relict spreading centers. Basins and ridges are oulined by the 4-km bathymetric contour,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

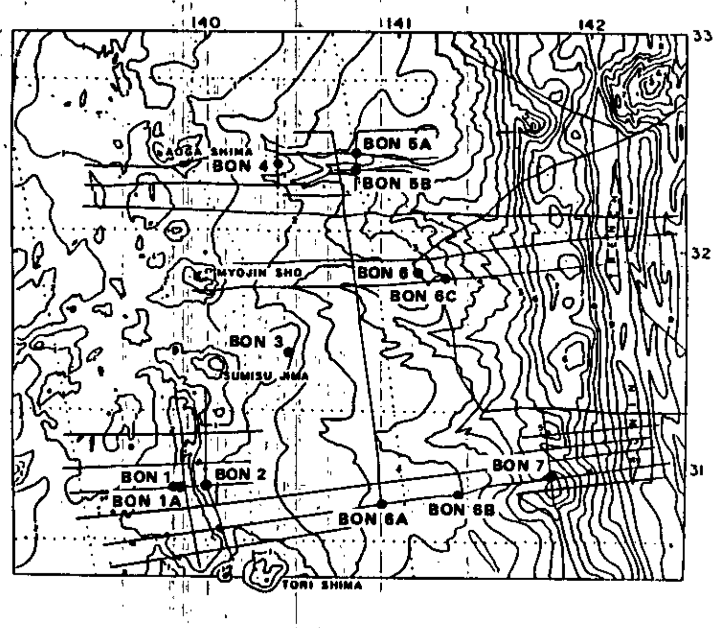

Figure 2. Location of multichannel seismic profiles and proposed ODP drill sites in the Bonin region.

near 29°N are surrounded by grabens (Taylor et al., 1985; in press). Volcanism continues along both active and "remnant" arcs, and volcanic centers have also developed in rift basins. The latter contain lavas with a bimodal basalt-rhyodacite composition. The basalts have major and trace element abundances that resemble the backarc basin basalts of the Mariana backarc basin rather than the island arc basalts of the adjacent Bonin arc (Fryer et al., 1985a).

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

Differences in arc-basin evolution between the Mariana and Bonin systems have produced corresponding differences in their forearcs. These differences are accentuated because seamount chains and aseismic ridges on the subducting plate have collided only with the Mariana forearc and southernmost Bonin arc. The Bonin forearc has experienced little deformation since subduction began (Honza and Tamaki, 1985); thus, it comprises a broad forearc basin filled with volcaniclastic and hemipelagic sediments that developed behind an outer-arc high. Biostratigraphic dating of the strata that lap onto this high, both at sea and on its outcropping on the Bonin Islands (Hanzawa, 1947), suggests that this high has been a positive topographic feature since its uplift in early Eocene. Several mature, dendritic submarine canyon systems cross the Bonin forearc basin and outer-arc high. Canyons have cut as much as 1 km into the 1.5-4 km sedimentary section (Taylor and Smoot, 1984).

The Mariana forearc has a broadly similar structure but has undergone extensive vertical uplift and subsidence resulting from seamount collision, and tensional and rotational fracturing associated with adjustments to plate subduction and to changes in configuration of the arc. Fracturing has provided easy egress for rising serpentinite from the underlying mantle wedge. A broad zone of serpentinite seamounts (up to 2500 m high and 30 km in diameter), 50 to 120 km from the trench axis, occurs along the trench-slope break (outer-arc high) of the Mariana system. These seamounts are formed by the diapiric rise and eruption of serpentinite (Fryer et al., 1985b; Fryer and Fryer, 1987). In the Bonin forearc, chloritized basic and serpentinized ultrabasic rocks have been dredged from a chain of local highs located less than 50 km from the trench axis along a lower slope terrace. These serpentinite seamounts may represent the nonaccretionary intraoceanic forearc analogue of dewatering zones in accretionary sedimentary wedges. Only very minor, and probably ephemeral, accretionary complexes occur at the bases of the inner walls of the Bonin and Mariana trenches.

DRILLING OBJECTIVES

The Bonin-Mariana regions are the best studied intraoceanic arc-trench systems. They are the type examples with which other older or less well-studied systems are compared. Yet fundamental questions about their evolution remain with regard to (1) arc rifting, (2) arc/forearc magmatism and structure, (3) arc/forearc stratigraphy and vertical tectonics, and (4) outer forearc serpentinite diapirism. To address these questions, Legs 125 and 126 have the following objectives.

RIFTING OF THE BONIN ARC: Sites BON-1 and BON-2 (Leg 126)

Overall Objectives:

1. The differential uplift/subsidence history of the rift basin and adjacent arc.
2. The nature of volcanism and sedimentation in the rift and on the arc.

3. The duration of rifting and the nature of the rift basement.
4. The chemistry of hydrothermal fluids circulating in the rift basin.

The processes associated with the rifting and subsequent separation of continental lithosphere have been a major research focus and drilling objective for some time. In contrast, the rifting of arc lithosphere prior to backarc spreading has, until recently, received almost no attention, despite the fact that similar processes and questions are involved (e.g., the extent and nature of crustal stretching, the duration of rifting, and the interaction between vertical tectonics, rift sedimentation and volcanism). These processes may be best observed in active rifts before the syn-ruft sediments are buried by arc volcaniclastics. To date, no seaward-dipping seismic reflectors, interpreted to represent massive outpourings of volcanic material, have been recognized in backarc basins. However, SeaMARC II surveys in the Bonin region have revealed widespread synrift volcanism, not only on the active and "remnant" arcs but in the rift basins as well (Taylor et al., in press). Most dredged samples are basalts, but andesites, dacites and rhyolites have also been recovered. The fact that the basalts are similar to Mariana Trough basalts means that mantle relatively unmodified by a subduction component is melted even during the initial stage of backarc opening.

The Sumisu Rift, located between the active arc volcanoes of Sumisu Jima and Tori Shima (Fig. 2), is a graben bounded by high-angle normal faults. The locus of maximum subsidence lies within an inner subgraben on its eastern side (Murakami, 1988). Faulting occurs along NNE/NNW doglegs, forming an orthorhombic fabric similar to that found in continental rifts (Brown and Taylor, 1988; Taylor et al., in press). Surface sediments in the rift basin include hemipelagic muds and volcaniclastic turbidites, with both ash and pumice layers (Nishimura and Murakami, 1988). Whether the basement of the graben is formed of stretched, subsided arc crust, recently intruded crust, or some combination of the two, is unknown, as the duration of rifting. Drilling sites BON and BON2 on the center and eastern flanks of the graben, respectively, will help us to determine whether volcanism began at the same time as, or subsequent to, rifting in the Mariana backarc basin (~10 Ma), whether arc volcanism continued throughout its development, and when extrusion of backarc-type basalts began.

The uplifted horst blocks bounding the basin are isolated from recent submarine volcaniclastic flow deposits and therefore form a good site to drill (BON-2), both to determine the differential vertical tectonics with respect to the graben and to penetrate to the older arc basement.

The tectonic setting and volcanic associations of the Bonin rifts are similar to those of the Kuroko district in Japan during its ore-forming period at about 13-14 Ma (Cathles et al., 1981; Fujioka, 1983). Iron hydroxide and barite deposits sampled with ALVIN from rhyolite caps of the basalt ridges in the Sumisu Rift (Taylor et al., 1987) have similar trace metal abundances to the iron chert (Tetsusekei) overlying the Kuroko massive sulfide deposits (Urabe, pers. comm., 1988). The chemistry of the fluids responsible for precipitating these deposits, and presumably sulfide deposits at depth, is unknown. Heat flow measurements in the rift basin require hydrothermal circulation to explain the locally high, but widely variable, values ranging 12 to 700 mW/m^2 (Yamazaki, 1988; pers. comm., 1988). Drilling in the Sumisu Rift will thus enable us to investigate the metallogenic implications of arc rifting.

ARC/FOREARC DEVELOPMENT: Sites BON-3-BON-5 (Leg 126) and BON-6 (Leg 125)

Overall Objectives:

1. The uplift/subsidence history across the forearc to provide information on forearc flexure and basin

development as well as the extent of tectonic erosion.
2. The stratigraphy of the forearc with its record of sedimentation, depositional environment and paleoceanography; and the variations in intensity and chemistry of arc volcanism over time.
3. The nature of igneous basement forming the frontal arc, outer-arc high and beneath the intervening basin, to answer questions concerning the initial stages of subduction-related volcanism, the origin of boninites, and the formation of the 200 km wide arc-type forearc crust.
4. The micro-structural deformation and the large scale rotation and translation of the forearc.

With the exception of dredges from inner trench walls and large fault scarps (Bloomer and Hawkins, 1983; Bloomer and Fisher, 1987; Johnson and Fryer, 1988) our direct knowledge of intraoceanic forearc basement is based primarily on data from three island chains and two DSDP sites: the Mariana and Tonga frontal arc islands (Guam, Saipan and 'Eua) and the Bonin islands, which expose Eocene island arc tholeiites and boninites (Reagan and Meijer, 1984; Ewart et al., 1977; Shiraki et al., 1980; and DSDP Leg 60, Sites 459 and 458), which sampled Eocene arc tholeiites and lower Oligocene boninites and arc tholeiites, respectively, from the Mariana outer-arc high. Basement beneath the thickly sedimented upper-slope basin between the frontal arc and outer-arc high has never been sampled. Only in dredge hauls at one site in the Mariana forearc, close to Conical Seamount (MAR-3A), has the deep forearc basement beneath the carapace of interbedded arc pillow lavas, flows, and sills been sampled (Johnson and Fryer, 1988). From the available data, it appears that the present 150-200 km wide Bonin-Mariana forearc formed largely by volcanism during the early stages of arc development in the Eocene and early Oligocene. Similar volcanism has not occurred since and cannot, to our knowledge, be studied as an active phenomenon anywhere on Earth at present. However, the eruptive style and exact tectonic setting of the Eocene volcanism is unclear. Multichannel seismic (MCS) surveys of the Bonin forearc have revealed a complicated basement which is often seismically stratified and cut by dipping reflectors. These reflection characteristics are unlike those of normal ocean crustal sections and suggest that the Eocene volcanism may have been accompanied by stretching tectonics and/or that it was superimposed on an older arc terrane such as the Amani Plateau (Taylor et al., in press). The Bonin forearc basin drill sites, BON-3 through BON-6 will sample the hitherto unstudied forearc basement in order to constrain existing models for forearc evolution.

The uplift-subsidence history across the forearc will be determined, using backstripping techniques on cored/logged holes and seismic stratigraphic analyses of interconnecting MCS profiles. Microstructures in the drill cores should also help determine the intensity of faulting in space and time across the forearc terrane. We also do not know whether the frontal arc and outer-arc high developed by igneous construction or by differential uplift, or whether the upper-slope basin between them is caused by forearc spreading or differential subsidence, or whether flexural loading either by arc volcanoes or by coupling with the subducting plate is an important process. Determining the forearc vertical displacement field will provide some of the information on forearc flexure and basin development needed to evaluate these hypotheses.

The forearc stratigraphy should also record a history of the variations in intensity and chemistry of arc volcanism, and allow the correlation of these variations with such parameters as subduction rate and backarc spreading. Studies of the tephrachronology, and the frequency and geochemistry of ash and pyroclastic flow deposits in the forearc basin drill cores, will enable the various models of initiation of backarc rifting (Karig, 1975; Scott and Kroenke, 1981; Hussong and Uyeda, 1981) to be evaluated. Such studies will also test whether boninitic (Beccaluva et al., 1980), alkalic (Stern et al., 1984), and/or rhyodacitic (Gill et al., 1984; Fryer et al., 1984) volcanism characterizes periods of arc rifting.

Paleomagnetic studies of the subaerial portions of the Bonin and Mariana forearcs have shown at least 20° of northward drift and 30° to over 90° of clockwise rotation since the Eocene (Keating et al., 1981). How and when these motions occur, and the nature of their relationship to the overall structural evolution of the forearc are enigmatic.

SERPENTINITE SEAMOUNTS: Sites MAR-3A, MAR-3B and BON-7 (Leg 125)

Overall Objectives:

1. The timing and mechanism of emplacement of the serpentinite seamounts, including their internal fabric, fracture patterns and flow structures.
2. The chemistry and hence source of the associated fluids.
3. The conditions at depth in the outer forearc from the igneous and metamorphic pertology of the lower crust/upper mantle rocks.

Drilling of Mariana and Bonin forearc sites in serpentinite materials will address the problems of the nature and origin of serpentinite in nonaccretionary, intraoceanic forearcs and provide information on the dewatering of the lithosphere during subduction, the composition of the mantle wedge, and the development of the outer forearc regions of intraoceanic island arcs.

Conical Seamount, the site for MAR-3A (the summit site) and MA3B (the flank site) (Fig. 3) is in the broad zone of forearc seamounts along the Mariana

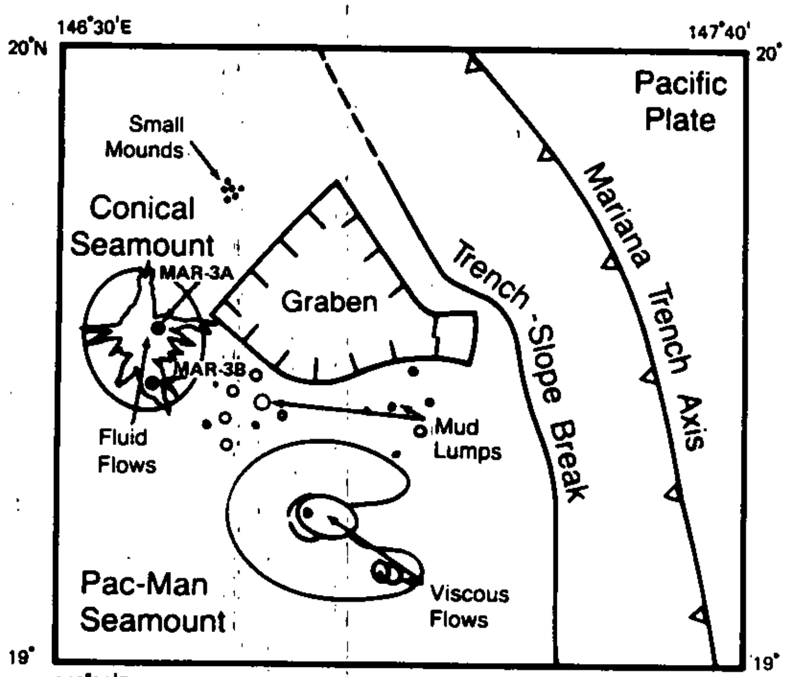

Figure 3. Mariana forearc geologic sketch showing locations of MAR-3A and MAR-3B.

outer-arc high. It is a roughly circular seamount, rising 2000 m above the seafloor a distance of 100 km from the trench axis. Recent flows of unconsolidated sedimentary serpentinite mantle its surface, and evidence within the edifice indicates recent deformation of the forearc sedimentary and basement sequences. Fluids are seeping from chimneys and related structures on the summit of the seamount, precipitating carbonate and silicate compounds that are cementing the uppermost portion of the sedimentary serpentinite flows (Fryer et al., 1987). Hydration of the crust and upper mantle of the forearc wedge is clearly facilitated by the escape of fluids from the subducting Pacific plate (Fryer et al., 1985b; Fryer and Fryer, 1987). The mantle and lower crust of the forearc wedge thus accomodates large volumes of fluids through metamorphic processes (Fryer and Fryer, 1987). Under appropriate tectonic conditions, serpentinite diapirs could be emplaced in any nonaccretionary forearc. Forearc serpentinite deposits have indeed been identified in the circum Pacific, Mediterranean, and Caribbean areas. By comparison with modern forearcs, the Mariana forearc is more extensively deformed (Fryer and Fryer, 1987). Conical Seamount is one of only two Mariana forearc seamounts where active protrusion of sedimentary serpentinite is known to be occurring at present. Conical Seamount therefore provides an *in situ* locality for studying the formation of diapirically emplaced sedimentary serpentinite bodies and their associated mineral deposits.

Site-specific objectives for MAR-3A include investigation of (1) the mechanical properties of the diapiric neck and emplacement mechanism of the diapir, (2) the composition of the associated fluids and entrained metamorphosed xenoliths, and (3) the compositional and physical variability of the rising diapiric material in order to determine the potential for ore deposition within the diapir. At proposed site MAR-3B we will investigate the history of uplift and metasomatism of the surrounding country rock near the diapiric neck. The relationship of diapirism to the history of development of the forearc region of an intraoceanic arc system, and the geochemical mass balance of the subduction process are thematic objectives. The diapirs provide "windows" through which we can observe the alteration and metamorphism of the central forearc at depth by components derived from the subducting slab, and through which we can trace the changes in P-T regimes of the deep forearc.

The physical properties of the diapir and the mechanism of its emplacement will be studied in greatest detail at MAR-3A. The study of the physical properties of the diapiric material and documentation of changes in the physical properties of the diapir with depth and age will alow us better to interpret sedimentary serpentinite deposits studied in subaerial exposures such as those of the basal Great Valley sequence in Napa County, California (Phipps, 1984). The rate of uplift of the seamounts as the diapirs rise beneath them will also be investigated. Drilling on the south flank of Conical Seamount (MAR-3B) should provide sufficient stratigraphy to allow determination of the uplift rate of the seamount.

Chemical analyses of fluids actively seeping from Chimney structures on Conical Seamount imply that deep-seated serpentinization processes, juvenile mantle fluids, interaction of seawater with crustal rocks, and interactions of seawater with the serpentinite may all contribute to the composition of the fluids. By detailed sampling within the serpentinite body and in the neighboring country rock, it should be possible to constrain either the nature of the shallow level reactions influencing the fluid composition or the possible sources of the fluids. Drilling is also the only way in which to secure samples that will allow us to constrain the small-scale variations in conditions of fluids within the serpentinite.

The process of serpentinization of forearc materials will be investigated at the Mariana sites, and also at proposed site BON-7 on the outermost part of the Bonin forearc (Fig. 2). Serpentinites in the Bonin forearc are found along the lower slope terrace, 20-30 km wide, which runs along the inner wall of the Bonin Trench (Taylor and Smoot, 1984). Swath-mapping shows that this feature is not a simple linear structural ridge. It is composed of a series of seamounts spaced at intervals of 15 to 40 km, with summit depths between 4 and 7 km. Salients on some of the seamounts appear geomorphically similar to rift zones on volcanic seamounts. However, several dredges and one core from seamounts on this ridge have yielded serpentinized harzburgite, metamorphosed gabbro, dolerite, and basalt, and their sedimentary derivatives (serpentinite breccia, sandstone and mudstone). SeaMARC II surveys of the three domes south of 32°N indicate sedimented slopes with some radial debris flows and seismic reflection profiles along and across the domes reveal an acoustically chaotic basement with thin or no sediment cover . BON-7 is situated on the flank of one of these domes. The major objectives in studying the serpentinite in these two forearc locations are (1) to compare and contrast the nature and genesis of greenschist facies metamorphism in the forearc regime and (2) to establish and members for investigations of geochemical mass balance and fluid flux in convergent zones.

OPERATIONS PLAN:

Nine primary and five alternate sites have been identified to meet the cruise objectives of Legs 125 & 126. Leg 125 is scheduled to drill proposed sites MAR-3A, MAR-3B, BON-6A, BON-6B and BON-7; alternate sites are BON-6C and BON-6. Leg 126 is scheduled to drill proposed sites BON-1A, BON-2, BON-5B and BON-4 in that order; alternate sites are BON-1, BON-3 and BON-5A.

<u>Leg 125</u>

Leg 125 will first occupy the serpentinite diapir sites in the Mariana region (MAR-3A and MAR-3B). Both sites will be APC/XCB-cored to refusal, followed by RCB coring to the total depth of 700 m (or deeper is time permits) at each site. The holes will be logged with the standard Schlumberger suite. In addition, wireline packer measurements will be made and the borehole televiewer run at MAR-3B. The ship will then transit to the Bonin region and drill sites BON-6A and BON-6B, Both sites will be APC/XCB-cored to basement. RCB coring 150 m into basement will be accomplished in a second hole at each site. Standard Schlumberger logs, borehole televiewer, magnetic susceptibility, and packer runs will be made at both sites. As time permits, a reentry cone will be set at BON-6A.

Finally, Leg 125 will core site BON-7, with the APC/XCB in a first hole to refusal followed with the RCB to a total depth of ~500 m in a second hole. Standard Schlumberger data will be collected.

<u>Leg 126</u>

A standard reentry cone will be set at site BON-2; minicones may be used at the other sites if drilling conditions so dictate. Standard Schlumberger logging and formation microscanner (FMS) data will be collected at all sites. The wireline packer and vertical seismic profiler (VSP) will be run at sites BON-1A and BON-2. A magnetic/susceptibility log will also be run at site BON-2. If time allows, Leg 126 will also reoccupy the reentry hole established during Leg 125 at BON-6A and run the FMS and VSP tools.

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TABLE 1a
LEG 125

Number	Latitude	Longitude	Water Depth (m)	Total Penetration (mbsf)	Priority	Drilling	Logging & BHTV	Total	Cumulative	Comments
						Days				
Transit from Guam to MAR-3A = 1 day[a]									1.0	
MAR-3A	19°32.5'N	146°39.6'E	3112	700	1	8.0	1.6	9.6	10.6	
MAR-3B	19°27.0'N	146°39.0'E	3450	700	1	8.0	2.0	10.0	20.6	
Transit MAR-3B to BON-6A = 1 day[a]									21.6	
BON-6A	30°50.5'N	140°55.0'E	2625	750	1	12.8	2.3	15.1	36.7	150 m into basement
BON-6B	30°53.5'N	141°18.0'E	2970	550	1	7.0	2.1	9.1	45.8	150 m into basement
BON-7	30°58.0'N	141°48.0'E	4600	500	1	7.3	1.5	8.8	54.6	350 m into basement
BON-6C	31°52.5'N	141°14.0'E	3100	200	2	3.4	0.0	3.4	--	50 m into basement
BON-6	31°54.0'N	141°06.0'E	2850	1100	2	21.1	2.8	23.9	--	re-entry site 150 m into basement
Transit BON-7 to Tokyo = 1 day[a]									55.6	

a. Transit assumes average speed of 10 kt.

TABLE 1b
LEG 126

Number	Latitude	Longitude	Water Depth (m)	Total Penetration (mbsf)	Priority	Drilling (Days)	Logging & BHTV (Days)	Total (Days)	Cumulative (Days)	Comments
Transit from Tokyo to BON-1A = 1 day[a]									1.0	
BON-1A	30°55.0'N	139°51.5'E	2270	1050	1	10.0	3.5	13.6	14.6	
BON-2	30°55.0'N	140°00.0'E	1110	1200	1	11.6	3.6	15.2	29.8	re-entry site
BON-5B	32°23.0'N	140°48.0'E	3400	900	1	11.0	1.6	12.6	42.4	100 m into basement
BON-4	32°24.0'N	142°23.0'E	1800	900	1	8.4	1.4	9.8	52.2	50 m into basement
BON-6A	30°50.5'N	140°55.0'E	2625	--	2	1.0	1.5	2.5	54.7	
BON-1	30°55.0'N	139°52.5'E	2270	1050	2	10.1	2.3	12.4	--	
BON-3	31°32.0'N	140°17.4'E	1430	900	2	6.8	1.4	8.2	--	
BON-5A	32°26.0'N	140°47.0'E	2700	925	2	8.5	1.5	10.0	--	
Transit BON-6A to Tokyo = 1 day[a]									55.7	

a. Transit assumes average speed of 10 kt.

WIRELINE SERVICES CONTRACTOR REPORT

The Leg 122 report below was prepared by Xenia Golovchenko, Lamont logging representative on Leg 122. David Castillo, Lamont logging representative on Leg 123, prepared the Leg 123 report. JOIDES logger for this leg was Cedric M. Griffiths. For further information, contact the Borehole Research Group, Lamont-Doherty Geological Observatory, Palisades, NY 10964.

LEG 122: EXMOUTH PLATEAU STRATIGRAPHY REFINED BY WIRELINE LOGS

Leg 122 was used to drill the Exmouth Plateau, one of the oldest continental margins in the world with a relatively low sediment influx. The sediment-starved margin provided a unique opportunity to study the early rift history, complete stratigraphic sequences and history of eustacy within the limits of the drillbit. Downhole logs addressed these objectives by providing continuous records of variations in the physical and mineralogical properties and by tying the information from cores to regional seismic data. A total of 3100 m of logs from 7 sites were logged. Wireline logs were run on the Wombat Plateau (Sites 759, 760, 761 and 764) and on the southern Exmouth Plateau (Sites 762 and 763).

Wombat Plateau

The Wombat Plateau was studied to determine the early rift history and to provide a record of sea-level fluctuations by testing the eustatic cycle chart published by Exxon researchers. A transect of sites was designed to recover the complete Jurassic through Late Triassic section, overlain by a thin Tertiary cover. A wide range of nearshore paralic to carbonate bank environments were recovered.

Site 759 penetrated 308 m of Quaternary to lower Miocene nannofossil ooze overlying a thin terrigenous/pelagic sand, overlying Late Triassic upward-shoaling cycles in a carbonate platform sequence. Through comparison of logs to core data, a complete picture of alternating neritic carbonates and paralic claystones suggests either sea-level variations or moving deltaic lobes. Site 760 penetrated 506 m of Quaternary to Carnian oozes, claystones and shallow, marine limestones. Because of severe bridging problems, only the top 150 mbsf was logged. The downhole logs in Late Triassic subaerial clayey silt- and sandstones proved very useful in delineating upward shoaling sequences. Site 761 drilled through 437 m of Quaternary through Norian sediments. Bridging problems precluded running more than 160 m of open hole logs, but geochemical logs were run through pipe over the entire cored interval. The logs delineated the boundaries between the lithologic units and were important in refining the lithology of the shallow-water carbonates, a unit that was poorly recovered (Figure 1). Drilling at Site 764 penetrated 294 m of nannofossil oozes, chalks and shallow-water carbonates. Geochemical and lithoporosity logs were run through pipe because the drillbit could not be released at the bottom of the hole. Core recovery within the carbonate sequences was very poor (<10%), making the wireline log data crucial in refining the unit boundaries and characterizing the lithology within each unit. Changes in character in the log response were used to subdivide the shallow-water carbonate unit into three units based on changes in clay content and iron enrichment.

Exmouth Plateau

Two sites were drilled on the western part of the central Exmouth Plateau to identify and characterize the cycles of sea-level change in an area with excellent seismic stratigraphic control. In this region, Jurassic and Early Cretaceous marine to prodelta sediments overlie a thick paralic sequence of Triassic age. This succession is covered by Cretaceous to Cenozoic pelagic carbonates.
Site 762 was drilled to a total depth of 940 m and yielded sediments ranging

in age from Berriasian to Quaternary. The nannofossil oozes and chalks are underlain by a black shale representing an anoxic event of early Aptian age. Underlying this unit is a silty claystone and prodelta mudstone of Berriasian to Valanginian age. The hole was logged with the "standard" three Schlumberger logging strings for detailed *in situ* measurements and safety considerations. Lithostratigraphic boundaries, particularly the Cenomanian-Turonian and K-T, are characterized by sharp changes in log responses. Rhythmic variations in Ca elemental yields and gamma ray counts on the order of meters have been tentatively correlated with Milankovitch-type cycles. Lower frequency cycles ranging from tens of meters to over a hundred meters were observed on the gamma ray log and may be related to second-order sea-level cycles (Figure 2). Site 763 drilled through 1037 m of synrift prodelta mudstones and nannofossil chalks and oozes. Because of the poor hole conditions due to swelling of Early Cretaceous claystones, only the seismic stratigraphic toolstring was run in the upper half (690-200 mbsf) of the hole. The log responses correlate well with the lithostratigraphic unit boundaries. The low sedimentation rate, and major hiatus between Late Cretaceous and middle Eocene preclude a detailed interwell correlation between this site and Site 762.

LEG 123: ARGO ABYSSAL PLAIN

The primary objectives of Leg 123 were to drill the oldest sediments and oceanic crust of the Indian Ocean in order to understand the geolological processes related to rifting of the NW Australian margin, opening of the Indian Ocean, and subsequenct destruction of the Tethyan Sea. Another important objective was to establish a geochemical reference site for ocean sediments and crust close to a subduction zone.

Drilling at Site 765 provided over 1200 m of loggable borehole; percentages of data collected using the Schlumberger seismostratigraphy, lithoporosity and geochemical tools were 70%, 44% and 83%, respectively. Similarly, percentages for Site 766 (520 m loggable borehole) were 39%, 85% and 97%, respectively. Unfavorable hole conditions were the primary cause for logging less than 50% of the hole. The full suite of logging data will be useful both for understanding the sections of borehole where core recovery was moderate to poor, and for generating a nearly complete geochemical description for this important reference site.

<u>Site 765: Geochemical Reference Site</u>

Preliminary analyses of M-N plots (transit-time/porosity/density relationships) show sharp gradient changes correponding to boundaries between individual turbidite units. Spectrometer data show that both K- and Th-counts increase towards the top of the turbidites, while U decreases. An abrupt decrease in velocity and resistivity and an increase in gamma radiation mark the boundary between the claystones and zeolitic claystones in the Upper Cretaceous section. Low total gamma response in the Valanginian-Aptian claystones corresponds to the low calculated sedimentation rate.

The 270-m basalt section displayed considerable petrophysical variability; high sonic velocities show broad correlations with massive flow intervals. K-anomalies can be correlated with brecciated zones containing smectite and celadonite.

<u>Site 766: Initial Rifting of NW Australia</u>

Total penetration at this site was 527 mbsf; basement was placed at 466.7 mbsf. Drill pipe was set at 260 mbsf, below the upper sequence of pelagic clays and oozes. Seismostratigraphic and porosity logs were run below this depth. Lower Cretaceous sands and siltstones were successfully logged between 444-245 mbsf. Changes in petrophysical signature (total gamma activity) delineate the Eocene/Pliocene, K/T, Aptian/Berremian and Barremian-Hauterivian boundaries.

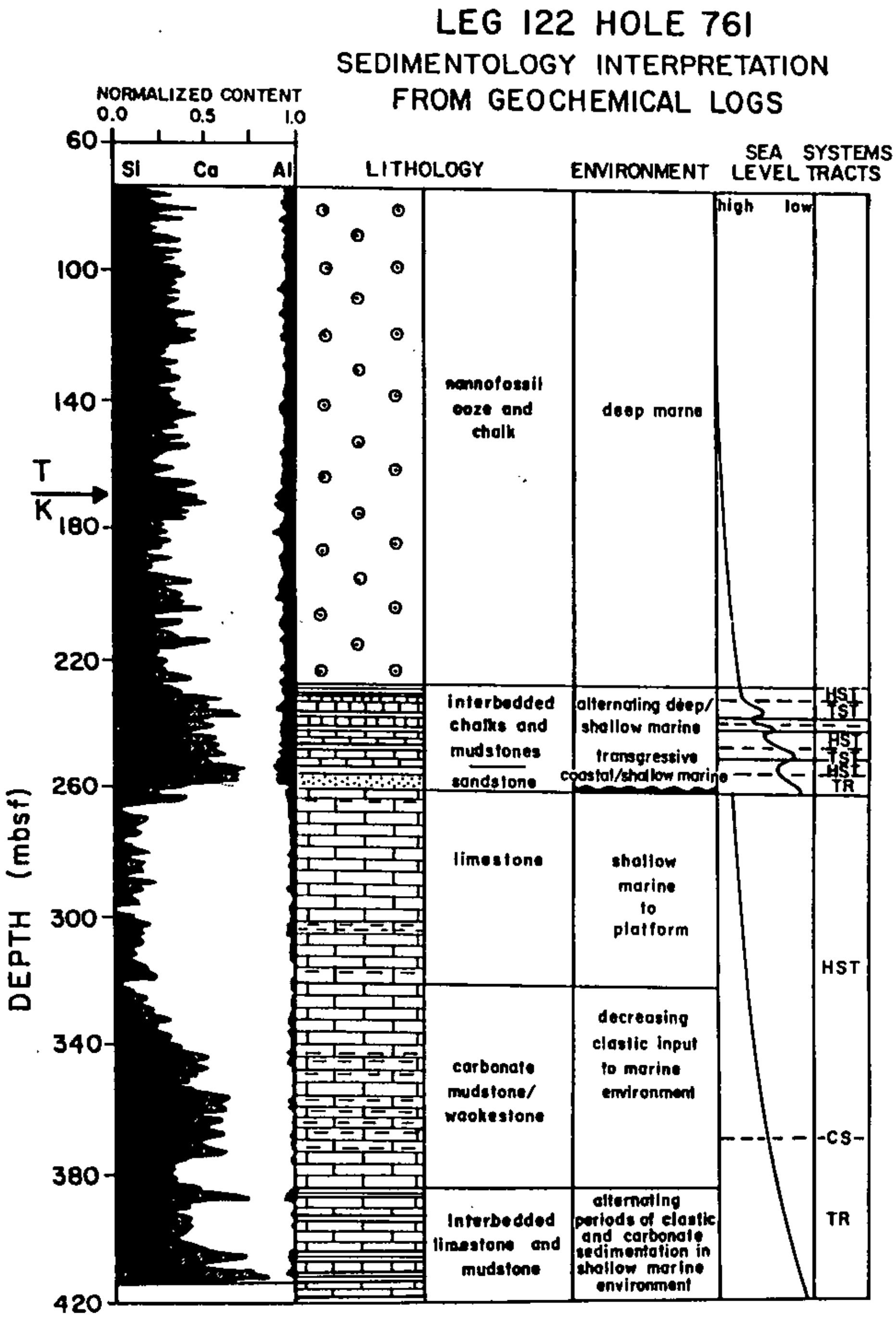

Figure 1. Geochemical logs from Site 761 on the Wombat Plateau off western Australia show an increase in silicon content during low stands of sea level. The elemental log variations were invaluable in refining the unit boundaries, lithologies and depositional environments at this site. The K-T boundary at 165 mbsf is characterized on the logs by a decrease in carbonate content.

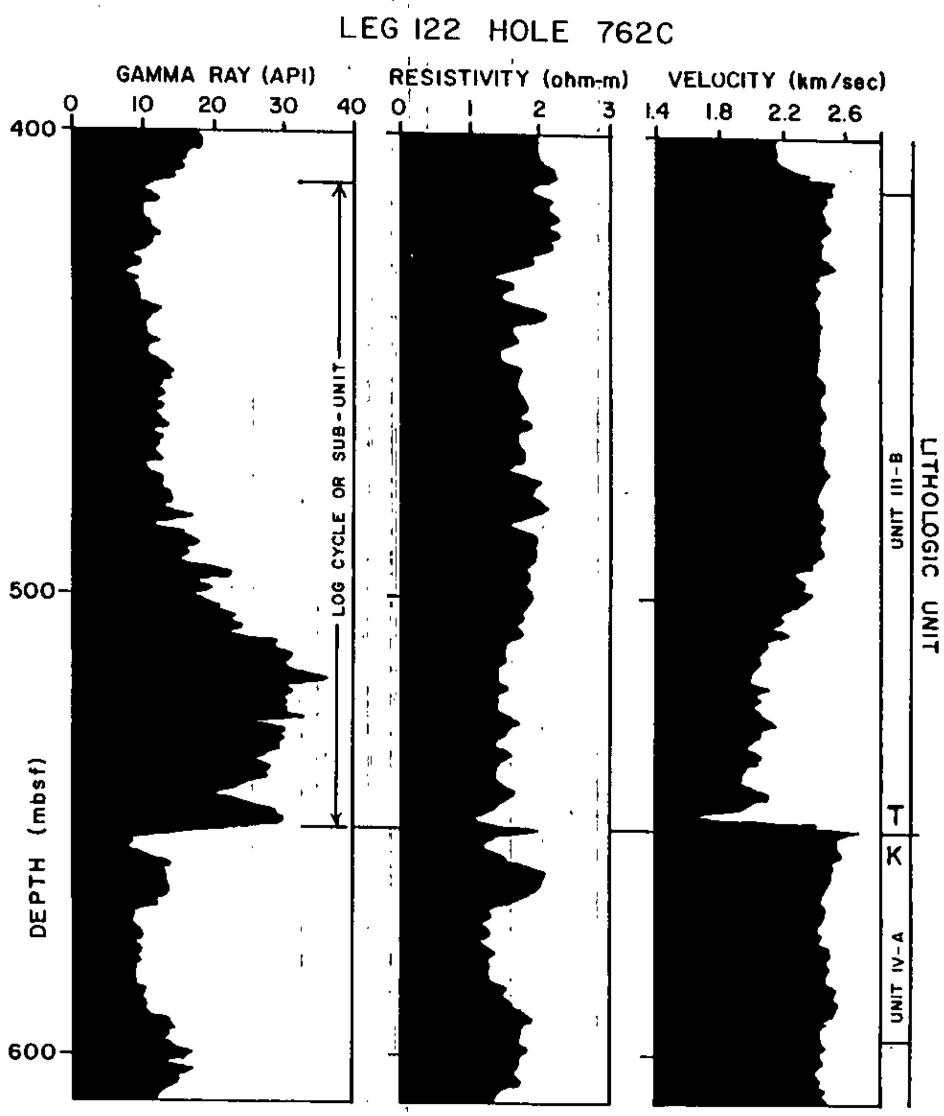

Figure 2. The K-T boundary at Site 762 on the Exmouth Plateau is characterized by a sharp change in gamma ray, resistivity and velocity response. A long-period cycle over 100 m in length may correspond to second-order sea level fluctuations. Superimposed on the long-term cycle is a higher frequency, rhythmic fluctuation that has tentatively been correlated with Milankovitch climatic frequencies.

PLANNING COMMITTEE REPORT

The Annual Planning Committee meeting was held 28 November-2 December 1988 at the Rosenstiel School of Marine and Atmospheric Science, Miami, Florida. The drilling schedule for FY90 and the status of the long-range planning document for ODP were the focus of the discussions. Highlights of the Miami meeting appear below. At PCOM's next meeting (2-4 May 1989, in Oslo) the agenda will focus on the four-year drilling plan and publication policy and the long-range planning document will be finalized.

ODP ENGINEERING REQUIREMENTS

Barry Harding gave the first part of the report for ODP/TAMU Engineering. The prospectus for Engineering Leg 124E remains on target. The new and improved final version of XCB is being "fine tuned" after the Leg 121 test. The Navidrill is online for testing using a new high-torque, lower RPM motor. The Phase I Pressure Core Sampler also will be tested on Leg 124E. The Diamond Coring System was given a quick test at Salt Lake City and was shipped to Manila; a one-day meeting in College Station among ODP/TAMU Engineering, SEDCO Operations, Tonto Drilling and other parties was scheduled to discuss plans, procedures and deployment of the drilling rig on the RESOLUTION. A new experiment has been added, using a rented bottom-imaging sonar device attached to the TV frame to look for chert layers around Site ENG-3, and to see what happens when chert drilling is attempted. A study of past chert drilling by both the DSDP and ODP programs is underway. The study will look at variables such as thickness of chert layers, drillbits used, success of method, etc. A similar study is underway to look at previous atoll drilling and associated recovery problems.

On Leg 122 a new system for recording drilling parameters was installed; this will aid in correlating lithologies and drilling speeds.

A second report, presented by Mike Storms, discussed three ODP Development Engineering Schedules: (1) Project Schedule; (2) Generic Technology Requirements and (3) Third Party Development Schedule. Finally, the vibra-percussion corer is still being studied through cooperation of the KTB Drilling Group, but no money is available for ODP testing.

Kate Moran gave a further update on several third party tools. The Phase I Lateral Stress Tool is in the testing phase; the Phase II Lateral Stress Tool has a three year design schedule and a prototype should be tested on the next engineering leg after 129E. The Geoprops tool being developed by Karig and Taylor is scheduled for deployment at Nankai.

SHIPBOARD UPGRADES

Shipboard computer upgrades will begin on Leg 124E and be completed by Leg 125 (See Bulletins, p. 66, this issue). A new sonar dome was installed forward of the moon pool in an attempt to improve resolution of the 3.5 kHz seismic records. A new multi-sensor tracker system will be installed on Leg 124E in the Physical Properties Section.

ODP LOGGING PROGRAM

The Slim Formation Microscanner together with its computer system and software is expected to be operational for Leg 126. Testing of the wireline packer is nearing completion and deployment on Leg 126 is anticipated. The following discussion focused on tool losses and failures. (Note: A formal policy on "fishing" for lost logging tools now exists. In summary: (1) In the event of loss of downhole tools, all reasonable efforts at drillstring and/or wireline fishing will be made. (2) Logging at any site will not ordinarily be curtailed because of the possibility that tool loss, requiring fishing-related delay, might occur. (3) TAMU will be financially responsible for logging or non-logging use of the cable cutter/crimper, minicones, bit releases and existing fishing equipment. LDGO will be financially responsible for logging or non-logging use of the winch and logging cable.)

In a separate session PCOM urged that the acquisition of two Digital Borehole Televiewers be advanced to the earliest time possible so that an improved stress-measurement program can be implemented.

PUBLICATIONS

Two recent external reviews of the ODP program, while overall quite favorable, identified publication timeliness as a deficiency. The primary cause of publication delays was identified as the failure of cruise participants to submit their manuscripts on time. Several options for speeding up the process are: (1) Use the system in place now, but reduce deadline time for Part B manuscripts from 18 months to 12 months; (2) Publication of results of individual scientists outside the ODP Volume B, once a fully acceptable (reviewed and reviews incorporated into text) manuscript (on the same topic) is completed for Part B; Independently publish all scientific results outside of ODP Volume B, which would then be a bound reprint collection.

The problem, as originally addressed to all panels, will be the subject of a survey to be completed and evaluated for presentation at a subsequent PCOM meeting.

LONG-RANGE PLANNING DOCUMENT

A discussion of the Long-Range Planning Document was led by its author, Nick Pisias. The document will be used as part of the proposal to renew ODP, for NSF and the non-US drilling partners. The document will receive final approval at the spring PCOM meeting. Successful completion of the Nankai, EPR and 504-B legs is important for the future of the program, in order to demonstrate that ODP can plan and execute high ranking scientific programs that are technologically difficult. ODP is a long-range project; the thematic objectives of highest priority already have more than 100 proposals, representing more than 17 years of drilling.

Related topics: A 50% increase in funding is not to be expected. An alternate drilling platform or another ship, while attractive, is not a reasonable expenditure, because as yet the long-range planning documents from the panels show little need for one. It should be kept in mind that other global initiatives are starting to gather momentum, and they will be competing with ODP for funding. The ODP approach is to deal with the Earth as an integrated global system, which can be divided into the four main topics of the long-range planning document.

FOUR-YEAR PLANNING MODE

PCOM cannot progress directly from its present thematic-priority, regional-planning mode to a four-year thematic-priority all-ocean planning mode, as there are insufficient <u>mature</u> proposals to do so. The main item for the Spring 1989 PCOM meeting will be planning the ship's general direction in a three-year mode (Spring 1989 to Spring 1992). By the following year (Spring 1990), panel reviews of new and existing proposals should allow PCOM to plan the general route for four years (Spring 1990 to Spring 1994).

DETAILED PLANNING GROUPS

The need for DPGs was discussed. DPGs serve to: Integrate the priorities of the thematic panels; insure full evaluation of proposals; work on specific requirements for a given site; improve program development; provide overall flexibility; and assemble special expertise. CEPAC, WPAC and SRWG memberships were retained as detailed planning groups CEPDPG, WPDPG and SRDPG, respectively. There will not be a Bering Sea-North Pacific DPG; CEPDPG will request additional expertise as needed to evaluate the program.

DRILLING PLANS FOR FY90

Nankai Trough

A general discussion was held to decide whether Nankai should be drilled as a one-leg or two-leg program. It was noted that a one-leg program would require moving NKT-2 upslope and preclude drilling at NKT-10. A minimum program requires three holes to be drilled at proposed sites NKT-1, NKT-2 and NKT-10 to properly determine the gradients as suggested by FPAPWG. *A Nankai leg was accepted into the FY90 drilling program consisting of drilling sites NKT-1 and NKT-2 with about 20 days of logging; a second Nankai leg will be considered after evaluation of the first Nankai leg.*

WPAC Programs

Since the Lau-Tonga, Vanuatu and Northeast Australian Margin programs were discussed in depth and accepted by PCOM previously, and since the drilling priorities and science objectives (as approved by PCOM) have not changed, *the Northeast Australia Margin, Vanuatu, and Lau-Tonga programs as most recently modified by WPAC were accepted into the FY90 drilling program.*

Geochemical Reference Sites

Geochemical reference sites were discussed extensively because of their previously low ranking by regional and thematic panels. The major objection, *i.e.*, that this is apparently a one-leg regional proposal, was dispelled when PCOM was reminded that this program was originally proposed as part of a larger thematic program. Drilling in the Mariana-Bonin system to determine crustal contributions to arc volcanism constitutes a first step toward achieving a major scientific objective identified in the Long Range Planning Document. The two sites BON-8 and MAR-4 are important for understanding old, altered crust and require at least 100 m penetration into the crust. *One Geochemical Reference Leg was accepted into the WPAC drilling program which will include sites BON-8 and MAR-4, plus appropriate downhole experiments and logging.*

CEPAC Programs

A general discussion was held regarding thematic ranking of proposals versus execution based on geographical and logistical constraints. It is possible that the RESOLUTION will not return to the Pacific for some time following the WPAC program. After FY91, with drilling open to all oceans, there will be an open competition between remaining CEPAC, WPAC and new proposals. PCOM must decide in the future whether it is acceptable to spend large amounts of time in transit between the highest priority legs or to insert lower priority legs that fill geographic or time gaps. Only mature proposals should be considered for drilling. With this in mind, the CEPAC programs were considered for insertion into the FY90 schedule. Of all the CEPAC proposals, PCOM agreed that the Ontong Java Plateau is the most complete at present, in terms of site surveys, and enjoys high priority within the thematic panels. *An Ontong Java Plateau Leg was placed within the FY90 program.*

Engineering

Although proposed southwest Pacific WPAC programs are generally more mature that the North Pacific programs, and normally would be considered for drilling after Nankai, cyclones in the southern areas off Australia during December through March present unsafe drilling conditions (until roughly 1.5 legs after Nankai). It was therefore suggested that the second engineering leg be drilled at this time. PCOM reached a concensus regarding engineering targets for this leg: *The Second Engineering Leg should be a further test of the mining coring system with emphasis on drilling and recovery of fractured crust and chert-chalk sequences, with reefal limestones, sandy sediments added, if there is time. The Third Engineering Leg in early FY91 should be aimed at meeting the science objectives in the Eastern Equatorial*

Pacific by preparing for drilling at 504B (clean or deviate hole) and EPR bare rock drilling (set hardrock guidebases). It was noted that this leg, with a long transit, may require 60 days, which would be in about December 1990 and January 1991.

This is the approximate cruise plan for FY90:

APPROXIMATE CRUISE PLAN FOR FY90 AND TENTATIVE PLAN FOR EARLY FY91

129	10/19-12/18	1989	2 mo.	Nankai
129E	12/23-01/21	1990	1 mo.	Engineering
130	Feb.-Mar.	1990	2 mo.	Geochemical Reference
131	Apr.-May	1990	2 mo.	Ontong Java Plateau
132	June-July	1990	2 mo.	NE Australia Margin
133	Aug.-Sept.	1990	2 mo.	Vanuatu
134	Oct.-Nov.	1990	2 mo.	Lau-Tonga
134E	Dec.	1990	2 mo.	Engineering

ODP SAMPLE DISTRIBUTION

The materials from ODP Leg 118 are now available for sampling by the scientific community. The twelve-month moratorium on cruise-related sample distribution is complete for Ocean Drilling Program Legs 101-118. Scientists who request samples from these cruises (after December 1988) are no longer required to contribute to ODP Proceedings volumes.

Preliminary sample record inventories for ODP Legs 101-122 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 institution 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 August through December, 1988:

Repository	Avg. No. Weeks Processing	Total # Samples
ECR	14	6,527
GCR	8	2,634
WCR	11	1,372

Investigators requiring information about the distribution of samples and/or desiring samples, or who want information about the sample investigation or sample records database, should address their requests to: The Curator, Ocean Drilling Program, 1000 Discovery Drive, College Station, TX 77840, Tel: (409) 845-4819.

JOIDES PANEL CHAIRMEN MEETING

JOIDES Panel Chairmen met on 27 November 1988 at the Rosenstiel School of Marine and Atmospheric Science, University of Miami. The following is excerpted from the Annual Report and Minutes of that meeting.

LONG RANGE PLANNING

The Long Range Planning Document (LRPD) as presented by Nick Pisias will be part of the proposal to renew ODP in the U.S. and partner nations. There will be other strong science programs in competition with ODP. If the LRPD is unsuccessful, the final year (FY93) of the existing program will be a phasing-out of ODP. The LRPD contains 16 scientific themes, with their implementation plan based on three phases. There is no strong need for an alternate platform in the next 10 years; there is no need for a riser, at least for the next few years.

Discussion centered on the concepts of focusing and establishing priorities among the 16 themes. One view was that the main themes and objectives be few, focused and new, and that these be of the highest priority. A small amount of drilling time would be available for the remainder. The objection was raised that if many of the objectives identified in COSOD II and white papers were removed, much of the scientific community might lose interest in supporting such a program. It was agreed, however, that the 16 should be focused into a few broad themes, and that priorities would be related to the constraints that engineering places on the 16. There should be no attempt to set priorities among the four first-order themes, which are:

1. Structure and composition of oceanic crust and mantle.
2. Causes and effects of oceanic climate and variability.
3. Fluid flow circulation in the lithosphere.
4. Dynamics, kinematics and deformation of the lithosphere.

It was recommended that introductions for each of these four should be rewritten. The tables of the LRPD will be modified to account for these four topics, and text and implementation plan will include what is required for pre-drilling work (mainly site surveys) and post-drilling work. The number of legs should be approximately 50% more than can be drilled in 10 years, to ensure strong competition among the proposals for legs.

NEW PANEL ADVISORY STRUCTURE

Communications

After a general discussion of the usefulness of liaison in communications, it was agreed that the liaison between thematic panels be reciprocal and clearly identified: TECP to LITHP and SGPP (and *ad hoc* to OHP); LITHP to TECP and SGPP; SGPP to all three; and OHP to SGPP (and *ad hoc* toTECP). Liaisons must be replaced at PCOM's earliest opportunity. Liaisons between thematic and service panels may be mainly *ad hoc.* Probably no formal liaison is needed between a thematic panel and a detailed planning group (DPG), as many DPGs are based on thematic requests and probably will have thematic panel members aboard. Regular scheduling of meetings and prompt circulation of minutes will assist communications.

Detailed Planning Groups

DPGs have a regional aspect, an *ad hoc* nature and short life, and proponents very likely will be members. Not all proposals will lead to a DPG. DPG recommendations normally will go to the appropriate thematic panels for their review and modification before submittal to PCOM.

Drilling Proposals

The three-phase history of proposals was discussed briefly: (1) An advocate submits a drilling proposal; the proposal is reviewed by all thematic panels.

(2) Thematic panels decide which proposals have high thematic objectives. The advocates have the opportunity to "mature" their proposal with assistance from the advisory structure, possibly including a DPG.
(3) PCOM decides which proposals are included in a year's drilling plan.

Planning Issues

Discussion centered on the perceived intrusion of political affairs into the science planning structure, which may affect WPAC and CEPAC planning. The Panel Chairmen unanimously adopted the following resolution:

"The Panel Chairmen agree that the planning of the ODP, and therefore the movement of the JOIDES RESOLUTION, should be driven by the science that is proposed. Every effort should be made to drill the sites that address the most important scientific problems in the most appropriate locations, without regard to parochial or political considerations that impose an arbitrary time frame or push to have the ship visit a particular area."

Second CEPAC Prospectus

David Rea emphasized the need for liaison to thematic panels, and the need for engineering legs to test engineering developments appropriate for CEPAC drilling in high-temperature environments, chert-chalk sequences, reefal limestone, and on brittle, fractured crust.

Engineering Needs and Developments

Much of future drilling depends on engineering development, and the panel chairmen were concerned that communications were not very clear among TAMU, PCOM, and the Panels. PCOM must keep better communications with TAMU engineers regarding developmental needs and their phasing. Perhaps once a year a panel should invite a TAMU engineer to its meeting to ensure that the scientific objective is understood. Occasionally, a JOIDES scientist should attend TEDCOM. The probable incompatibility of some advanced logging tools (geochemical, bore-hole televiewer) with the slim-hole, diamond-drilling method was given as a case in point where the essential information was not in hand at the time an annual Program Plan was written. The panel chairmen emphasize the need for continual feedback from Engineering in order for PCOM to make its next round of decisions.

Publications

Ted Moore led the initial response to PCOM's request for ways to promote thematic publications and reduce the delay of Part A and Part B publications. The question for Part A, where the most time-consuming task is agreement on the stratigraphic zonations of the cores, will be passed to OHP. The question of Part B may be whether or not Part B should be abolished and replaced by sets of collected reprints.

NEW PUBLICATION ANNOUNCED

The Ocean Drilling Program announced the publication in December 1988 of the Scientific Results portions of Volumes 101/102 and 103 of the Proceedings of the Ocean Drilling Program. The Scientific Results volumes represent peer-reviewed papers covering a wide range of specialized research of as much as 1-1/2 years duration. The papers published in these volumes will enable future investigators to gain ready access to the results of the present authors' research. The Scientific Results volumes bear International Standard Serial Number (ISSN) 0884-5891 issued by the Library of Congress. The Initial Reports volume for Legs 101 and 102 was distributed in December 1986. The Leg 103 Initial Reports was distributed in April 1987.

SEDIMENTS AND OCEAN HISTORY PANEL WHITE PAPER

INTRODUCTION

The Sediments and Ocean History Panel (SOHP) was charged with advising the JOIDES Planning Committee (PCOM) on all matters relating to paleoceanography, stratigraphy, sedimentary processes, and geochemistry. This covers an extraordinarily wide range of fields as is evident from the fact that seven of the twelve final recommendations of COSOD I and three of the five working groups of COSOD II fell within the SOHP mandate. Because of concerns that this mandate was too broad to be adequately represented by a single panel, SOHP has been divided into two panels--the Ocean History Panel (OHP) and the Sedimentary and Geochemical Processes Panel (SGPP). The preparation of this white paper predates the division of the panel; the first four of the six themes are most appropriately placed under the mandate of OHP, and two under the mandate of SGPP.

NEOGENE PALEOCEANOGRAPHY

Overview of Objectives

Understanding the causes and consequences of global climatic and environmental change is one of the most important challenges facing us today. Virtually all aspects of the history of life on Earth are controlled by the surface environment; an understanding of the complex interactions in the Earth climate system is essential if we are to learn to deal with the consequences of future global change. Paleoceanographic records give us the chance to reconstruct the temperature, chemical composition and circulation of the atmosphere, the changing wind- and water-borne flux of materials from the continents, the level of productivity of different regions of the ocean, and the evolutionary response of the biosphere to all these changes. Thus they allow us to test current models of the fundamental processes controlling the working of the global ocean-atmosphere-cryosphere-biosphere system.

When less than a decade ago deep ocean drilling gained the capability to recover truly undisturbed records of Neogene sediments, it was rapidly appreciated that the ultimate origin of most environmental variability on geologically short timescales is changes in the geometry of the Earth-Sun orbital system. The amplitude of response to this external forcing was surprisingly high during the middle and late Pleistocene (ice-age cycles). This discovery provides us with the basis for constructing and testing useful models describing the operation of the whole climate system; these models in turn permit us to target future drilling with increasing precision. Were this the whole story, it would be appropriate to focus only on the recent past. However, we have also learned that the sensitivity of the system to orbital forcing has changed in the past--sometimes slowly and sometimes rather rapidly. The environmental changes that will occur over the next century will depend very much on whether this sensitivity remains stable as projected atmospheric carbon dioxide levels go outside the range that has been experienced at least over the past million years.

The record of the history of global change has proved to be best studied in pelagic sediments. One reason is that the regional overprint in marginal marine and lacustrine sediments is usually large enough to interfere with the recovery of the global signal. For the past 0.3 million years the ocean record is accessible to conventional piston coring. However for older material, ocean drilling and particularly the hydraulic piston corer, is the only tool capable of recovering sequences of appropriate quality and resolution to tackle these problems. Even for the past 0.3 My, ultra-high resolution records like those collected from the Gulf of California, are accessible only through HPC/APC drilling.

During earlier phases of ocean drilling, we have established that climate-related signals can be recovered and decoded. We have also demonstrated that we can correlate and date these signals with sufficient precision that they can be integrated, allowing us to build up a picture of the working of the whole system and to evaluate the phase relationships between different components of the whole system. In addition, thanks to the computer revolution, we are beginning to have models (of varying complexity) that evaluate this system and can guide us towards those parts of the system that are under-determined due to lack of geological data. These modelling efforts will be of increasing value in guiding us as the interaction between modelers and observational scientists in the drilling program increases.

Scientific Opportunities and Objectives for Future Drilling

1. **To reconstruct the spatial and temporal variability of the oceanic heat budget:** For today's state oceanographers have constructed atlases and sections describing the distribution of temperature, salinity, dissolved oxygen, nutrients, radiocarbon, and other tracers in three dimensions. These distributions are used in constructing models of considerable complexity describing the dynamics of ocean-atmosphere interaction in terms of the heat budget, and enabling us to evaluate the role of the ocean in climate development. Future drilling will be designed to approach this kind of coverage for the past, encompassing the time dimension. Since total coverage is, of course, impossible to even contemplate, our task is to identify and sample those specific regions of the past ocean that are critical to the understanding of particular aspects of the system.

2. **To reconstruct the record of variability in the chemical composition of the ocean and its influence on atmospheric carbon dioxide, and to calibrate its climatic significance:** Within the past few years we have rapidly gained understanding of the way in which the atmospheric carbon dioxide level has varied over the last major climatic cycle (160ka), and, at the same time, have made great steps in understanding the mechanisms by which this is controlled by the chemistry of the ocean. We are now in a position to build up records of the changing carbon-related chemistry of the ocean and so to recontruct a longer record of the composition of the atmosphere. This, in turn, will enable us to evaluate the sensitivity of the climate to changes in atmospheric carbon dioxide.

3. **To understand the evolution of marine organisms:** The investigation of evolutionary mechanisms remains a central area in the Earth Sciences, and the sequences that are available from deep-sea drilling are those best suited to address some of the most pressing problems being discussed at present (e.g. the question of punctuated versus gradual evolution). The study of interactions within the biosphere at times of evolutionary change may also give us insight into the implications of massive anthropogenic intervention in the marine biosphere. Additionally, with improvements in non-biostratigraphic chronostratigraphic techniques, it should be possible to map migrations and diachronous events over broad geographic areas.

The Drilling Approach Needed to Meet These Objectives

How has the temperature and chemical structure of the deep ocean varied in response to orbital forcing? By what mechanism is Milankovitch frequency variability imprinted on deep ocean sediments (including their seismic character) in glacial and pre-glacial times? What aspects of whole-ocean chemistry have responded to orbital forcing? How has the abyssal fauna responded to high-frequency variability in food supply? These questions all require drilling transects to recover sediment deposited over a range of water depths. Ideally, the sites are closely spaced so as to have experienced the same flux of material from the photic zone, in which case the dissolution flux can be determined as a function of paleo-waterdepth. Examples would be Ceara Rise; Walvis Ridge (where DSDP Leg 74 obtained very valuable Paleogene sequences but poor Neogene records); Ontong Java Plateau; the North Pacific (where a depth transect could only be constructed from widely spaced topographic highs); 90°E Ridge; both sides of the sills bounding the Norwegian Sea. It is also essential that we exploit the opportunity for recovering high-resolution records in older (Paleogene and Mesozoic) sections so that the response of different ocean states to the same astronomical forcing may be measured.

How has the latitudinal temperature gradient, the mid-latitude East-West temperature gradients, the East-West equatorial temperature gradient (all monitoring heat transport) varied? These questions require the drilling of carefully planned transects capable of monitoring the gradients and their evolution. Transects across the California Current; the Subantarctic Indian Ocean around Broken Ridge; the Subantarctic Pacific Ocean on the East Pacific Rise; the equatorial Atlantic (well covered only in the East); the mid-latitude South Atlantic. Arctic coverage has extremely high priority; when the Arctic Ocean was not ice-bound (perhaps only a few million years ago) as it is today, it must have played an important role in climate control that cannot be evaluated so long as we have absolutely no records from the Arctic ocean. We believe that when the results of recent Antarctic drilling have been evaluated it will be found that there are still gaps in our knowledge of the Neogene at high Southern latitudes that must be filled if we are to understand the operation of the carbon system.

How has the mass budget of the ocean varied? How has the productivity changed? How has the flux of aeolian sediment changed? How has the input from the world's great rivers changed? These questions are addressed in some of the transects outlined above, with a few additional sites towards the gyre centers and sites toward the margins where fluxes rise rapidly. An important additional requirement here is that extremely precise time control is needed to generate flux estimates; virtually no DSDP site and only selected ODP sites, have sufficiently good recovery and continuity for this purpose.

Many of the important questions regarding the changing chemistry of the ocean (including the carbon system) will be tackled in the transects outlined above. However the solution of these questions will guide their prioritization; for example, for nutrient cycling and atmospheric carbon dioxide reconstruction it is especially important to record the "new" (at present, North Atlantic) and "old" (at present, North Pacific) extremes of the first order deep circulation path. On the other hand, the average chemical composition of the ocean is best monitored at an intermediate point along this path.

<u>Technology Issues</u>

A requirement that is common to all the objectives considered under this theme is the complete recovery of undisturbed sections. We believe that the JOIDES RESOLUTION is capable of achieving this very effectively; if any different platform were to be considered, it would be important not to sacrifice the advances that have been made since the end of DSDP. In the past, the HPC/APC has not been deployed as efficiently as desirable; frequently optimum recovery has not been achieved, though the quality of the material recovered is excellent. The recent drilling at Site 758 has shown that the recovery of a complete, <u>oriented</u> section <u>is</u> possible. However, sample requirements are increasing rapidly as the quality of recovery improves, and thought should be given to ways of increasing the quantity of material available for study. The critical need for data from the Arctic regions presents extremely difficult technological challenges. The JOIDES RESOLUTION is capable of drilling in some subpolar regions, but for high Arctic drilling another platform will be needed. In addition, the question of site surveys in Arctic regions must also be addressed.

HISTORY OF SEA LEVEL

Overview of Objectives

Sea level fluctuations provide some of the most dramatic and pervasive influences on the stratigraphic record, and have ramifications in almost all aspects of Earth history. The hypothesis that certain sea level events are globally synchronous and are expressed as depositional sequences of onlap and offlap (and intervening unconformities on continental margins) has, in the past decade, revolutionized the interpretation of seismic data from marine sedimentary environments. As our stratigraphic, geophysical and geochemical tools improve, the originally proposed 'eustatic sea level curve' is now recognized to be the result of a complicated interaction between sediment supply, tectonic history, subsidence, and eustacy. We have recognized links between sea level fluctuations and climatic variations, tectonic events, ocean chemistry and circulation changes, as well as faunal boundaries. However, fundamental questions remain with regard to the true synchroneity of these events and the causal linkages among them.

Much of our present knowledge of the timing and amplitude of sea level changes has been derived from studies of passive margins and from the oxygen isotope records of pelagic and benthic microfossils. The passive margin signal is greatly influenced by changes in subsidence, sediment supply and tectonic uplift, and is susceptible to numerous sources of error. The best opportunity for reconstructing a complete picture of global sea level history lies in a well formulated program of drilling a series of holes in the slopes, rises and abyssal plains of the world -- a program that only ODP can undertake.

The history of sea level fluctuations is so complex that no single technique or single site can be expected to provide a global picture of sea level variations. In support of the recommendations of the COSOD II we propose three independent approaches, each with its limitations and advantages, to attempt to document and quantify global sea level history. These include passive margin and atoll drilling, and the recovery of pelagic sedimentary sequences in order to establish a complete high resolution oxygen isotope record. Probably more than any other SOHP objective, drilling to establish a global sea level curve will have to be supported by high resolution geophysical surveys, high-quality well log records, and complete core recovery.

Scientific Opportunities and Objectives for Future Drilling

The fundamental task of a global sea level history program is to quantitatively establish the timing and amplitude of major global sea level fluctuations. Specific objectives for sea level related drilling include:

1. **Determination of the timing and global correlation of sea level cycles.**

2. **Determination of amplitude of sea level cycles (2nd and higher order).**

3. **Evaluation of the mechanisms responsible for global sea level cycles.**

4. **Extraction of regional sea level signals from a composite and global sea level curve and understanding of mechanisms responsible for the regional signals.**

5. **Determination of the effect of sea level fluctuation on basin sedimentation and the deep sea record.**

The Drilling Approach Needed to Address These Objectives

Three independent approaches needed to address these objectives defined by COSOD II and SOHP include: (1) drilling of passive margin transects; (2) atoll drilling; and (3) the recovery of continuous sedimentary sequences to establish oxygen isotopic records. By combining these different approaches it may be possible to overcome the limitations inherent to each approach, and extract a global sea level signal.

The passive margin approach, developed by Vail and his colleagues, estimates global sea level variations from stratigraphic information coded in coastal onlap and offlap patterns on different continental margins. Because of the uncertainty of the prediction of subsidence and other factors affecting sea level fluctuations in any one area, it is necessary to stack information from different margins in order to extract the eustatic component. We propose to drill transects on passive margins with different tectonic histories and sediment (carbonate and siliciclastic) supplies. Drilling on margins with relatively simple subsidence histories is required, preferably near to where good land outcrop sections and industry data from wells are available. At least one transect per margin type is needed, extending from the contintal shelf onto the adjacent basin plain and penetrating a sedimentary sequence as completely as possible. The approach should be sequential, beginning with the Neogene, where we have the highest resolution and then applying our results and models to older sequences. There are only a few areas on the globe where a high resolution (third and higher order) seismic sequence stratigraphy and the means to date it precisely (e.g. by bio-, magneto-, and isotopic stratigraphies) exist. Potential areas for the Neogene record include the Northeast Australian Margin, the South China Sea Margin, the Maldives, and the Gulf of Mexico. Transects along the east coast of North America or the west African Margin, the Exmouth Plateau and the east African Margin are proposed to obtain the longer Mesozoic-Cenozoic history.

The atoll approach has recently been proposed because the advent of Sr-isotope dating now permits the dating of previously undatable atoll carbonate sequences. This approach uses the stratigraphic record of atoll carbonates as dipsticks in areas having a 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 Ma) information on the amplitude of post-Eocene eustatic sea level 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 the Eocene. Paired atoll/drowned atoll depth transects, in a major atoll chain that extends over a wide latitude and age are preferable in order to drill the early sea level record on the drowned atoll and the more recent record on the current 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 into the platform top. The USGS Eniwetak and the French Mururoa sites may provide this information.

To test the validity of results based on atoll drilling, core transects along low-relief carbonate bank-slope-basin systems should be compared to the proposed transects on Pacific high-relief atoll transects. Gentle carbonate slope-to-basin systems should be compared to the proposed transects on Pacific high-relief atoll transects. Gentle carbonate slope-to-basin transitions contain low-stand sedimentary records. Sea level curves derived from the lower relief areas of the Maldives and Queensland Plateau may be an ideal comparison with sea level curves derived from Pacific-atoll drilling.

A third approach to the sea level problem depends on the oceanic oxygen isotope record which is one component of the required multiple stratigraphies and, more importantly, can provide insight into the mechanism of sea level change. The oxygen isotope approach infers changes in global ice volume from the isotopic composition of benthic and planktic foraminifera. The reliability of this approach depends on the accuracy of assumptions regarding water temperature and the isotopic composition of glacial ice (an important component of Theme 1). Proper use of this approach requires the compilation and validation of records from both benthic and planktic 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 time correlative oxygen isotope record.

Technology Issues

There are demanding engineering developments required to be able to address the topic of global sea level fluctuations. Further developments in the short term should emphasize: (1) continuous core recovery of all types of sediments including sands, chert and especially shallow water carbonates (i.e. coral debris); and (2) continuous core logging. Intermediate range objectives will require drilling within atoll lagoons and on atoll rims. It is probably not cost effective (or feasible in some instances) 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 margin transects and to provide the pre-Neogene sea level record.

PRE-NEOGENE PALEOCEANOGRAPHY

Overview of Objectives

The Paleogene and Cretaceous, dominated by warm oceans, represent a vast period of time with circulation and sediment patterns entirely different from those of today. Exploring the Earth's response to significantly different conditions offers the opportunity to gain critical insight into the behavior of the earth/ocean system. After 20 years of deep drilling, however, this promise has not yet been realized; there are wide gaps in our knowledge of how the oceans and their biota behaved during the Jurassic, Cretaceous and Paleogene. Reconstructing the ocean-climate history during this expanse of time represents a major challenge to future ocean drilling. For the Paleogene, the challenge will be to elucidate the important ocean-climate changes that include transition from an ice-free to a glaciated world and formation of deep cold waters in polar regions. For the Cretaceous, the next ten years of drilling will focus on better understanding the interaction and effect of global warmth, widespread anoxia, carbonate chemistry, high global sea levels, and changes in atmospheric and oceanic circulation on the evolution of oceanic biota (particularly the dramatic evolution of calcareous nannofossils, radiolaria and plantonic foranminifera). For the Jurassic, where recovery is spotty, sampling will allow us to draw analogies to the Cretaceous and explore the differences.

Key questions include: Did tectonic and orbital forcing functions drive the global environmental changes during these time periods as they did during the Quaternary? What are the mechanisms linking changes in the global environment with the successive rise to dominance of various calcareous and siliceous plankton groups in the ocean? Was the Earth environment periodically perturbed by extra-terrestrial causes as indicated by the episodic recurrence of mass extinctions of biota? How were large volumes of organic material concentrated and preserved on the continental margins and deep-sea basins, during certain periods of the Mesozoic and Tertiary when sea level stood higher and climate was more equable than at present? The critical objective in the study of pre-Neogene oceans is the recovery of information about a range of ocean dynamics which are outside of present day experience, e.g. haline-dominated deep circulation, slow deep-water renewal, low oxygen content and hyper-stratification. In addition, the pre-Neogene offers insights into the transitions from warm- to cold-ocean dynamics (e.g. onset of psychrosphere in the late middle Eocene).

Our knowledge about the geographic configuration of ancient ocean basins has increased rapidly in the last two decades. However, we do not know how changes in geographic configuration translate into changes in circulation, ocean chemistry, productivity, and evolution. Although speculation abounds, our models are quite primitive. Much of our information on the early history of present day ocean basins comes from sequences of the former Tethyan and Atlantic margins (mostly disturbed by subsequent orogeny and plate collision) or from sequences deposited in shallow epicontinental seas.

The limitation of the Paleogene record is derived from an incomplete geographical sampling, specifically from the Pacific. For example, the Paleocene-lower Eocene Pacific carbonate record is represented at only one site (577), and there is no suitable middle Eocene Pacific carbonate record in low latitudes. Characterization of Mesozoic oceanic conditions will be based on the relatively more extensive, more stratigraphically continuous Cretaceous record. Fortunately, there is a broad correspondence in biochemical patterns between the Cretaceous and Jurassic periods. Much less than 1% of all recovered deep-sea sediments is pre-Cretaceous in age. To date, however, open marine sediments of early Liassic age either on land or through deep drilling (Leg 79) rest on subsiding passive margins of the Tethys. No data are available on the type of sediments that accumulated in the abyssal plains, if indeed they existed.

Scientific Opportunities and Objectives for Future Drilling

1. **To understand circulation patterns in a warm ocean, entirely different from today's.** Were Mesozoic oceanic conditions always more equable and stable than today's? If so, why?

2. **To study the mechanisms of climatic change in a predominantly ice-free system.** What were the oceanographic conditions that led to the transition from an ice-free to glaciated world in the Paleogene?

3. **To study productivity and biogenic sedimentation patterns in a low-oxygen ocean.** What oceanographic conditions led to the onset of ocean anoxia? Were conditions constant through the Mesozoic?

4. **To determine the environmental conditions that led to the transitions from silica-rich to carbonate-rich sedimentation and the increase in deep-sea carbonate during the Mesozoic.** Are these global changes due to major evolutionary changes or are they driven by changes in environmental parameters? What are the consequences of cycling carbonate and carbon in the oceans--how did this affect atmospheric circulation?

5. **To understand whether evolution is more strongly dominated by environmental change and stability, or by internal (biological) mechanisms.** Have geographically isolated areas such as those in high latitudes and deep water basins given rise to new species or did they diverge along evolutionary gradients?

6. **To determine the conditions that led to major and minor extinction events. Although these changes are well**

documented, the causes of extinction are still poorly understood. Do species extinctions occur independently of one another, or are they "clumped" in time? Are mass extinctions simply scaled-up versions of the smaller, clumped extinctions? To what extent was the biota affected by global anoxia? Was the ecologic specialization of bathyal foraminifers during the mid-Cretaceous related to the development of oxygen minimum zones or in surface productivity? What is the relationship of changes in productivity to the evolutionary turnover of marine biota?

7. **To investigate biotic radiation events.** Examples include a rise to dominance of a biotic group, and radiation following extinction events. What are the rates of diversification? Do they differ between the styles of radiation events? Are the rates uniform or do they fluctuate with time? Do the rates become high immediately following extinction events, or are there substantial lags?

8. **To study rhythmic sedimentation patterns in oceanic sediments and to develop a coherent cyclostratigraphy.** Do certain cycles record orbital variations? How widespread are such signals in space and time? What can they tell us about geochronology, orbital variations, paleoclimate and sedimentary processes? Are there short magnetic polarity reversals in the Cretaceous long-normal superchron that can be used for more precise global correlations?

Approach Needed to Address These Objectives

The recovery of undisturbed Mesozoic to Paleogene oceanic sedimentary sequences from different ocean basins is required in order to obtain a record of global environmental changes with high temporal resolution. The limited occurrence of pre-Neogene crust implies that sites will have to be selected within a well controlled plate reconstruction framework. This program will require the recovery of cores from thick, continental- margin sequences (deep stratigraphic test holes), ocean-basin sediments, and carbonate caps on submerged volcanic edifices. The recovery will form a global array of Cretaceous and Jurassic sites that will utilize HPC/APC and multiple reentry technologies. Specifically, transects are required in:

1. High latitudes: Knowledge of pre-Neogene ocean history suffers from a lack of data from high latitude sites. Specific target areas include the Arctic Ocean, Bering Sea, Norwegian-Greenland Sea, areas surrounding Antarctica, and sites originally formed at high latitude, i.e. Louisville Ridge and areas adjacent to Australia.

2. Old Mesozoic sediments: To address questions of ocean chemistry, anoxia, climate changes and biotic evolution in the Jurassic and early Cretaceous of particular interest are targets in the Western Pacific, Moroccan Basin, Venezuelan and Somali Basins (deep stratigraphic test holes).

3. Atolls, guyots and oceanic plateaus: Drilling of caps and flanks of topographic highs to recover a record of subsidence, sea-level changes and biogeochemical changes resulting from plate motions. (see Theme 2). Targets of special interest are Manihiki, Ontong Java, and Ogassawara Plateaus.

4. Passive margin transects: Deep sequences are needed to examine anoxia, high productivity, and early rifting environments. Important areas are the southern and western Australian margins, and the eastern and western South Atlantic margins.

5. History of Old Tethys to Paleogene closing of the seaway: Eastern Mediterranean.

6. Deep ocean basins: To address the formation of deep bottom waters, biotic evolution and anoxia. Areas of particular interest are Argentine and Angola Basins, and the western Pacific.

Technology Issues

To achieve many of the goals identified, good recovery of geologically older material is imperative. This means an improvement in XCB capabilities. Recovery of alternating hard and soft layers and shallow water carbonates requires new technology to be developed. New technology must be developed to assure deeper penetration of the ocean floor. Well-log data obtainable with the use of the borehole televiewer and microscanner are complimentary to laboratory core data and their continuity often leads to the solution of problems, such as those of cyclicity, which continuous core data alone cannot address satisfactorily. Once again, the requirement for Arctic and high latitude drilling implies the use of an alternative platform and specialized site survey techniques.

THE CARBON CYCLE AND PALEOPRODUCTIVITY

Overview of Objectives

The thermal and atmospheric balances of the Earth are intimately linked to the global cycling of carbon. The marine carbon cycle, and thus the partitioning of carbon between reservoirs, is closely linked to climate in two ways: (1) climatic change produces changes in the patterns of deposition of carbonate and organic matter, and (2) changes in such patterns affect the chemistry of the ocean and hence the carbon dioxide concentration in the atmosphere. This, in turn, affects the radiation budget of the Earth. The chief means for reconstructing the carbon cycle are the recovery of the global patterns of carbonate stratigraphy, of the record of preservation and $\partial^{13}C$ in calcareous fossils, and of the inventories of productivity-sensitive microfossils.

Fluctuations in the distribution patterns of carbonates--the carbonate cycles and supercycles--are the dominant facies aspect of pelagic marine sedimentation. These patterns are a direct, albeit complicated, response of deep ocean circulation and the geochemical balance of carbon input and output to climatic forcing. Much of this forcing has been shown to be ultimately tied to orbital variations, so that it can, in principle, be predicted, allowing a quantitative extraction of the response function. Thus the carbonate record, together with associated organic carbon patterns, reflects the dynamic state of carbon throughput at any one time, and hence the level and character of biological activity which provides the background for climatologic, ecologic and evolutionary studies.

High-productivity zones (HPZs; equatorial, coastal and high latitude) play a special role in that they are very sensitive to changes in wind patterns and to the nutrient content of intermediate waters. In places, HPZs yield a record reflecting changes in the global ocean-climate system in a very distinct manner. Also, HPZs are crucial in controlling fractionation of dissolved inorganic carbon between the major ocean reservoirs, and in the extraction of carbon from seawater and its sequestration into the sediment. In this way, productivity fluctuations control the oxygen content of the deep sea, and general biogenic sedimentation patterns, as well as provide feedback to climate change. The sediments in coastal HPZs record not only the productivity of overlying waters but also the influx of terrigenous organic material (as well as other terrigenous contributions). Thus they directly reflect the patterns of exchange between ocean and continental carbon reservoirs, and yield clues to sea level fluctuations and their relationship to coastal ocean productivity.

Short and long-term cycles: The presence of Pleistocene-type carbonate cycles has now been established back into the middle Miocene, and similar cycles are seen in earlier periods as well. It appears that for the Neogene, Pacific and Indian Ocean cycles run parallel, while the Atlantic follows different dynamics. These patterns contain clues to basin-shelf exchange patterns, and to the intensity of basin-basin fractionation through time. The same processes are also reflected in the $\partial^{13}C$ signals within the benthic foraminifera. Together with the corresponding $\partial^{18}O$ records, these signals provide a qualitative view of the relationships between the major components of ocean dynamics and ocean carbon chemistry, as they respond to Milankovitch forcing.

Similar to the carbonate cycles, pelagic and hemipelagic organic carbon cycles are tied to glacial-interglacial climatic fluctuations, and can be followed back to the middle Miocene. Again, similar cycles are observed even earlier in the record, within an ocean-atmosphere system whose dynamics differed considerably from those of the Neogene. Silica cycles show parallel patterns, presumably likewise tagging productivity fluctuations. Amplitudes, interrelationships between carbon and silica facies, and relative power within the frequencies of the fluctuations change through time, as a function of as yet largely unknown mechanisms.

The less vigorous circulation in warm oceans as compared with the present cold ocean, and the lesser oxygenation of deep waters, provides for overall differences in depositional patterns of biogenic sediments. Of special interest is the influence of productivity in upper waters and of preservation on the seafloor of the distributional patterns of organic matter in Paleogene and Cretaceous sediments. The discovery that carbonate/organic carbon cycles are forced by Milankovitch frequencies as far back as 100 million years ago has raised questions regarding climate feedback mechanisms in an ice-free or ice-poor world.

Scientific Opportunities and Objectives for the Future

1. **Reconstruction of atmospheric CO_2:** A number of critical issues relating to the carbon cycle and paleoproductivity should next be addressed by the drilling program. These include the detailed correspondence of short-term changes in sedimentation patterns from one ocean to the other, and from the deep sea to the margin. These patterns must be put within the framework of changes in microfossil content, to capture clues on climate and productivity control. Also, the exact relationships to the $\partial^{13}C$ record must be established on a global scale.

   In principle, it is possible to test rigorously the various propositions, from geochemical modelling, regarding CO_2 fluctuations in the atmosphere for the last 100 million years. It can be shown that a full global characterization of the ocean carbon system, from its calcareous and carbonaceous sediments, is sufficient to obtain reliable estimates of the carbon-dioxide content of the atmosphere and the level of productivity of the ocean. Such reconstruction will be necessary if the feedback mechanisms between ocean and climate are to be fully documented.

2. **The Role of HPZs:** The expanded records in the HPZs are of special significance in that the details of climatic forcing can be resolved on a much finer time scale here than in normal pelagic sediments. In places, it is possible to obtain windows into annual variations of climatic state. Thus, varved sediments in the Gulf of California and elsewhere allow the recovery of the frequency of unusual climatic events (e.g. Super El Niños) as a function of general climatic state. In addition, hemipelagic sediments of coastal upwelling systems commonly reflect climatic-tectonic events on the adjacent continents. Finally,

sediments of HPZs, being major repositories of carbon and phosphorus, act as sinks and also as transient reservoirs for these elements, potentially functioning as geochemical amplifiers of climatic forcing. Intriguing reactions of broad significance take place in HPZ sediments, including nitrate reduction, sulfate reduction, trace-metal mobilization and fixation, hydrocarbon fractionation, phosphorite production, and dolomite formation.

3. **History of upwelling systems and relationships to global climate:** Present upwelling systems are well defined. Occupying less than 10 percent of the area of the ocean, they determine more than 50 percent of the carbon cycle. Does this dominance extend into the past? When did these systems become established? Did they turn on and off, and, if so, when and why did this happen? Did upwelling systems exist in areas where they are now?

Most prior efforts on the history of upwelling and productivity have focused on the Quaternary record. We now need to go further back to examine older records, to appreciate the role of upwelling in entirely different climatic and geochemical settings, including that of an ice-free or ice-poor world. In addition we need to expand global coverage of past ocean productivity to include records from entirely different geographic settings, including tropical and subpolar ones. This should bring elucidation of the relative importance of tropical versus subpolar upwelling in the short-term control of atmospheric CO_2, under different conditions through geologic time.

The history of upwelling must be compared with that of climate, and the two linked through proper modelling. How have upwelling systems evolved in response to major paleoclimatic and paleoceanographic changes? And how did these changes affect global fluxes of C, P, and Si? What is the effect of the onset of events like glaciation, or deglaciation, on the different upwelling systems? For example, what effect did the development of polar ice masses have on the intensity and location of Cenozoic high-productivity areas? Was there positive feedback between ice buildup and upwelling, as suggested, e.g., in the "Monterey" scenario?

In this context, the role of small, high-productivity ocean basins along the continental margins is of special interest. For example, the Gulf of California accounts for about 3 percent of the silica output of the ocean. How important are marginal basins as sinks for carbon, phosphate, and silica, and what is the history of this role? What are the effects of opening and closing of deep (and surface) water passages between these basins and the world ocean? Can we relate the climate records of mid-marginal basins to the high latitude climate record?

Such questions are of great importance in view of the climate modification expected from the changing CO_2 content of the atmosphere.

<u>The Drilling Approach Needed to Meet These Objectives</u>

The drilling strategies necessary to achieve the objectives of carbon cycle reconstruction and paleoproductivity must proceed from building a global three-dimensional matrix based on depth, latitude and level of productivity, for the major ocean basins, and for typical geographic settings along continental margins and within small marginal basins.

For a global picture of carbonate sedimentation, depth transects across the slopes of plateaus and across MOR flanks are needed in regions of importance, including the equatorial areas of each major ocean basin, the gyre centers, the major eastern and western coastal systems, and the subpolar systems. Also, transects are needed at right angles to productivity gradients, so that a cross-transect pattern is established, within a depth/productivity matrix. Obvious examples of favorable regions for drilling are the Ontong Java Plateau in the western equatorial Pacific and other plateaus like it in various settings, Ceara Rise and Sierra Leone Rise in the tropical Atlantic, Walvis Ridge in the South Atlantic, and Kerguelen-Gaussberg Ridge in the Indian Ocean. Other promising target areas for transects are on the sediment-covered flanks of the MOR wherever it crosses the equator, or runs through the central gyre, or intersects the Antarctic Circumpolar Current.

For the history of HPZs, and their influence on the carbon cycle, closely spaced sites are needed along and across productivity gradients, within the major high productivity systems: eastern equatorial areas, coastal upwelling regions, selected Antarctic and Sub-arctic areas. These transects are to provide records of the changing extent and intensity of driving currents and accompanying upwelling activity. The history of the major HPZs, pelagic and coastal, needs to be compared from one to the other, and the productivity record of polar regions and of selected marginal basins needs to be tied to that of the dominant HPZs.

Since there is reason to believe that the carbon cycle runs in a number of strictly different modes--depending on the partitioning of carbon between the more reactive reservoirs, and the degree of mobility of the carbon in the exchange between them--detailed records must be established for a number of periods within the Cenozoic and within the Cretaceous. The meaning of the proxies of productivity may change from one period to another: the correct transfer functions will only be discovered if the various proxies are compared in parallel within a high-resolution time-scale, on a global basis (using, in addition to biostratigraphy and magnetostratigraphy, strontium isotopes and other chemical tracers). Thus, the type of studies here envisaged will require complete recovery of undisturbed sections, as far as possible.

Technology Issues

As with Theme I, the basic strategy of a carbon cycle program calls for high-resolution transects with broad geographic coverage. The JOIDES RESOLUTION has demonstrated its ability to provide the material appropriate for these types of studies in the part of the section that can be recovered with the HPC. Similar capabilities are now needed for the XCB to allow us to extend the high-resolution record further back in time. Recovery of gassy sediments and full development of the pressure core barrel also will be required. Because of their importance to global budgets, HPZ studies should include regional survey data for targeting drilling such that the results can be extrapolated to provide a budgetary assessment of the HPZ through time. Also, the carbon cycle program will require the capability to drill deep holes (for long-term cycles and margin sections) and the technology for Arctic drilling and site surveys.

SEDIMENTARY GEOCHEMICAL PROCESSES

Overview of Objectives

Reactions and chemical redistribution of elements within the sediment column affect many aspects of the evolution of the ocean, atmosphere, and sediment system, as well as our ability to interpret global environmental change from sedimentary records. In this section we consider the role that ocean drilling can play in understanding major sedimentary geochemical processes which, for this discussion, are subdivided into the overall categories of fluid processes and diagenesis.

Recognition of the importance of fluid flow through the oceanic crust is viewed as an important new scientific breakthrough. In the marine realm, this revolution touches on several subjects including evolution of seawater, the alteration of deep-sea sediments and oceanic crust, and metallogenesis; ultimately fluid flow affects the budget of most major and minor elements. Specifically, our concepts about the history of seawater now reflect advances made in tracing fluid flow through the oceanic crust. For example, the geochemical cycle of Mg could not be understood without recognition of the important sink for this element within altered mid-ocean ridge basalt. More recently, new fluid-flow regimes have been recognized involving fluxes *via* expulsion of pore fluids in subducting and accreting sediments on active margins, free convection of seawater through low-temperature ridge flanks, and leakage of continental fresh and saline groundwaters along continental margins. The lithification of accretionary prism complexes by carbonate cementation and compaction as well as the short-circuited pathway of volatiles through décollement zones (particularly carbon and water) are but two examples of the fundamental role of convergence-induced fluid processes. As highlighted in the COSOD II document, these sediment-based fluid-flow systems may play a significant role in fine-tuning the geochemical cycles of elements and gases whose balances affect the composition of the atmosphere and thus climate.

Studies of diagenesis have played a long-standing role in our understanding of geochemical, mineralogical and paleoceanographic processes. In the context of ocean drilling, three new aspects have emerged that are of special importance: First, diagenesis can enhance physical property contrasts within a sedimentary sequence that allows for recognition of paleoceanographic events and cycles by seismic methods. Second, it produces an overprint on the stratigraphy that interferes with the interpretation of sediments in terms of the orginal environment but offers insights into the nature and rates of reactions within the sediment column (i.e. the significance of early chert formation). Third, the recognition of fluid flow through oceanic crust and sedimentary systems has opened new perspectives on the genesis of metalliferous ore deposits. At present, we lack a three-dimensional picture of the active processes of metal and sulfur transport and deposition required to understand fully modern and ancient equivalents to ocean-basalt-hosted massive sulfide and sediment-hosted, Mississippi Valley-type deposits, both of significant economic value.

Scientific Opportunities and Objectives for Future Drilling

Through studies of the processes of submarine fluid circulation, we are now in a position for major advances in our understanding of geochemical cycling of major elements in seawater, carbon, nutrients and metals; we are at the threshold of gaining new understanding of how accretionary complexes and ridge flank sediments are dewatered, lithified, and how they respond to tectonic stress. A large portion of the scientific community has agreed that this frontier of research should be exploited and become the target for a suite of future drilling efforts in which tectonic, lithosphere, and geochemical objectives become intertwined. Major objectives for this drilling include:

1. **Fluids and circulation patterns:**

   - **Can the mass transport of critical elements be quantified? What changes in mass transport rates have occurred over the last 100 million years?**
   - **What is the magnitude of subduction-zone cycling compared to mid-ocean ridge cycling, i.e., what is the subduction equation?**
   - **What is the range of composition of the fluids? Are there diagnostic compositions for MOR-, subduction-, and gravity-driven fluids?**
   - **What are the driving mechanisms of fluid flow (gravity, heat, tectonic overpressure) and how do they affect the nature of the fluids?**
   - **What are the sources of fluids in plate-collision zones (i.e., gas hydrate decomposition, ultralithification, clay**

dehydration, subduction-slab dewatering)?

2. **Diagenesis:**

•What are the reaction dynamics and rates of alteration and how are they expressed as diagenetic overprint? How do these dynamics vary as a function of sediment and fluid type and time?
•Can diagenetic "fronts" be identified on high-resolution seismic profiles and, if so, can seismic records be used to map paleoceanographic events?
•What is the three-dimensional nature of changes in metal and sulfur concentrations in pore fluids of sediment-hosted systems and oceanic basalt systems?
•What is the effect of differences in host sediment type (porosity, permeability and chemical make-up) on determining the nature of metal deposits.
•Can paleoceanographic information (e.g. rates of hydro-thermal circulation, oxygen content of bottom waters) be extracted from metalliferous deposits?

<u>The Drilling Approach Needed to Address These Objectives</u>

<u>Fluid Circulation:</u> To understand the effect of fluid exchange on oceanic and sedimentary geochemistry and how the lithosphere is altered by the exchange processes and, as a consequence, how it responds in different tectonic environments.

Our strategy calls for transects of both active and passive margins. These transects should be designed to evaluate the fluid-flow systems and associated sedimentologic-diagenetic phenomena. Such studies must be linked to geophysical data providing the structural and geotechnical constraints upon fluid flow. The key parameters to be addressed here are: fluid driving forces, source depths and origin, the influence of sediment and style of deformation on fluid migration rates and flow paths. The fluid compositions are affected by all these parameters and may develop diagnostic criteria. Since these fluid-flow systems are not static, evaluation of their dynamic evolution in space and time is required to assess their global geochemical impact. Ultimately we seek to develop dewatering models in concert with thermal models, constrained by seismic information and relying on chemical criteria and tracers.

Accretionary wedges are the sites of active fluid venting to the seafloor. Transects of these systems (e.g., the Barbados, Nankai, and Cascadia prisms), perpendicular and parallel to the deformation front, will allow the study of fluid evolution as a function of evolving tectonic settings. These transects must be linked to geophysical and geotechnical information on the tectonics of deformation to develop a three-dimensional view of fluid-flow rock alteration patterns. Variability in tectonic style, type of sediment, thickness of accreting sediments and thermal history of subducted slab are the major parameters by which to select the drilling transects. In addition, the hydrology of the forearc should be the target of drilling. The possibility of fluids originating from the subducted slab, penetrating through the leading edge of the continental massif and escaping in the forearc basins should be considered along with drilling targets which would track long-distance fluid flow across the margin.

For ridge-flank sediments, we need a program coordinated with lithosphere objectives. Drilling 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.

Specific strategies for the study of continent-derived pore fluids along margins call for drilling transects perpendicular to the shoreline in order to establish gradients in pore water salinity and concentrations of specific cations and anions. Appropriate sites would be off the Atlantic margin of the U.S. where large fresh-water prisms occur or the coast of South America off Peru where continent-derived brines occur in the sediments. A companion program should be to drill longitudinal transects parallel to the coastline, crossing climatic zones (e.g. from near the equator to mid-latitudes). For example, we could examine pore fluids in forearc basins west of South America starting off Ecuador and extending south to southern Chile.

Diagenesis: Diagenesis encompasses a wide range of chemical reactions and the redistribution of elements below the sediment-water interface; it has been, and will continue to be, a cornerstone of geochemical and sedimentary process studies. There are several newly recognized processes of interest because of their effects on interpretation of sediment stratigraphy, on formulating geochemical mass balances and on understanding metallogenesis.

Overprint stratigraphy occurs in practically all environments and affects a large range of investigations. The focus here is on a matrix that encompasses as many different types of sedimentary sequences as possible. Thus any strategy that results in providing a variety of sediments from a number of depositional settings is appropriate to this purpose. Normally the coring strategies associated with detailed paleoceanographic work of Themes II, III and IV, will provide appropriate materials for this work.

Sediments of upwelling areas, with their abundant carbon, phosphate and opal-A, are chemically very reactive and known to produce a variety of authigenic minerals during diagensis. The nature of this distinctive diagenesis, in the context of paleoupwelling studies, will be important to determine; i.e. if upwelling systems in high and low latitudes, with different fluxes of C, P, and Si yield different sequences in response to diagenesis, and if pore fluids in sediments of coastal upwelling sequences show latitudinal differences.

Evaluation of the potential of the high-resolution seismic record as a means of identifying and mapping diagenetic horizons requires continuous cores and logs (along with digitally recorded seismic records) in regions of high sedimentation rate and with well established stratigraphic markers. Depth and latitudinal transects across major water-mass boundaries and fronts are quite similar to those required for Themes I and III and call for depth transects on low-latitude oceanic plateaus (Ceara Rise, Ontong Java Plateau) and latitudinal transects in equatorial high-productivity regions. The focus of studies of metallogenic processes should be to define the three-dimensional fluid flow and chemistry, and rock-alteration characteristics within the oceanic ridge sediments hosting metal sulfide and oxide accumulations. Defining the three-dimensional nature of a hydrothermal system requires both longitudinal and transverse sections in a matrix of sediment lithologies. For example, hydrothermal-fluid circulation in the Guaymas Basin occurs within siliceous, organic-rich muds. In contrast, hydrothermal processes in the Escanaba Trough off the Oregon coast are hosted by relatively organic-poor interbedded turbidites and pelagic sediments. Finally, because the fluid movement is thermally driven in these systems, it will be necessary to examine metallogenesis at ridges with varying spreading rates.

Active back-arc spreading centers in sediment-filled basins provide environments for accumulation of metalliferous deposits as yet not adequately explored by drilling. Current work in back-arc basins may identify new drilling objectives. Metallogenesis within the submarine portions of island arcs provide an additional exciting prospect for future drilling targets.

Technology Issues

The study of sedimentary diagenesis, fluid flow and metallogenesis requires a comparative study of undisturbed sediments and their contained pore fluids. For certain of the programs, *in situ* physical property measurements of the sediments are also required.

The dominant role in fluid flow played by coarse-grained terrigenous clastic sediments in continental margin prisms demands improved recovery of undisturbed sediment and uncontaminated pore fluids. As noted in COSOD II, stabilization of reentry holes in unstable sedimentary sections is urgently needed.

Each of the programs described requires a careful analysis of pore water chemistry and, for certain of the processes, the development of new technologies capable of measuring *in situ* pore pressure, temperature, *p*H, and other dissolved constituents, including gases perhaps with a top hole packer that contains passive (diffusive) tracers to monitor advection of pore fluids both up and down the hole. A pressure core barrel will be needed to recover hydrates and volatile pore-fluid constituents. This device should also be capable of preserving the sediment fabric for transfer to shore based labs. A side wall corer with *in situ* pore-water probe and sampler will be required to recover sediment from the hole in core gaps, and to provide additional solid and aqueous sample material at important depth boundaries. Finally, we look towards the ability to recover variable lithologies (chert-limestone sequences) without disturbance in order to address some of the important problems in sediment geochemistry. Long-term goals require the ability to drill in high temperature environments, the emplacement of borehole monitoring devices (for temperature, tilt, stress, fluid flow, etc.) and the use of wireline reentry instrumentation.

FACIES EVOLUTION AND DEPOSITIONAL ENVIRONMENTS: DEPOSITIONAL MANIFESTATIONS OF CONTINENTAL UPLIFT AND EROSION

Overview and Objectives

The deposits of the continetal margins and adjacent basins contain within them records of the tectonic, volcanic and surficial processes within the continents. Historically, these processes have been studied only in sedimentary sections that, through tectonism and erosion, have been incorporated into mountain belts and exposed. The resulting record is overprinted and fragmentary at best. Deep sea drilling provides the only means possible to collect undisturbed records of the biologic, geologic and chemical processes on adjacent continents, to tie this record directly to open-ocean sequences, and to integrate continental geologic studies with those of modern marine systems. These studies will contribute to understanding global sediment balances, the origin of sedimentary basins (and the role of sea level in their evolution), and the testing of models for the development of sedimentary facies. For example, Hay et al. (1987) propose a model for using mass balance in a system of sources and sinks to derive paleotopography. In this model, the primary inputs are the average stratigraphic column and variations in sea level. To test such models properly, however, will require an understanding of the sedimentary processes that are responsible for the stratigraphic column.

PCOM convened a subgroup of the COMFAN II Conference to prepare a submission dealing with sedimentary processes. The following represents the contribution of that group.

The objectives of this section are discussed under three basic headings that reflect different spatial and temporal scales of both the products and processes of marine sedimentation. At the largest scale, **stratigraphic** problems that need to be addressed include sediment mass balances, carbon budgets, and glacial history. Regional-scale models of the controls on **deposition and basin evolution** also need to be tested (including both allocyclic controls and autocyclic processes). The evolution of the physical properties of the sediments is an integral part of this theme. Finally, at the scale of individual depocenters, there is a need to evaluate (and develop) models for **facies evolution and depositional processes.** The history of the continental regions as recorded in deep-sea sediments cannot be correctly deciphered without reliable and tested models for depositional controls on facies (the rock record). Conventional drilling programs can accomplish the first and second objectives, but special strategies are required for evaluating the facies models, the study of which will provide the building blocks for understanding the growth of continental areas.

In general, ocean drilling on continental margins has not been aimed at testing general process-oriented models; instead, it has complimented efforts to address regional tectonic and gross stratigraphic questions. In many cases, sedimentologists did not have a fundamental role in either the selection of sites or the definition of drilling objectives. Industry drilling on continental margins in water depths to 2500 m has not answered the questions presented because (1) sequences above economic-objective intervals are generally not cored, (2) biostratigraphic control lacks the resolution to address critical aspects, (3) data are not released in a timely fashion (if at all), and (4) the specific sites selected by industry are those most likely to cause concern from ODP safety concerns.

Scientific Opportunities and Objectives for the Future

Stratigraphic Objectives:

1. **Sediment mass balance for the world ocean:** Drilling is required to document changes in the sediment input from the great rivers of the world because the sediment mass balance is a result of the denudation history of orogens, recycling of continental crust, and shelf-to-ocean basin sediment balance related to sea-level change.

2. **The margin expression of major oceanographic events:** Determine the timing, extent and magnitude of geostrophic circulation to evaluate its effect on the erosion and transport of slope-rise-fan sediments and its relationship to regional deep-water unconformities.

3. **Carbon budgets:** Determine the long-term record of the carbon contribution to the continental margin and evaluate its importance as a sink; relate cyclicity in the carbon flux recorded in margin sediments to that in the open ocean.

4. **Glacial history:** Determine the timing, location and intensity of continental glaciation to provide independent boundary conditions for climatic models based on other types of data. Determine the contribution by glacial erosion to the denudation history of continental areas, and examine the relation between eustacy and ice loading of the continents.

5. **Record of volcanic eruptions and large earthquakes in sequences:** The offshore stratigraphic record lying closest to the orogens will give a superior record of volcanism and large earthquakes. Both direct air-fall pyroclastic material and fluvial/marine resedimented debris can record major volcanic eruptions. Large earthquakes along continental margins can be detected through mass-wasting products, missing stratigraphic sequences, and changes in sediment supply related to modification of relief between source area and marine depocenters.

Basin Evolution:

1. **Allocyclic controls on basin evolution:** Drilling in the main types of marginal basins can address several important questions: (1) What is the influence of sea-level changes on the nature (type, source area, rate and transport path) of sediment provided to the basin? (2) What is the influence of the source-area gradients (tectonism) on the sediment supply to the margins? (3) What is the influence of shelf characteristics,

including width, intrabasinal 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?

2. **Autocyclic controls:** Tests are necessary to address growth patterns of rapidly accumulating clastic systems where 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.

3. **Physical properties evolution in basin sequences:** Determination of the relation between the physical properties of the sediment and the deformational behavior with respect to diapirism, slumping, and associated mass-wasting processes, and tectonic deformation; diagenetic properties change both vertically (with burial depth) and through time and thus need to be determined for individual margin depocenters.

Facies Evolution and Depositional Processes:

The depositional processes on continental margins (and related facies) are of major importance to understanding the history of the Earth and, specifically, continental areas. Turbidites and related deposits, such as deposits of mass wasting and interbedded pelagic material are volumetrically the most important accumulations in the deep ocean. Many components of margin depocenters are poorly documented (e.g. volcanic and glacial influx to the total sediment budget). One major objective of this aspect of drilling will be the ability to relate facies distinctions based on seismic-stratigraphic analyses 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 the sedimentary facies units and thus help to establish depositional processes. Specific problems to be addressed include:

1. **Turbidite facies:** Turbidite facies are quite varied and the form of the deposits reflects variations in sediment type (lithology, grain size), basin shape, tectonic activity, number and size of sources, sea level variations, geostrophic currents, and other environmental factors. In addition, individual facies types can vary in horizontal and vertical scales by as much as two orders of magnitude. As a minimum, "type localities" for drilling are needed for the following distinctive facies: overbank (with and without levee relief), channel floor, depositional lobe, channel/inner-lobe transition zone, basin plain, mass-wasted intervals and base-of-slope ramps.

2. **Volcanic sedimentary facies:** Evaluation of pyroclastic and volcaniclastic transporation processes in the marine environment, including the transformation from pyroclastic process to normal pelagic settling and subaqueous sediment gravity flow.

3. **Ice margin deposits:** Evaluation of ice-margin processes in large continental ice-sheet systems. Distinguishing deposition from direct glacial input to slope and deep-sea environments from remobilization of sediment temporarily stored on glaciated margins.

4. **Sediment drifts:** Testing sedimentation models for sediment-drift structures and contourite depositional processes, especially with an aim to improving recognition of sediment-drift deposits in the geologic record and to using bedforms for determining past variations in bottom-current flow.

5. **Mass-movement facies:** Determination of *in situ* properties of the range of deposits attributed to mass failure on continental margins.

Providing distinction of deposit characteristics relative to the mechanism of failure and analysis of subsequent flow structures. Relate failure type and age to continental-margin type (or setting; e.g. do certain types of failures characterize passive-margin deposits as distinct from other slope environments?).

6. **Resedimentation products from carbonate-producing margins:** Unconsolidated carbonate sediment moved from shelf and upper slope areas of continental margins provides significant volume of deep sea sediments. The different physical and chemical characteristics of carbonate grains contribute to significantly different facies characteristics relative to siliciclastic deposits formed by the same depositional processes. Thus, the distinction of turbidite and mass-movement facies for carbonate environments will require a distinct drilling program to understand the differences in depositional processes (from siliciclastic systems).

The Drilling Approach Needed to Meet These Objectives

The site survey requirements and drilling strategies will differ for the three themes based on the spatial and temporal scales of the site objectives. The stratigraphic objectives will be targeted for specific chrono-stratigraphic levels; only normal site-survey documentation will be required.

The basin-evolution objectives can be achieved through any suitable stratigraphic level(s) and normal site-survey data will suffice. The basin setting and history, however, will need to be well documented to ensure that the conditions exist for a definitive test of the model proposed.

Drilling for facies evolution and depositional processes will require well studied "type" examples from which particular facies models have been distilled. The complicated three-dimensional geometry of the architectural elements that comprise the primary sedimentary facies means that testing requires a high degree of morphologic and stratigraphic control. In addition, the facies testing requires a high degree of morphologic and stratigraphic control. In addition, the facies units(s) to be tested must be clearly understood within the framework of tectonic setting and allocyclic controls. extensive site survey data will be required to define the three-dimensional character of the facies and its lateral equivalents. Detailed studies of small areas with several drill sites may be required.

Technology Issues

Past problems with sand recovery have resulted in a serious bias toward mud-rich systems (in both our understanding of margin sedimentation and the selection of drill sites). Huge gaps in our knowledge must be filled before we can understand the total sediment budget of margins. Sandy targets need to be added to our overall drilling framework.

Discussion of recovery problems at two recent scientific meetings that included industry participants (SEPM and COMFAN II) indicated that the technology for drilling unconsolidated sand exists and may be transferable to ODP. We recommend immediate investigation of the possibility of adapting this technology. If existing techniques cannot be adapted, the we request their development within ODP.

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

PROPOSALS RECEIVED BY THE JOIDES OFFICE

1 September 1988 - 31 December 1988

Ref. No.	Date Rec'd.	Title	Investigator(s)	Inst.	Site Survey Avail. Data	Site Survey Future Need	Panel Reference	Ref. Remarks
			WESTERN PACIFIC OCEAN					
314/D	09/21/88	Fluid Flow & Mechanical Response, Accretionary Prism, Nankai Trough	D. Karig et al.	Cornell Univ.	Yes		LITHP 09/88 TECP 09/88 SOHP 09/88 WPAC 09/88	
316/E	10/26/88	Gas-Hydrate Hole	R. Hesse et al.	McGill Univ.	Yes		LITHP 10/88 TECP 10/88 SOHP 10/88 WPAC 10/88 APWG 10/88	Related to Rev. 50/D
			ATLANTIC OCEAN					
0/A	09/21/88	Geochemical Sampling, E. Greenland	A. Morton, et al.	Brit. Geol. Survey	Yes		LITHP 09/88 SOHP 09/88 TECP 09/88 ARP 09/88	
A	09/21/88	Sedimentary Equivalent of Dipping, Rockall	D. Masson et al.	Inst. Oceanogr. Sciences	Yes		LITHP 09/88 SOHP 09/88 TECP 09/88 ARP 09/88	
	09/21/88	Potential of Drilling on Reykjanes Ridge	J. Cann & C. Powell	Science Labs., U.K.	Yes	Yes	LITHP 09/88 SOHP 09/88 TECP 09/88 ARP 09/88	ARP 09/88

Ref. No.	Date Rec'd.	Title	Investigator(s)	Inst.	Site Survey Avail. Data	Site Survey Future Need	Panel Reference	Ref.Remarks
			ATLANTIC, CONTINUED					
313/A	09/21/88	Evolution of Oceanogr. Pathway: The Equatorial Atlantic	E. Jones et al.	Univ. College London	Yes	Yes	LITHP 09/88 SOHP 09/88 TECP 09/88 ARP 09/88	
59A	09/21/88	Revision: Cont. Margin Sed. Instabilities - Turbidite Sequences	P.P.E. Weaver et al.	Inst. Oceanogr. Sciences	Yes	Yes	LITHP 09/88 SOHP 09/88 TECP 09/88 ARP 09/88	Related to 59/A
			GENERAL AND INSTRUMENTAL					
309/F	9/24/88	VSP at Bonins	P. Cooper & B. Taylor	HIG	Yes		TECP 10/88 DMP 10/88	Related to 171/D
315/F	10/17/88	Network of Ocean Floor Broad Band Seismometers	Purdy & Dziewonski	W.H.O.I	Yes	Yes	LITHP 10/88 SOHP 10/88 TECP 10/88 DMP 10/88 CEPDPG - 10/88	

JOIDES/ODP BULLETIN BOARD

JOIDES MEETING SCHEDULE (01/17/89)

Date	Place	Committee/Panel
27-28 February* Approved	College Station, TX	SMP
27 Feb - 1 Mar	Hannover, FRG	TECP
2-3 March	Tokyo, Japan	PPSP
7-9 March	Washington, DC	BCOM
8-10 March	College Station, TX	IHP
13-15 March	Denver, CO	SGPP
28-30 March Approved	Miami, FL	LITHP
4-5 April*	Miami, FL	OHP
10-~~14~~ 12 April* Approved	~~Honolulu~~ Hilo, HI	CEPDPG
10-12 April*	Honolulu, HI	SSP
27-28 April	College Station, TX	TEDCOM
2-4 May	Oslo, Norway	PCOM
31 May-2 June	Palisades, NY	EXCOM & ODP Council
24-27 July*	Hannover, FRG	CEPDPG
22-24 August	Seattle, WA	PCOM
2-4 October	The Netherlands	EXCOM
26 November	Woods Hole, MA	Panel Chairmen
27-30 November	Woods Hole, MA	PCOM
24-26 April, 1990	France	PCOM

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

NEW JOI TELEX NUMBER

Effective immediately, the telex number for the JOI office has been changed from 257828 BAKE UR to **7401433 BAKE UC.** The new carrier is CCI.

CALL FOR ODP DRILLING PROPOSALS

Although the planning structure of JOIDES has undergone some changes, ODP remains a proposal-driven program. Through proposals, individual scientists and groups have the opportunity to respond to the major thematic drilling priorities for ODP and contribute their expertise. The two major sources for defining the direction of ODP science are the COSOD II report and priorities developed by the thematic panels and published in the JOIDES Journal.

The listing of proposals received by the JOIDES Office has traditionally been organized by oceans. However, the JOIDES Office forwards proposals to all thematic panels; if a proposal is accepted as having merit in terms of thematic issues, then that proposal is forwarded to the appropriate service panels, working groups and detailed planning groups for further evaluation. If a proposal is found to have no merit in terms of thematic issues, then the deficiencies are summarized and the proposal is returned to the proponent. Proponents are asked to supply as complete a data base as possible and note upcoming surveys.

The guidelines for submission also require that proponents forward ten copies of the proposal to the JOIDES Office. [Note: Keep foldouts to a minimum as they slow down copying and mailing of proposals.] For further information on requirements for submission of proposals to ODP, see JOIDES Journal, Special Issue No. 6, or contact the JOIDES Office.

LOGGING SCHOOL

INTERNATIONAL GEOLOGICAL CONGRESS: July 8, 1989, Washington, D.C.

The first JOI/USSAC sponsored Ocean Drilling Program Logging Schools were taught at the Geological Society of America annual meeting in Denver and at the fall meeting of the American Geophysical Union in San Francisco. The next Logging School will be held at the International Geological Congress in Washington, D.C.

The ODP Logging School has been designed to introduce the scientific applications of downhole logging used in the Ocean Drilling Program to scientists of varying disciplines. ODP logging specialists from Borehole Research Group at Lamont-Doherty Geological Observatory will demonstrate how logging data are being used to solve scientific problems of paleoenvironment, stratigraphy, geochemistry, basement structure, hydrogeology, geomechanics and tectonics.

The course will be taught at a hotel across from the Washington D.C. Convention Center. There will be a fee of $50 for the short course. Preregistration for the course as well as for the IGC is recommended, though on-site registration for both will be available. For information about the course, contact: Robin Smith at JOI, Inc., 1755 Massachusetts Ave., NW, Suite 800, Washington, D.C. 20036, Tel: (202) 232-3900, telemail: R.Smith.JOI (omnet). For information about IGC, contact: 28th International Geological Congress, PO Box 727, Tulsa, OK 74101-0727

WORKSHOPS SCHEDULED

DRILLING THE OCEANIC LOWER CRUST AND UPPER MANTLE

Jointly sponsored by JOI/USSAC, The International Lithosphere Program Working Group on the Nature and Evolution of the Oceanic Lithosphere, and the W.M. Keck Geodynamics Program of the Woods Hole Oceanographic Institution, the workshop is scheduled for March 8-10, 1989, at Woods Hole, Massachusetts.

The purpose of this workshop is to assemble a wide variety of investigators from the ocean and earth science communities to review our current state of understanding of the geology and geophysics of the oceanic lower crust and upper mantle and to establish the major objectives for deep crustal drilling. The goal is to identify the opportunities and strategies for this drilling, and create a detailed program for the next decade. Members of the workshop will be asked to participate in the development of mature drilling proposals and become proponents for clearly identified drilling targets.

Attendance will be open, though limited to 200. Advance registration is required. Graduate students are encouraged to attend. Limited travel funds for U.S. participants are available through funding from JOI/USSAC, and some funds for foreign participants are available through the WHOI Geodynamics program. Some contributed talks will be accepted for the presentation portion of the meeting, and individual drilling proposals are invited as poster sessions. The meeting convenor is Dr. Henry J.B. Dick. Abstracts and questions regarding participation, travel funds, and accomodations should be directed to: Janet Johnson, Dept. of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543; Tel: (508) 548-1400 x 2623. For information on USSAC funding for U.S. participants, contact Dr. Ellen Kappel at JOI, Inc. (Telemail: E.Kappel).

A WORKSHOP TO DEFINE THE SCIENTIFIC OBJECTIVES FOR PROGRAMS WHICH WOULD BETTER LINK ODP TO GLOBAL CLIMATE INITIATIVES

A JOI/USSAC-sponsored workshop will be convened to examine how the new information from the Global Geosciences Program can be linked to the Ocean Drilling Program. Specifically, the workshop will address how unified global information on ocean circulation, wind patterns, primary productivity, and particle formation and transformation processes can be used to improve our understanding of past oceans and climate; what information is needed to link the short-term observations of the present with the sedimentary record; and at what resolution can we make inferences about paleoceanography and past climate based upon the sediment record. In turn, the sedimentary data can provide information about the scale and magnitude of changes in circulation, fluxes, etc., that are not available in the modern ocean.

Convenors are Drs. N. Pisias, M. Lyle, A. Mix, W. Prell and R. Thunell. The meeting date and place are tentatively scheduled as June 1989 at Oregon State University. For more information on this workshop contact Dr. Nicklas Pisias, College of Oceanography, Oregon State University, Corvallis, OR 97331-5503; Tel: (503) 754-2296; Telemail: N.Pisias.

WORKSHOP REPORTS AVAILABLE

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

Scientific Seamount Drilling, Drs. Tony Watts and Rodey Batiza, convenors.

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

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

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

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

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

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

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

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

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

JOI/USSSP OCEAN DRILLING PROGRAM FELLOWSHIP

The JOI/U. S. Science Support Program is continuing their Ocean Drilling Program Graduate Fellowship. The objectives of the JOI/USSSP ODP Fellowship are to provide opportunities for research on problems compatible with the research interests of the ODP to scientists of unusual promise and ability that are in residence at U.S. institutions. The award for a doctoral candidate is $18,000 and is payable through the candidate's home institution. The fellowship money is intended to be used for student stipend, tuition and benefits, research costs and incidental travel, if any. The deadline for applications to participate as a shipboard scientist on the JOIDES RESOLUTION for Leg 130 (Lau Basin) and Leg 131 (Vanuatu) is May 1, 1989, and the deadline for Leg 132 (Northeast Australian Margin) and Leg 133 (Geochemical Reference Holes) is September 1, 1989. Applications that do not involve participation in an ODP cruise must be submitted by January 1, 1990. Summary information about upcoming legs as well as information on applications and procedures, all necessary forms, and a list of supporting documents are available in the application packet from: JOI/USSSP ODP Fellowship, JOI, Inc., 1755 Massachusetts Ave., N.W., Washington, D.C., 20036. Qualified applicants will receive consideration without regard to race, creed, color, sex, age or national origin.

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, LDGO, 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

2. Proceedings of the Ocean Drilling Program, Scientific Results

   Volumes 101/102 (combined) Dec 88
   Volume 103 published Dec 88

3. Technical Notes

   #1 Preliminary time estimates for coring operations (Revised Dec 86)
   #2 Operational and laboratory capabilities of JOIDES RESOLUTION (June 85)
   #3 Shipboard Scientist's Handbook (Revised July 87)
   #4 Five papers on the Ocean Drilling Program from "Oceans '85" (May 86)
   #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 Shipboard Sedimentologist's Handbook (Aug 88)
   #9 Deep Sea Drilling Project data file documents (Jan 88)
   #10 A Guide to ODP Tools for Downhole Measurement (June 88)

4. Scientific Prospectuses

   #16 (May 87) Leg 116
   #17 (June 87) Leg 117
   #18 (June 87) Leg 118
   #19 (Sept 87) Leg 119
   #20 (Oct 87) Leg 120
   #21 (Mar 88) Leg 121
   #22/23 (June 88) Legs 122 & 123
   #24 (Aug 88) Leg 124
   #25/26 (Dec 88) Legs 125 & 126

5. Preliminary Reports

   #16 (Sept 87) Leg 116
   #17 (Nov 87) Leg 117
   #18 (Feb 88) Leg 118
   #19 (Mar 88) Leg 119
   #20 (June 88) Leg 120
   #21 (Aug 88) Leg 121
   #22 (Oct 88) Leg 122
   #23 (Dec 88) Leg 123
   #24 (Feb 89) Leg 124

6. Engineering Prospectuses: #1 (Aug 88) Leg 124E

7. Other Items Available

   - Ocean Drilling Program brochure (English, French, Spanish, German or Japanese)
   - Onboard JOIDES RESOLUTION (new edition, 24 pages)
   - ODP Sample Distribution Policy

Bibliography of the Ocean Drilling Program, continued

- Instructions for Contributors to ODP Proceedings (Revised April 88)
- ODP Engineering and Drilling Operations
- Multilingual brochure with a synopsis of ODP (English, French, Spanish, German and Japanese)
- ODP Poster

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

Wireline Logging Manual (3rd Edition, 1988)

DSDP DATA AVAILABLE SOON ON CD-ROM

The National Geophysical Data Center (NGDC) is currently working on a project to produce a 2-volume set of Compact Disk-Read Only Memory (CD-ROMs) of available digital data from the Deep Sea Drilling Project (DSDP). All marine geological data bases including the DSDP Index, Bibliography and Core Sample Inventory files will be placed on Vol. 1; Vol. 2 will include logging information in the standard LIS format and underway geophysical data in the MGD77 exchange format. The CDs will be in the ISO 9660 format. Minimum system access requirements are: PC/XT/AT-compatible machines running DOS version 2.1 or higher with a minimum of 640K memory, hercules/monochrome or EGA graphics capability with a 10 megabyte hard drive and a CD-ROM reader. Accession software for Macintosh machines will be available in early summer. If you are interested in obtaining a set of CDs, contact: Ellen Kappel at JOI Inc., 1755 Massachusetts Ave., N.W., Suite 800, Washington, D.C., 20036; Telemail is E.Kappel.

ODP SHIPBOARD COMPUTER SYSTEMS UPGRADED

On Leg 124E the following upgrades were made in the shipboard computer systems:

- Two Macintosh SEs, two Macintosh IIs, and Apple LaserWriter II printer, and a variety of Macintosh software packages were installed.
- Two VAX 3500 minicomputers were added to the central computer system, quadrupling its computing capacity. One of the new 3500s will serve as a backup for the other.
- Optical disk drives will be installed to enhance data archiving procedures and reduce the physical storage volume of archived data. The expected lifetime of an optical disk is 50 years, compared to six years for magnetic tape. One 5.25-inch optical disk holds the equivalent of about 48,000 feet of magnetic tape.
- DecServers will be installed to connect terminals to the Ethernet network.
- The Local Area Vax Cluster (LAVC) software package will be installed to link all the VAX systems in a cluster configuration, which further enhances system performance.

The Computer Services Group (CSG) will monitor all phases of the shipboard computer system to evaluate how well all components are functioning and to determine whether they meet the needs of the shipboard party.

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 101-119, and all DSDP/ODP core photos (Legs 1-119). 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 that 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 closeup 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: Kathy Lightly, 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. For larger orders, an invoice will be sent and must be paid before the request will be processed.

Data Available from National Geophysical Data Center (NGDC)

DSDP data files can be provided on magnetic tape according to user specifications (see table next page). 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., Nat'l. 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 color, 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, shore laboratory	Minor element chemical analyses of igneous, metamorphic, and some sedimentary rocks composed of volcanic material.	

AVAILABLE DATA (Continued)

Data Available	Data Source	Description	Comments
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.		

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 106 through 119 are listed below. Please note that: *indicates Co-Chief Scientist; **indicates Staff Scientist; ***indicates Outside Scientist.

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Cowan, D.	PCOM	(206)543-4033	9104740096/UW UI
Cronan, D.	WPDPG	(44)1-589-5111	261503/IMPCOL G
Dalziel, I.*	TECP	(512)471-0431	9108741380/UTIG AUS
Davies, T*	EXCOM	(512)471-0409	9108741380/UTIG AUS
Davis, D.	TECP	(516)632-8217	5102287767/SUNNADMIN STBK
Davis, E.	CEPDPG,SRDPG	(604)356-6453	0497281/DFO PAT BAY
Delaney. M.*	OHP	(408)429-4736	7607936/UCSC UC
Delas, C.	PPSP	(33)42-91-40-00	615700/F
Dennis, B.	TEDCOM	(505)667-5697	660495/LOS ALAMOS LAB
Detrick, R.*	SRDPG	(401)792-6926	257882/DETR UR
Dorman, C.	EXCOM	(508) 548-1400	951679/OCEANIST WOOH

d'Ozouville, L.*	JOIDES	(808)948-7939	7238861/HIGCY HR
Dreiss, S.*	SGPP	(408)429-2225	7607936/UCSC UC
Droxler, A.	OHP	(713)527-4880	not available
Duce, R.	EXCOM	(401)792-6222	257580/KNAU UR
Duennebier, F.*	SSP	(808)948-8711	7238861/HIGCY HR
Düerbaum, H.	EXCOM	(49)511-643-3247	923730/BGR HA D
Eade, J.	WPDPG	(679)381139	2330/SOPACPRO FJ
Elderfield, H.*	LITHP,SGPP	(44)223-337181	81240/CAMSPL G
Eldholm, O.	PCOM	(47)2-45-66-76	79367/ESCON N
Engebretson, D.	TECP	(206)676-3581	not available
Erzinger, J.	LITHP	(49)641-702-8390	482956/GRIWOTY UNIGI D
Flower, M.	CEPDPG	(312)996-9662	253846/UNIV ILL CCC CGO
Floyd, P.	CEPDPG	(44)782-62-1111	36113/UNKLIB G
Forster, C.	SRDPG	(801)750-1247	3789426/UTAHSTATEU LOGAN
Francheteau, J.	CEPDPG,SRDPG	(33)43-45-13-22	202810/VOLSISM F
Franklin, J.	LITHP,SRDPG	(613)995-4137	not available
Fratta, M.	ODPC	(33)8835-3063	890440/ESF F
Fricker, P.	ODPC	(41)31-24-54-24	33413/CH
Frieman, E.*	EXCOM	(619)534-2826	9103371271/UCWWD SIO SDG
Froelich, P.*	SGPP	(914)359-2900X485	7105762653/LAMONTGEO
Fronteir, M.	PPSP	(613)991-2036	0534366/EMR RMCB OTT
Fujii, T.*	LITHP	(81)3-812-2111X5751	25607/ORIUT J
Fujimoto, H.*	TEDCOM,SGPP	(81)3-376-1251	25607/ORIUT J
Garrison, L.*	ODP/TAMU	(409)845-8480	792779/ODP TAMU
Garrison, R.	OHP	(408)429-2114	9105984408/UC SC LIB SACZ
Gibson, I.	IHP	(519)885-1221X3231	06955259/UOFW WTLO
Gieskes,	DMP	(619)534-4257	9103371271/UCWWD SIO SDG
Gill, J.	WPDPG	(408)429-2425	9105984408/UC SC LIB SAC
Goldhaber, M.	SGPP	(303)236-1521	9109370740/GSA FTS LKWD
Golovchenko, X.*	LDGO Fax 365-3182	(914)359-2900X336	7105762653/LAMONTGEO
Gradstein, F.*	SGPP	(902)426-4870	01931552/BIO DRT
Grassick, D.	TEDCOM	(44)1-930-1212	8950611/EPRISE G
Green, A.	PPSP	(713)965-4172	9108813649/USEPR TEX HOU
Green, G.*	NSF	(202)357-9639	257653/NSFO UR
Harding, B.*	ODP/TAMU	(409)845-5204	792779/ODP TAMU
Harrison, C.*	EXCOM	(305)361-4610	317454/VOFM RSMAS MIA
Haseldonckx, P.	PPSP	(49)201-726-3905	8571141/DX D
Hayes, D.*	EXCOM, PCOM	(914)359-2900X470	7105762653/LAMONTGEO
Heath, G.	EXCOM	(206)543-6605	9104740096/UW UI
Hedberg, D.	IHP	(46)151-580	13599/RESCOUN S
Heinrichs, D.*	NSF,ODPC	(202)357-7837	257653/NSFO UR
Helsley, C.*	EXCOM	(808)948-8760	7238861/HIGCY HR
Hey, R.	SSP	(808)948-8711	7238861/HIGCY HR
Hertogen, J.	SRDPG	(32) 16-201015	23674/KULEUV B
Hinz, K.	TECP	(49)511-643-3244	923730/BGR HA D
Horn, D.	PPSP	(49)201-726-3905	8571141/DX D
Hovland, M.	PPSP	(47)02-80-7130	73600/STAST N
Howard, S.*	SRDPG	(409)845-8480	792779/ODP TAMU
Howell, D.	TECP	(415)856-7141	176994/MARFAC
Howell, E.	DMP	(214)422-6857	794784/ARCO PLNO
Humphris, S.*	LITHP	(508)540-3954	951679/OCEANIST WOOH
Hyndman, R.	WPDPG,EXCOM	(604)656-8438	0497281/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	not available
Iwamura, H.*	JOIDES	(808)948-8765	7238861/HIGCY HR
Jansen, E.*	OHP	(914) 359-2900	7105762653/LAMONTGEO
Jarrard, R.*	LDGO	(914)359-2900X343	7105762653/LAMONTGEO
Jenkyns, H.	PCOM	(44)0865272023	not available
JOIDES Office*		(808)948-8765	7238861/HIGCY HR
Jones, E.	SSP	(44)1-387-7050	28722/UCPHYS G
Jones, M.	IHP	(44)51-653-8633	628591/OCEANB G

Kappel, E.*	JOI	(202)232-3900	7401433/BAKE UC
Karig, D.	DMP	(607)255-3679	6713054/CORNELL ITCA
Kasahara, J.	TEDCOM	not available	272 2148 ERI TOK
Kastner, M.*	PCOM	(619)534-2065	9103371271/UCWWD SIO SDG
Kent, D.*	OHP	(914)359-2900X544	7105762653/LAMONTGEO
Kidd, R.	SSP	(44)792-295-149	48358/UCSWAN G
Kinoshita, H.*	DMP	(81)3-472-51-1111	25607/ORIUT J
Kobayashi, K.*	EXCOM, PCOM	(81)3-376-1251	25607/ORIUT J
Kristjansson, L.	ODPC	(354)1-213-40	2307/ISINFO IS
Kroenke, L.*	CEPDPG	(808)948-7845	7238861/HIGCY HR
Kudrass, H.	WPDPG	(49)511-643-2787	0923730/BGR HA D
Lancelot, Y.	PCOM	(33)1-43-36-25-25	200145/UPMC SIX F
Langseth, M.*	PCOM	(914)359-2900X518	7105762653/LAMONTGEO
Larsen, B.	SSP	(45)288-40-22X3210	37529/DTHDIA DK
Larsen, G.	ODPC	(45)6-12-82-33	64767/DK
Larsen, H-C.	TECP	(45)1-11-88-66	19066/JJUTEL DK
Larson, R.*	PCOM	(401)792-6165	7400188/LARS UC
Last, A.	PPSP	(44)1-588-8000	884614/TRIOIL G
Laughton, A.*	EXCOM	(44)42-879-4141	858833/OCEANS G
Le Pichon, X.	FPAPWG	(33)14-31-84-88	842202601/ENULM F
Leinen, M.*	PCOM	(401)792-6268	257580/KNAU UR
Levi, S.*	PCOM	(503)754-2296	5105960682/OSU COVS
Lewis, B.	EXCOM	(206)543-6487	9104740096/UW UI
Lewis, S.	SSP	(415)354-3041	171449/PCS USGS MNPK
Loeblich, A.	IHP	(213)825-1563	3716012/UCLA LSA
Louden, K.*	SSP	(902)424-3557	01921863/DALUNIVLIB HFX
Loughridge, M.	IHP	(303)497-6487	258169/WDCA UR
Lyle, M.	SRDPG	(503)754-2749	5105960682/OSU COVS
Lysne, P.	DMP	(505)846-6328	169012/SANDIA LABS
MacKenzie, D.	PPSP	(303)794-4750	not available
Maldonado, A.	FPAPWG	(34)3-310-64-50	59367/INPB E
Malfait, B.*	NSF	(202)357-9849	257653/NSFO UR
Malpas, J.	PCOM	(709)737-4382	0164101/MEMORIAL SNF
Manchester, K.*	TEDCOM	(902)426-3411	01931552/BIO DRT
Maronde, D.	ODPC	(49)228-885-2328	17841228312/DFG
Masuda, F.	SGPP	not available	not available
Mauffret, A.	SSP	(33)43-36-2525X5172	200145/UPMC SIX F
Maxwell, A.*	EXCOM	(512)471-4860	9108741380/UTIG AUS
Mayer, L.*	SGPP	(33)43-29-61-84	200145/UPMC SIX F
McKenzie, J.	SGPP	(41)1-256-38-28	817379/EHHG CH
McLerran, A.	TEDCOM	(619)481-0482	not available
Merrell, W.*	EXCOM	(409)740-4403	not available
Merrill, R.*	ODP/TAMU	(409)845-9324	7922779/ODP TAMU
Mevel, C.	LITHP,SRDPG	(33)43-36-25-25	200145/UPMC SIX F
Meyer, A.*	ODP/TAMU	(409)845-2197	792779/ODP TAMU
Meyer, H.	SSP	(511)643-3128	0923730/BGR HA D
Michot, J.	ODPC	(32)2-649-00-30	23069/B
Mienert, J.	SGPP	(508)548-1400	951679/OCEANIST WOOH
Millheim, K.	TEDCOM	(918)660-3381	284255/CDFTU UR
Mix, A.*	OHP	(503)754-2296	5105960682/OSU COVS
Moberly, R.*	PCOM,EXCOM	(808)948-8765	7238861/HIGCY HR
Moore, G.*	WPDPG	(808)948-6797	7238861/HIGCY HR
Moore, J.	FPAPWG	(4408)429-2574	not available
Moore, T.	IHP	(713)973-3054	9108813649/USEPR TEX HOU
Moran, K.	SMP	(902)426-8159	not available
Morgan, J.*	LITHP	(617) 253-5951	not available
Morin, R.	DMP	(303)236-5613	not available
Moss, M.*	EXCOM	(619)534-2836	not available
Mottl, M.*	SRDPG,SMP	(808)948-7006	7238861/HIGCY HR
Mountain, G.*	SSP	(914)359-2900X541	7105762653/LAMONTGEO
Mutter, J.*	LITHP	(914)359-2900X525	258294/MCSP UR
Natland, J.*	WPDPG	(619)534-3538	9103371271/UCWWD SIO SDG
Nemoto, T.*	EXCOM, ODPC	(81)3-376-1251	25607/ORIUT J
Nickless, E.	NERC	(44)793-40101	444293/ENVRE G

Nobes, P.	DMP	(519)885-1211	not available
Normark, W.	SGPP	(415)329-5101	171449/PCS USGS MNPK
Nowak, J.	IHP	(49)511-643-2815	922739/GFIZ D
NSF (ODP)*		(202)357-9849	257653/NFSO UR
Nuti, T.	FPAPWG	(0039)50-41503	not available
O'Connell, S.*	DMP	(409)845-0507	792779/ODP TAMU
ODP/TAMU*		(409)845-2673	792779/ODP TAMU
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)23631-1421X2588	25607/ORIUT J
Orcutt, J.*	LITHP	(619)534-2887	9103371271/UCWWD SIO SDG
Ottosson, M-O.	EXCOM, ODPC	(46)8-15-15-80	13599/RESCOUN S
Pascal, G.	DMP	(33)98-46-25-21	940627/OCEAN F
Paxton, A.	TEDCOM	(44)224-574555	739721/BRTOIL G
Pearce, J.	LITHP	(44)632-328511	53654/UNINEW G
Perfit, M.	LITHP	(904)392-2128	not available
Peirce, J.*	SSP	(403)296-5809	03821524/PETROCANRS CGY
Peveraro, R.	DMP	(44)41-226-5555	777633/BRTOIL G
Pisias, N.*	PCOM	(503)754-2296	258682/PISI UR
Porter, R.	DMP	(206)543-6515	9104740096/UW UI
Pozzi, J-P.	DMP	(33)43-29-12-25	202601/NORMSUP F
Prahl, F.*	SGPP	(503)754-4172	5105960682/OSU COVS
Premoli-Silva, I.	OHP	(39)2-23-88-13	320484/UNIMI I
Puchelt, H.	LITHP	not available	not available
Pyle, T.*	JOI	(202)232-3900	7401433/BAKE UC
Rabinowitz, P.*	ODP/TAMU	(409)845-2673	792779/ODP TAMU
Raleigh, B.*	EXCOM	(914)359-2900X345	7105762653/LAMONTGEO
Rangin, C.	WPDPG	(33)43-36-25-25X5257	200145/UPMC SIX F
Rea, D.	CEPDPG	(313)936-0521	not available
Renard, V.	SSP	(33)98-22-40-40	940627/OCEAN F
Rhodes, J.	SMP	(213)545-2841	not available
Richards, A.	SMP	(31)15-78-68-43	not available
Riddihough, R.	TECP	(613)995-4482	not available
Riedel, K.*	ODP/TAMU	(409)845-8480	792779/ODP TAMU
Rischmueller, 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
Roure, F.	TECP	(33)47-52-68-13	203050/IFP A F
Saito, T.*	OHP	(81)236-311421X2585	25607/ORIUT J
Sancetta, C.*	CEPDPG	(914)359-2900X412	7105762653/LAMONTGEO
Sartori, R.	SSP	(39)51-22-54-44	511350/I
Saunders, R.	IHP	(41)61-25-82-82	not available
Schaaf, A.	IHP	not available	not available
Schilling, J-G.	EXCOM	(401)792-6102	257580/KNAU UR
Schlanger, S.	CEPDPG	(312)491-5097	not available
Schrader, H.	CEPDPG	(47)5-21-35-00	42877/UBBRB N
Schuh, F.	TEDCOM	(214)380-0203	794784/ARCO PLNO
Scott, S.	WPDPG	(416)978-5424	0623887/GEOLOGY TOR
Sengor, A.	CEPDPG, ODPC	(90)1-433-100	23706/ITU TR
Serocki, S.*	ODP/TAMU	(409)845-2099	792779/ODP TAMU
Shackleton, N.*	OHP	(44)223-334871	81240/CAMSPL G
Shipley, T.*	PCOM,FPAPWG	(512)471-6156	9108741380/UTIG AUS
Simoneit, B.	SRDPG	(503)754-2155	5105960682/OSU COVS
Sliter, W.	CEPDPG	(415)853-8300	171449/PCS USGS MNPK
Small, L.	EXCOM	(503)754-4763	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)12-36-50	74745/POLAR N
Sondergeld, C.	DMP	(918)660-3917	200654/AMOCO UR
Spall, H.	IHP	(703)648-6078	not available
Sparks, C.	TEDCOM	(33)47-52-63-95	203050/IFP A F
Srivastava, S.*	TECP	(902)426-3148	01931552/BIO DRT

Stanton, P.	TEDCOM	(713)940-3793	9108815579/USEPRTX HOU
Stein, R.*	OHP	(49)641-702-8365	482956/GRIWOTY UNIGI D
Stel, J.	EXCOM, ODPC	(31)70-82-42-31	20000/MEMO NL
Stephansson,	DMP	(920)91359	not available
Storms, M.*	ODP/TAMU	(409)845-2102	792779/ODP TAMU
Strand, H.	TEDCOM	(47)04-677610	not available
Stow, D.	SGPP	((0602)506101	not available
Suess, E.	SGPP,FPAPWG	(49)431-720-020	not available
Summerhayes, C.	OHP	(44)9327-762672	296041/BPSUNA G
Sutherland, A.*	NSF	(202)357-9849	257653/NSFO UR
Suyehiro, K.*	SSP	(81)3-376-1251	25607/ORIUT J
Svendsen, W.	TEDCOM	(612)331-1331	210685/LYHQ UR
Taira, A.*	PCOM	(81)3-376-1251X256	25607/ORIUT J
Tamaki, K.*	SSP,IHP,CEPDPG	(81)3-376-1251	25607/ORIUT J
Taylor, B.*	WPDPG	(808)948-6649	7238861/HIGCY HR
Thierstein, H.	PCOM	(41)1-256-3666	53178/ETHBI CH
Thomas, E.*	SMP	(203)347-9411	not available
Tokuyama, H.	SMP	not available	not available
Tucholke, B.*	PCOM	(508)548-1400X2494	951679/OCEANIST WOOH
Van Lieshout, R.	ODPC	(31)2159-457-39	890440/ESF F
Van Weering, Tj.	WPDPG	(31)02226-541	not available
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)43-36-25-25X5162	200145/UPMC SIX F
Vogt, P.	TECP	(202)767-2024	897437/NRL LIMA WSH
Von Huene, R.	FPAPWG	(415)354-3144	not available
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
Watkins, J.	PCOM	(409)845-8478	not available
Watts, T.*	TECP	(914)359-2900X533	7105762653/LAMONTGEO
Wefer, G.	OHP	(49)421-218-3389	245811/UNI D
Weigel, W.	SSP	(49)40-4123-2981	214732/UNI HH D
Westbrook, G.	TECP,FPAPWG	(44)21-414-6153	338938/SPAPHY G
Westgaard, L.	ODPC	(47)2-15-70-12	not available
Wilkins, R.*	DMP	(808)944-0404	7238861/HIGCY HR
Winterer, E.*	PCOM	(619)534-2360	9103371271/UCWWD SIO SDG
Wortel, R.	TECP	(31)30-53-50-74	40704/VMLRU NL
Worthington, P.	DMP	(44)9327-63263	296041/BPSUNA G
Zierenberg, R.	SRDPG	(415)329-5437	171449/PCS USGS MNPK

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Special Issue No. 1: Manual on Pollution Prevention and Safety, 1976 (Vol. II)

Special Issue No. 2: Initial Site Prospectus, Supplement One, April 1978 (Vol. III)

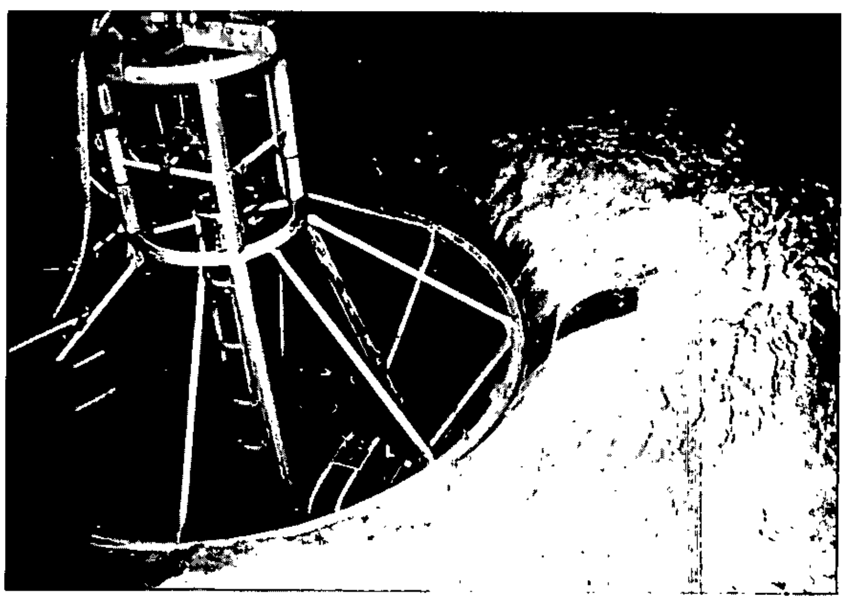
Special Issue No. 3: Initial Site Prospectus, Supplement Two, June 1980 (Vol. VI)

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

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

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

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



In July 1988 IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) carried out the first reentry of a borehole on the deep seafloor using NADIA (NAvette DIAgraphie - logging schuttle) and the deep submersible, NAUTILE. The target hole was DSDP Site 396-B, located near the Mid-Atlantic Ridge and the Kane Fracture Zone. Water depth was 4455 m. NADIA is a cone-shaped frame, fitted with a winch, docked into the reentry cone, and operated by a manned submersible. It is a non-propelled and free-falling system; descent to the seafloor and return to the surface are acheived by gravity and buoyancy. Félicitations, NAUTILE!