JOI/USSAC
NEWSLETTER

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African climate and human evolution: the ODP link

contributed by Peter deMenocal

Did changes in Africa's climate influence the evolutionary paths of our ancestors? As early as the 1850s Charles Darwin recognized this possibility through corresponding changes in ecology (so-called vicariance) and genetic isolation. In recent years, scientists have built on those basic macroevolutionary principles to propose a hotly debated hypothesis: that major junctures in the Pliocene-Pleistocene evolution of early hominids (and other African vertebrates) correlate with changes in African climate [*Vrba*, 1995; *Vrba et al.*, 1989]. Critics have been quick to point out that the idea could not be adequately tested because paleoclimate records were even more scant, discontinuous and poorly dated than the fossil record itself.

Detailed records of African paleoclimate change during the Plio-Pleistocene are rare from exposed terrestrial sequences because of erosion, non-deposition and active tectonics. But the ocean has proven a rich repository of ancient climate data. New ocean drilling results have produced a set of continuous, well-dated and detailed records of African paleoclimate variability spanning the past five million years [*Bloemendal and deMenocal*, 1989; *Clemens et al.*, 1996; *deMenocal*, 1995; *deMenocal et al.*, 1993; *Ruddiman and Janecek*, 1989; *Tiedemann et al.*, 1994]. These data link climate changes in Africa and the Northern Hemisphere, and they make specific predictions about Pliocene-Pleistocene African ecological change that can be used to formally test African climate-evolution hypotheses.

Ocean drilling of marine sedimentary sequences off West Africa (ODP Leg 108, Sites 659, 661, 662, 663, 664) and East Africa/Arabia (Leg 117, Sites 721 and 722) has produced several continuous and well-dated records of wind-borne (eolian) dust variability, which serve as proxies of subtropical African climate change over the past several million years. These legs were drilled specifically to reconstruct past variations in African/Asian climate and monsoonal circulation. Because of its highly seasonal monsoonal climate, subtropical West Africa exports over one billion tons of mineral aerosol (dust) to the adjacent tropical Atlantic each year [*Pye*, 1987]. Perhaps presciently, Darwin commented on these African dust storms during his 1846 *Beagle* voyage off Cape Verde [*Darwin*, 1846]: "…During our stay of three weeks at St. Jago (Cape Verde), the wind was NE as is always the case this time of year; the atmosphere was often hazy, and very fine dust was constantly falling, so that the astronomical instruments were roughened and a little injured."

Annual variations in Africa dust export are closely tied to the climate of the dust source areas. Not surprisingly, drier years are dustier. Over geologic timescales, shifts in African aridity are recorded stratigraphically as variable concentrations of mineral dust in offshore sediments. Continuous stratigraphic sequences were developed by "splicing" a single complete record from multiple-hole sites. These spliced records were then sampled at high-resolution and a sequential geochemical extraction procedure was used to isolate the mineral (dust) fraction from other sedimentary components. Once these records were constrained by oxygen isotopic stratigraphies, time-dependent changes in the amplitude, phase, and frequency of wind-borne African dust concentration and flux variability were used to constrain how (and why) African climates varied during the Pliocene-Pleistocene.

INSIDE...

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Previous results have shown that Pliocene-Pleistocene was most notably punctuated by the onset of Northern Hemisphere glacial cycles near 2.8 Ma, with subsequent increases in climate variability after ~1.0 Ma [*Raymo*, 1994]. The entire subpolar climate system evidently marched in step to the regular 41-kyr orbital tilt cycle after the initial growth of polar ice sheets at ~2.8 Ma, with synchronous glacial increases in abundances of coarse ice-rafted debris, cooler subpolar sea-surface temperatures, and associated changes in deep ocean circulation.

But how did African climate vary during this same interval? Analysis of the eight eolian dust records off subtropical West and East Africa reveals a consistent pattern of variability (Figure 1, [*deMenocal*, 1995]). The records show a cooler and drier African climate after 2.8 Ma, and intensification of these conditions after 1.7 Ma and 1.0 Ma. Before 2.8 Ma, African aridity varied dominantly at the 23-19-kyr periods corresponding to low-latitude insolation variations due to earth orbital precession. The longest record (Arabian Sea Site 721/722) shows that this pattern of variability persisted at least into the late Oligocene. However, after 2.8 Ma the marine African eolian dust records shifted abruptly to a dominant 41-kyr period of variation, mimicking the high-latitude signature of glacial climate cycles. After 1.7 Ma, the dust records exhibit higher amplitude 41-kyr aridity cycles. After 1.0 Ma, the dust records indicate a further shift to the higher-amplitude and longer-period 100-kyr cycles, again mimicking high-latitude ice sheet variability. Glacial dust flux values during the latest Pleistocene were between three to five times greater than during interglacials, and greatly increased abundances of dumbbell-shaped grass phytoliths (siliceous structural bodies in savannah grasses also blown offshore) document a more southward position of the African savannah grasslands. Marine pollen records from West African Site 658 confirm the onset of “glacial-arid” African climate cycles after 2.8 Ma [*Dupont and Leroy*, 1995].

Climate model experiments have been used to understand these shifts in African climate variability. In the absence of significant changes in high-latitude climate, climate models have shown that African (and Asian) monsoonal climate respond directly to variations in low-latitude seasonal insolation due to Earth precession [*Kutzbach and Guetter*, 1986; *Prell and Kutzbach*, 1987]. Monsoonal circulation is essentially a heat engine response to solar insolation: increased summer season insolation warms land surfaces more efficiently than the ocean’s mixed layer, the stronger ocean-to-land pressure gradient that develops drives the inflow of moist, maritime air, in turn, supplies the summer monsoonal rainfall. Hence, the dominant 23-19-kyr African paleoclimate cycles before 2.8 Ma reflect direct precessional forcing of African monsoonal climate;

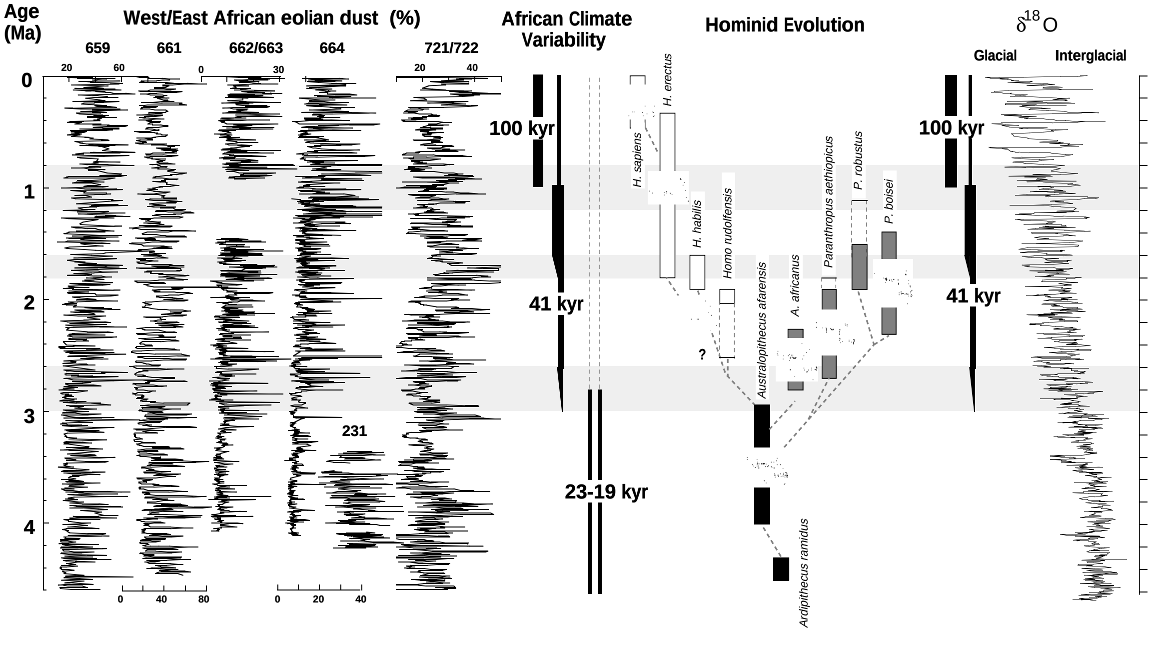

Fig. 1: Pliocene-Pleistocene records of terrigenous (eolian) percentage variations at West African Sites 659, 661, 662, 663, and 664 [*Bloemendal and deMenocal*, 1989; *deMenocal et al.*, 1993; *Ruddiman and Janecek*, 1989; *Tiedemann et al.*, 1994] and East African/Arabian Sea Sites 231, 721, and 722 [*Bloemendal and deMenocal*, 1989; *deMenocal*, 1995]. Pronounced shifts in African climate variability occur in all records near 2.8 Ma, 1.7 Ma, and 1.0 Ma (shaded bars). These variability shifts, with corresponding changes in eolian flux, document aridification of subtropical Africa due to dynamical effects related the onset and intensification of high-latitude glacial cycles after 2.8 Ma. Marine and terrestrial pollen data [*Bonnefille*, 1983; *Dupont and Leroy*, 1995] and carbon isotopic analyses of East African soil carbonates [*Cerling*, 1992] also support these trends toward more open and arid conditions. Major junctures in the evolution of African hominids and other vertebrates coincide with these shifts suggesting that some speciation events may have been climatically mediated.

that is, direct low-latitude forcing of low-latitude climate.

Glaciation of the Northern Hemisphere, beginning at 2.8 Ma, forever changed this relationship. Cold “glacial” North Atlantic sea surface temperatures (SSTs) cause subtropical Africa to become cooler, drier and windier [*deMenocal*, 1995; *deMenocal and Rind*, 1993]. Climate model results show that the imposition of cold SSTs cooled subtropical Africa by 1-3° C, reduced African summer monsoonal rainfall by ~30%, and nearly doubled the strength of the winter (dust-transporting) trade winds (Figure 2). These same linkages are also characteristic of modern drought occurrences in the Sahel. When ice sheets expanded after 2.8 Ma, and large glacial-interglacial oscillations were sustained, African climate became partially dependent upon the amplitude and rhythm of high-latitude climate.

Major events in early hominid evolution appear to be coeval with these African climate shifts. Marine records support previous assertions that certain junctures in human evolution may have been climatically mediated [*Vrba*, 1995; *Vrba et al.*, 1989]. Although the fossil record is still too fragmentary to establish precise correlations with paleoclimate records, the marine eolian records provide an exciting new opportunity to examine the available African fossil record of hominid and other vertebrate evolution within the context of regional paleoenvironmental change.

The most significant development in early hominid evolution occurs between 3.0-2.5 Ma, when at least two distinct lineages emerge from a single bipedal ancestral line (Figure 1). Earliest members of the “robust” australopithecine lineage first occur in the fossil record near 2.7 Ma and are distinguished by their stout, large-boned frame and apparently unique masticatory adaptations (for example, extremely large chewing teeth). A second lineage, represented by the earliest members of our genus *Homo*, first occurs near 2.5 Ma [*Wood*, 1992] (Figure 1). Earliest fossils of the *Homo* clade are characterized by larger absolute cranial volumes and more graceful frames. The earliest known stone tools (crude choppers and scrapers) occur near 2.4-2.6 Ma. The synchronous existence of two distinct hominid lineages has been interpreted by some to reflect separate adaptations to a more arid, varied environment. Fossil African bovid and rodent assemblages also indicate shifts toward arid-adapted species between 2.7-2.5 Ma. By 1.6 Ma, *Homo habilis* became extinct and its immediate successor, and our direct ancestor, *H. erectus*, first occurs in the fossil record near 1.8 Ma. H. erectus may have migrated to southeast Asia as early as 1.8-1.6 Ma. At 1.7 Ma East African bovid assemblages include greater numbers of arid-adapted species. Earliest occurrences of the more sophisticated tools (i.e., bifacal handaxes) occur near 1.4 Ma. By 1 Ma, final members of the “robust” australopithecine lineage became extinct.

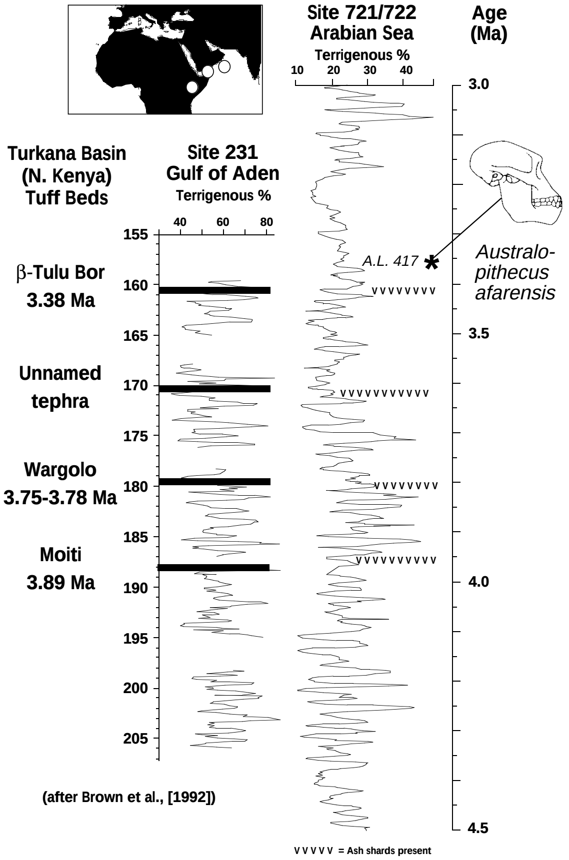

Fig. 2: Tephrostratigraphic correlations between East African hominid fossil localities in Ethiopia and Kenya and marine sediment records. The Tulu Bor tuff defines the age of the *A. afarensis* specimen A.L. 417. Microprobe analyses of ash shards from this tuff and from sparse ash layers in Sites 231 and 721/722 enable correlation of the marine and terrestrial records [*Brown et al.*, 1992].

The Arabian Sea sediments also contain numerous very thin, sparse ash layers from volcanic eruptions in Ethiopia and Kenya. Microprobe analyses of extracted ash shards allow us to use a geochemical fingerprinting technique to directly intercorrelate the fossil-bearing East African sedimentary sequences with the marine paleoclimate records [*Brown et al.*, 1992]. For example, Figure 2 shows the precise placement of hominid fossil specimen A.L. 417 (belonging to *A. afarensis*, a “first family” member similar to Lucy) within the Site 231 and 721/722 precessional African aridity cycles using tephrostratigraphic correlation of the Tulu Bor tuff.

The drilling results, by placing specific constraints on the changing paleoenvironments of subtropical Africa, not only reveal the stage on which a fascinating evolutionary drama unfolded, they may help us understand how and why the story turned out as it did.

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Fellowship Profile

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Faculty Advisor:
Jeffrey A. Karson

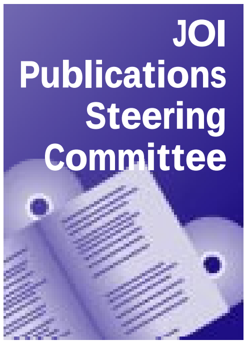
Paleomagnetic and rock magnetic constraints in large-scale normal faults on the Mid-Atlantic Ridge

ODP Leg 153 drilled along the western median valley wall of the Mid-Atlantic Ridge (MAR) at the Kane transform (MARK Area, 23°N) in the first attempt at deep crustal "offset drilling" in slow-spreading crust. By integrating magnetic, paleomagnetic, and structural data adapted from studies of continental extensional terranes, I demonstrated that the serpentinites in the detachment footwall at Site 920 have not been rotated since acquiring remanence. Hence, the footwall and structures within it (including the major detachment faults) are in their original orientations. These results provide definitive kinematic constraints on the large-scale tectonics of the slow-spreading MAR.

As known for decades, slow-spreading ridges display a characteristic rift valley morphology. However, their structural development remains poorly understood. My fellowship research focused on quantifying displacement along and tectonic rotation associated with major detachment faults that define the rift valley walls of some spreading segments. Paleomagnetic studies on Site 920 serpentinites constrain the kinematics of the fault zone that exposes hydrated upper mantle peridotites. Magnetite, formed during serpentinization, is the sole magnetic carrier. Although magnetite occurs in a number of paragenetic settings, a consistent (~30° dipping) metamorphic fabric imparts a pervasive anisotropy of magnetic susceptibility (AMS). Paleomagnetic remanence studies demonstrate a consistent univectorial remanence (inclination = 32.7°±1°). Distinct from the predicted inclination of 41°, this suggests a finite tectonic rotation. Anisotropy of remanence experiments show, despite the strong AMS, only a small deflection of the remanence acquisition, resulting in a corrected inclination of 38.2°±1.5°. Either secular variations or deviation of the drill hole from vertical explain this small remaining difference. The magnetic results indicate no significant tectonic rotation of the serpentinites implying that the low-angle serpentinite detachment fault slipped in its present orientation and that the footwall uplift occurred without significant rotations.

This integrated structural and paleomagnetic approach was applied at two asymmetric slow-spreading segments in the MARK area. The major mechanism of extension appears to be a single non-rotational, low-angle detachment fault. (The other study used oriented *Alvin* submersible samples of diabase dikes from a spreading segment 100 km to the south.) Together these results imply that low-angle, detachment faults accommodate mechanical extension at different MAR segments where a range of rock types and crustal assemblages occur, further improving our understanding of the geometry and kinematics of extensional tectonics along slow-spreading ridges.

Publish (on paper) or perish?



Over the last few months, JOI set up a Publications Steering Committee (PUBCOM) whose mandate is to advise JOI in the implementation of the ODP Publications Strategy. A PUBCOM is explicitly mentioned in this strategy (see the November *JOI/USSAC Newsletter* for a summary), which states that the shift to electronic publication of the ODP "Initial Reports" or "Scientific Results" volumes will proceed only if JOI receives a positive recommendation from PUBCOM and the endorsement of the JOIDES Scientific Committee (SCICOM). Specifically, PUBCOM's mandate is to:

- Provide an ongoing evaluation of the ODP Publications Strategy and recommend to JOI any changes that should be made;
- Ensure that the Strategy is in step with the direction of the scientific publishing world and the needs of the scientific community;
- Make recommendations on the design and function of formats for electronic *ODP Proceedings* volumes;
- Evaluate new formats for electronic CD-ROM volumes as well as a WWW (Internet) version of the *ODP Proceedings*;
- Recommend a timetable to move forward toward a complete or mostly electronic publishing of ODP scientific data and results; and
- Develop a strategy to ensure an archival record of all *ODP Proceedings* materials.

PUBCOM membership is now complete (see the box), and the committee will hold its first meeting April 3-4 in Washington, DC. One of the key items to be addressed is whether the Publications Strategy, as it currently stands, will satisfy the current publication/information needs of the community. If not, how should the Strategy be changed? Any changes would have to be endorsed by SCICOM at their late April meeting. The full meeting agenda also includes discussions on how PUBCOM can best reach out to our constituency to get an accurate assessment of the current and anticipated practices and preferences in assimilating and electronically using ODP information. PUBCOM will help educate the community about information-transfer enhancements that are uniquely provided by electronic publications, but are impossible through the print medium. Finally it is vitally important that PUBCOM become fully informed about electronic publication with respect to its real powers and current limitations, if this committee is to make educated recommendations to JOI.

To begin the education process, at the April meeting, there will be several guests who will share with PUBCOM their experiences in the electronic publication world. Special presentations will be made by:

- Judy Holoviak, Director, American Geophysical Union (AGU) Publications, who will discuss AGU electronic publications — business and economic realities of publishing premier earth science journals;
- Jim Smith, U.S. Geological Survey (USGS), who will discuss USGS electronic publications — products/major benefits to customers/strategies to avoid pitfalls and bad decisions/how our libraries will work in the future;
- Norm MacLeod, Natural History Museum, London, core organizer of PaleoNet and Palaeontologica Electronica, who will discuss electronic paleontology — the goals and products for a visualizing research community; and
- Carolyn Ruppel, Georgia Tech, who will discuss electronic scientific publications of the AGU — views and insights from an AGU advisor and ODP scientist.

PUBCOM
MEMBERSHIP

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Warner Bruekmann (GEOMAR, Germany)
Christian France-Lanord (CRPG-CNRS, France)
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Jennifer Rumford (ODP/TAMU)
Carl Richter (ODP/TAMU)
Mary Reagan (LDEO/BRG)

Summaries of upcoming ODP Legs 177-183

Ocean Drilling Program

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The ODP/TAMU web site has shipboard scientist applications on line at: http://www-odp.tamu.edu/sciops/cruise_application_info.html

In December 1996, the JOIDES Planning Committee finalized the drillship operations schedule for the fiscal years 1998 and early 1999. Brief descriptions of Legs 177-183 as taken from the JOIDES Science Plan follow. We encourage you to contact the leg co-chief scientists and/or Jamie Allan if you are interested in obtaining more information about a particular leg.

Leg 177: S. Ocean Paleoceanography
Co-Chiefs: Hodell (U.S.), Gersonde (FRG)

To investigate the paleoceanographic and climatic history of the southern high latitudes, Leg 177 will drill a latitudinal and depth transect across the Atlantic sector of the Antarctic Circumpolar Current. These drill sites will provide sedimentary sequences essential to expanding the known Cenozoic history of the Southern Ocean. Another major leg objective, inspired by high sedimentation rates at several target drill sites, is to obtain Neogene sediment sections to help resolve the timing of Southern Hemisphere climatic events relative to those documented in the Northern Hemisphere (an article on this subject will be printed in the July 1997 issue).

Leg 178: Antarctic Peninsula
Co-Chiefs: Barker (UK), Camerlenghi (ESF/Italy)

During Leg 178, the Antarctic Peninsula's western margin will be drilled to fulfill the scientific objectives of two programs: one to investigate Antarctic glacial history and sea-level change, and the other to explore paleoproductivity in the Antarctic coastal ocean. The target sediments in the first program were transported by grounded ice sheets to the Antarctic continental margin and deposited on the rise as drifts and on the shelf and slope as progradational wedges. The planned drill sites should yield an unprecedented high-resolution record of continental climate over the past 6-10 million years as well as a direct check on the presumed glacio-eustatic origin of global sea-level change over the same period. Potentially, our understanding of the Antarctic ice sheet's role in global climate dynamics will be significantly advanced by Leg 178.

Leg 179: NERO/Hammer Drilling
Co-Chiefs: TBN

By drilling on the Ninety East Ridge in the Indian Ocean, Leg 179 will provide a site for installing a broadband ocean seismometer and instrument package for the International Ocean Network (ION). This Ninety East Ridge Observatory (NERO) will fill a gap in the Global Seismic Network and permit study of Indian Plate dynamics. During Leg 179, Leg 121's Site 756 (primary target) or Site 757 (alternate target) will be reoccupied, and basement will be penetrated to at least 100 m to allow for the subsequent installation of the instrument package by submersible.

Leg 180: Woodlark Basin
Co-Chiefs: Taylor (U.S.), TBN

Leg 180 drilling in the Woodlark Basin (near Papua, New Guinea) will address the nature of low-angle faulting, continental breakup, and the evolution of conjugate rifted margins. Lateral variation from active continental rifting to seafloor spreading within a small region makes the western Woodlark Basin ideal for investigating the mechanics of lithospheric extension. The proposed drilling will: (1) initially characterize, and later monitor, the *in situ* properties of the active fault zone; and (2) reveal the vertical motion history of both the down-flexed upper plate and the unloaded lower plate allowing the estimation of the timing and amount of extension prior to spreading.

Leg 181: Southwest Pacific Gateway
Co-Chiefs: TBN

Leg 181 aims to reconstruct the Neogene history of stratigraphy, paleohydrology, and dynamics of the Pacific Ocean's Deep Western Boundary Current (DWBC) and related water masses. Today, 40% of Antarctic Bottom Water enters the world ocean through the SW Pacific Gateway as the thermohaline DWBC. A latitudinal and depth transect on the eastern margin of the New Zealand Plateau will yield information about the DWBC's development, which is fundamental to understanding global oceanic and climatic histories. Recovered sedimentary sequences will also allow other high-priority problems to be addressed.

Leg 182: Great Australian Bight
Co-Chiefs: Hine (U.S.), Feary (Australia)

Leg 182 will drill a ten-hole array across the Cenozoic shelf of the Great Australian Bight in order to: (1) document this carbonate platform's evolution since 65 Ma in response to oceanographic and biotic change; and (2) study global sea-level fluctuations, physical and chemical paleocean dynamics, biotic evolution, hydrology and diagenesis. This drilling will complement other ODP sea-level transects and will contribute to our understanding of climate and deepwater circulation throughout the Cenozoic evolution of the Southern Ocean. Leg findings will also contribute to modeling ancient open platforms and ramps.

Leg 183: Kerguelen Plateau
Co-Chiefs: TBN

Leg 183 is the first leg in a proposed two-leg program to investigate the origin, growth, compositional variation, and subsidence history of the Large Igneous Province (LIP) formed by the Kerguelen Plateau and Broken Ridge in the southeastern Indian Ocean. An array of holes in portions of the LIP will penetrate approximately 200 m of basement, and offset drilling is planned in the vicinity of major fault scarps where tectonic processes have exposed deeper crustal levels. The drilling will examine magma volumes and growth mechanisms—as well as the relative roles of the plume, asthenosphere, and continental lithosphere—as functions of time in forming this LIP.

JOIDES Resolution Schedule for Legs 172-183

Leg	Region	Co-Chiefs	Dep. Port	Date	Scientific Objectives
172	NW Atlantic Sed. Drifts	Keigwin Rio	Charleston	2/97	To reconstruct a high-resolution, deep- to intermediate-depth hydrographic record for the western subtropical North Atlantic during the last glacial maximum.
173	Iberia Margin	Beslier Whitmarsh	Lisbon	4/97	To investigate the history of this non-volcanic rifted margin, including timing/nature of melt generation during breakup and earliest generation of "normal" oceanic crust.
174A	New Jersey Shelf	Austin Christie-Blick	Halifax	6/97	To investigate the Oligocene-Holocene history of sea-level change by determining the geometry and age of the Oligocene-to-Miocene depositional sequences.
174B	CORK/ Engineering	Becker Pettigrew	New York	7/97	To install a borehole seal (CORK) at Hole 395A and to conduct engineering tests.
175	Benguela Current	Berger Wefer	Las Palmas	8/97	To reconstruct the history of the Benguela Current and coastal upwelling of the region between 5° and 32° S.
176	Return to 735B	Dick Natland	Cape Town	10/97	To deepen hole 735B and investigate the nature of magmatic, hydrothermal, and tectonic processes in the lower ocean crust at a slow-spreading ocean ridge.
177	S. Ocean Paleocean.	Gersonde Hodell	Cape Town	12/97	To investigate the Cenozoic and Neogene paleoceanographic and climatic history of the southern high latitudes.
178	Antarctic Peninsula	Barker Camerlenghi	Punta Arenas	2/98	To explore Antarctic glacial history and sea-level change and to investigate the paleoproductivity in the Antarctic coastal ocean.
179	NERO/Hammer Drilling	TBN	Cape Town	4/98	To install a broadband ocean seismometer and instrument package which will fill a gap in the Global Seismic Network and permit study of Indian Plate dynamics.
180	Woodlark Basin	Taylor TBN	Singapore	6/98	To investigate lithosphere extension, specifically the nature of low-angle faulting, continental breakup, and the evolution of conjugate rifted margins.
181	SW Pacific Gateway	TBN	Townsville	8/98	To reconstruct the stratigraphy, paleohydrology, and dynamics of the Pacific's Deep Western Boundary Current and related water masses since the early Miocene.
182	Great Australian Bight	Feary Hine	Wellington	10/98	To document this carbonate platform's evolution since 65 Ma in response to oceanographic and biotic change and to study global sea-level fluctuations, physical and chemical paleocean dynamics, biotic evolution, hydrology and diagenesis.
183	Kerguelen Plateau	TBN	Freemantle	12/98	To investigate the origin, growth, compositional variation, and subsidence history of the Large Igneous Province (LIP) formed by the Kerguelen Plateau and Broken Ridge.

Is there a microbial biosphere in the subseafloor?

Contributed by John A. Baross, Melanie Summit, and James F. Holden

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It has been known for decades that microorganisms inhabit the deep terrestrial subsurface. Recent studies have demonstrated the presence of unique microbial communities in deep aquifers, as well as thermophilic and hyperthermophilic microorganisms (growth at 55 and 90°C, respectively) in oil wells and boreholes. In contrast to the terrestrial subsurface, much less is known about the incidence, microbial diversity, and nutritional requirements of the microbial communities in the subseafloor. However, three separate lines of evidence from deep-sea environments support the notion that a significant biomass may exist within the brittle portion of the Earth's crust and sediments, particularly near zones of active volcanism. The evidence includes the presence of thermophiles and hyperthermophiles in fluids released from the seafloor following submarine volcanic eruptions, the presence of these same organisms in 5-30°C diffuse vent fluids at other hydrothermal vent sites and in oil wells, and the detection of microorganisms in deep cores from oceanic sediments.

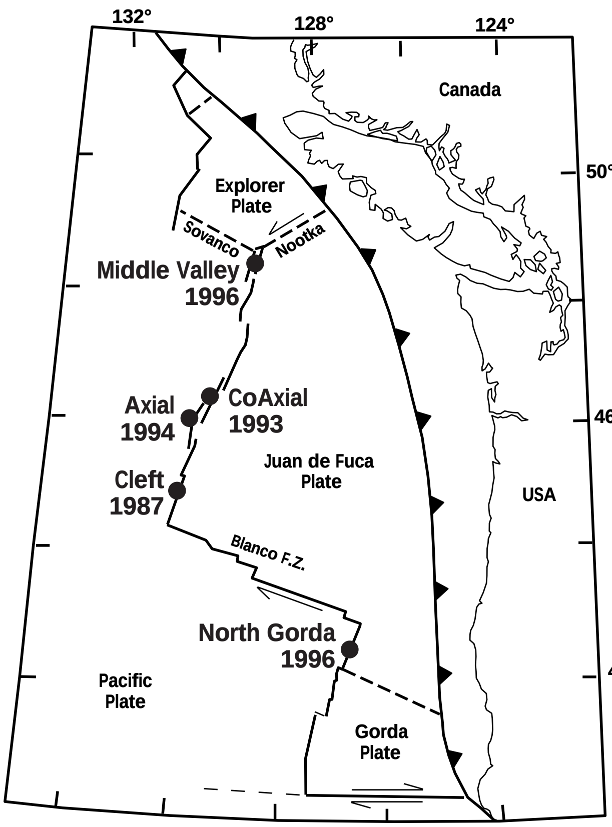

Fig. 1: North Pacific spreading centers, highlighting new eruption sites and seafloor events (modified from D. Kelley). CoAxial and North Gorda are the sites that have been most extensively sampled microbiologically.

Eight volcanic eruptions have been detected in the Pacific Ocean in the last 15 years. Massive amounts of white floc material referred to as "snow" have been observed at four of these sites, and thermophilic and/or hyperthermophilic microorganisms were cultured from three sites within days to months after the initial eruption (Table 1; Figure 1). At the CoAxial segment "Floc" site, thermophilic and hyperthermophilic anaerobic microorganisms were cultured from 18°C diffuse hydrothermal fluids in 1993, three months after the eruption. However, only moderate thermophiles could be detected in diffuse fluids in 1994 through 1996 as the system cooled and venting subsided. The detection of hyperthermophilic microorganisms in fluids from new eruption sites or other diffuse flow vents that are 40-50°C below the minimum growth temperature for these organisms signifies that they originated from a hot subseafloor habitat. In general, analyses of the low-temperature fluids at CoAxial (geochemical and microbial activity measurements and electron micrographs of microorganisms) indicate that a physiologically diverse microbial community inhabits the subseafloor and includes iron- and sulfur-oxidizing bacteria as well as methane producers and consumers (Table 2). Anomalously high methane levels and high sulfide and low sulfate levels in only low-temperature diffuse fluids from the three eruption sites suggest that vigorous biogenic methanogenesis and sulfate-reduction occur in the subseafloor following an eruption.

One of the characteristics of new eruption events is that they are often associated with large, symmetrical plumes of heated water ("megaplumes") believed to form rapidly by the catastrophic release of a preexisting subseafloor fluid reservoir [*Baker et al.*, 1989]. Therefore, these plumes may provide a record of the subseafloor prior to the event. When MacDonald Seamount erupted, hyperthermophiles were found in a plume within hours of the event [*Huber et al.*, 1990]. The origin of these microbes is uncertain, as MacDonald Seamount is too shallow to form a classic event plume. However, an event plume resulting from the February 1996 North Gorda Ridge eruptive event provided another opportunity to peer into the subseafloor. The

Table 1: Microbial observations at new ocean eruption sites

SITE	DATE	TEMPERATURE	FLOC OBSERVED	THERMOPHILES IDENTIFIED
MacDonald Seamount, SE Pacific	1988	no temperature measurements of source fluids	no observations	diverse assemblage of thermophiles[1] from plume and surface slick
9° N, East Pacific Rise	1991	30° C vent sampled (1994)[2]	Yes	hyperthermophiles[1] and methanogens cultured[2]
CoAxial, Juan de Fuca Ridge	October 1993	18° C at Floc site; 36° C at Flow site	Yes at Floc No at Flow	hyperthermophiles[1] and diverse thermophiles cultured from Floc; none from Flow
Axial, Juan de Fuca Ridge	July 1994	30° C vent sampled at nearby ASHES vent field (7/95)[2]	Yes	thermophiles cultured but no hyperthermophiles[2]
Cleft, Juan de Fuca Ridge	first observed in 1987	5° C at Pipe Organ; 27° C at Vent I site (6/94)	no observations	No growth detected at 55° C or 90° C
North Gorda Ridge	February to April 1996	no temperature measurements of source fluids	No	thermophiles and hyperthermophiles isolated from 2° C plume water
17° S, East Pacific Rise	observed in 1983, 1984	150° C fluid at one site	No	no observations
Middle Valley, Juan de Fuca Ridge	October 1996, drilling creates vents	~ 250° C	No	no observations
Loihi Seamount, Hawaii	August 1996	3° -4° C	yes	thermophiles and hyperthermophiles cultured (> 50,000 per liter)

[1] including pure cultures of the hyperthermophiles *Pyrococcus* and *Thermococcus*

[2] microbes cultured three years and one year after the events, respectively

Table 2: Microbially-mediated chemical conversions at new-eruption sites and diffuse-flow vents[1]

ENERGY REACTION	CARBON/ENERGY SOURCES	EVIDENCE FOR CONVERSION	
		CHEMICAL	BIOLOGICAL
Heterotrophy	buried C, *in situ* production?	ND	isolation of all thermal groups (< 20° to > 90° C)
Sulfate reduction	complex organics, organic acids, CO_2, H_2	high H_2S and low SO_4 relative to end member fluids	isolation of mesophilic species (10 to > 40° C)
Sulfur reduction	complex organics, organic acids, acetate, H_2	ND	isolation of hyper-thermophilic S° reducers (> 90° C)
Sulfide oxidation	CO_2, complex organics, organic acids, acetate	high particulate S°	morphotypes observed and isolation of mesophiles
Methanogenesis	formate, acetate, CO_2, H_2	high CH_4 and low H_2 relative to end member fluids	autofluorescent cells[2] and isolation of hyper-thermophiles
Methane oxidation	CH_4 and other C_1 compounds	^{14}C-CH_4 oxidation to ^{14}C-CO_2	morphotypes observed
Hydrogen oxidation	CO_2, C_1 and C_2 compounds	^{3}H-H_2 oxidation to ^{3}H-H_2O	ND
Nitrification (oxidation of NH_3 to NO_2^- and NO_3^-)	CO_2, acetate?	ND	morphotypes observed
Iron oxidation	organic acids, acetate, CO_2	iron-oxidation enzyme activity	morphotypes observed and isolation of mesophiles

ND = No data, [1]from Holden et al., in preparation, [2]methanogens have signature flavins that autofluoresce at specific wavelengths plume was sampled less than one week after its formation, making it the most rapid response to a new event. Enrichment cultures prepared shipboard yielded anaerobic moderate thermophiles and hyperthermophiles in 9 of 10 samples located throughout the plume at levels higher than 200 organisms per liter (Figure 2). No thermophiles or hyperthermophiles were cultured in 12 samples of seawater surrounding the plume. Hydrothermal plumes typically have dilution factors of at least one thousand, and as these anaerobic thermophiles cannot grow under plume conditions (low temperature and dissolved oxygen) their numbers must have exceeded 200,000 per liter in the original fluid that formed the plume. A novel group of thermophilic microorganisms (Figure 3) was grown from this event plume in an anaerobic medium containing simple organic acids and is currently being studied. Characterization of these organisms will help place thermal and chemical constraints on the subseafloor environment they inhabit.

The second line of evidence supporting a subseafloor microbial biosphere is that thermophiles and hyperthermophiles are repeatedly isolated from many 8-30° C diffuse flow vent sites which have not been impacted by eruptions. In diffuse-flow vents, the overall abundances of microorganisms remains relatively constant at different sites but the levels of culturable thermophiles and hyperthermophiles can vary by more than four orders of magnitude. The reason for this variation in abundance is unknown but may be related to the vertical and horizontal dimensions of the diffuse vent subseafloor fluid circulation zone. The depth of the high porosity extrusive layer at the Endeavour and at the CoAxial eruption site is greater than 500 meters [*Pruis and Johnson*, 1996]. Seismic evidence points to active cracking to depths of 5 km along the Endeavour segment, Juan de Fuca Ridge implying that hydrothermal fluid could circulate to these depths through cracks [*Archer and Wilcock*, 1996]. Does this imply that microorganisms could colonize the cracks in deep basalt associated with active ridges? Potentially, though more work is needed to verify that fluid actually does circulate in these cracks and whether the carbon, nitrogen and energy sources needed to sustain life are available (Table 2). The recent reports of microorganisms apparently living in basaltic glass [*Fisk et al.*, 1996] underscore the need to maintain an open mind about the physiological versatility of microorganisms.

Thermophilic and hyperthermophilic microorganisms have also been isolated from deep (> 2000 m) petroleum reservoirs on land and at sea [*Stetter et al.*, 1993, *L'Haridon et al.*, 1995]. The presence of high-temperature

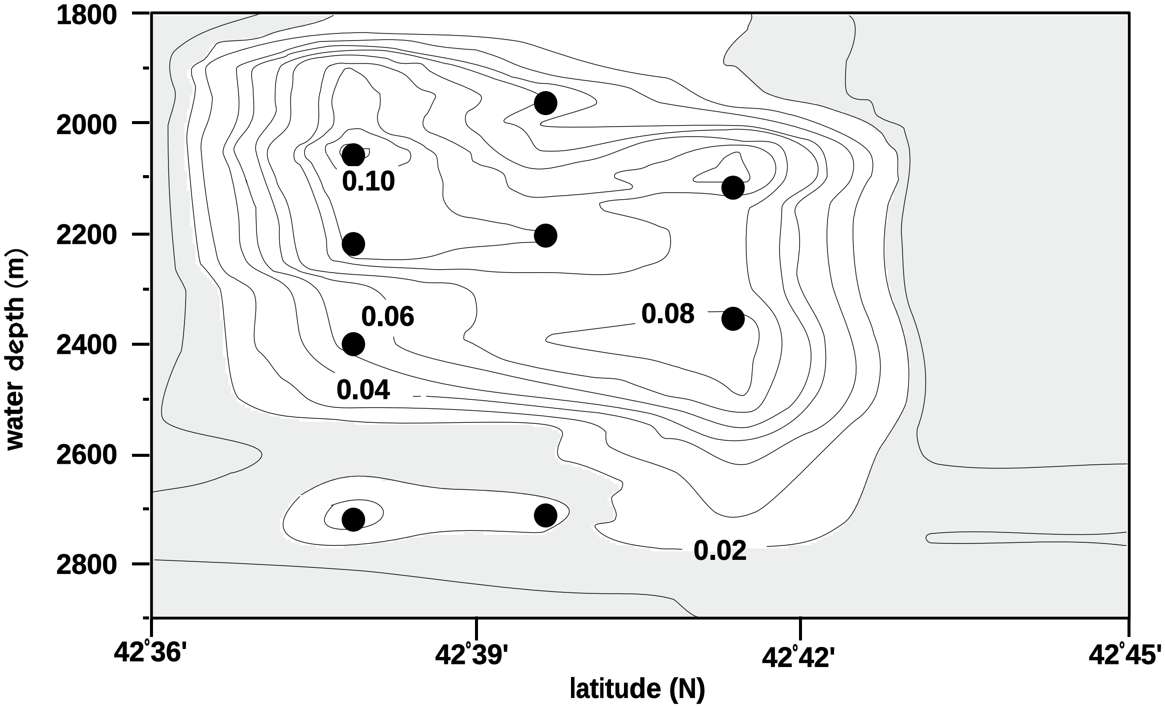

Fig. 2: 1996 North Gorda Ridge event plume 96A as of March 1996. Contours are temperature anomaly (.01°C/contour, modified from E. Baker). Dots indicate locations in the plume where thermophiles were cultured.

organisms in wells uncontaminated by seawater, which is sometimes introduced as pumping fluid, strongly suggests that they are indigenous and not seawater contaminants.

The third line of evidence for subseafloor organisms comes from drill cores. Drilling affords a more comprehensive sampling of the environment than fluid sampling, where microorganisms are removed from their habitat and flushed to the seafloor. Microbes have been repeatedly observed in drill cores from deep ocean sediments obtained through the Ocean Drilling Program (ODP). In fact, sediment cores from over ten sites have been examined for microbes, and all those cores harbored microorganisms. The deepest cores examined for microbes extended below 500 mbsf in the Japan Sea. Not only were microbes present throughout these cores, but further measurements showed the presence of active microbial sulfate reduction (see Parkes et al., [1994]). Microbial abundances show a strong negative correlation with depth in the spatially extensive deep sedimentary biosphere [*Parkes et al.*, 1994], though the controlling factors are unknown. Activity of microbes in these sediments has not yet been systematically addressed, but the supporting chemical and physical measurements made routinely on ODP legs would be invaluable in interpreting such results.

Many questions exist regarding the chemical and physical nature of the subseafloor habitat, but the most fundamental questions concern its dimensions. The vertical extent of the subseafloor biosphere in the hydrothermally influenced brittle crust remains controversial and completely unconstrained. The lateral extent of the subseafloor biosphere hinges on whether it must be localized to active vent fields or could be spatially extensive. The implication from results at new eruption sites and diffuse flow vents is that hydrothermal activity, mining energy sources from basalt, may be a prerequisite for an active subseafloor microbial biosphere. Fast spreading rates and propagating heat sources guarantee high intake of seawater and a dynamic heat source would result in continuous changes in the spatial and temporal dimensions of the subseafloor. As the community shifts its perception from the paradigm of localized vent fields to the realization that hydrothermal activity in the seafloor occurs fairly commonly, the possibility has opened that the subseafloor associated with ridges may harbor spatially vast microbial communities.

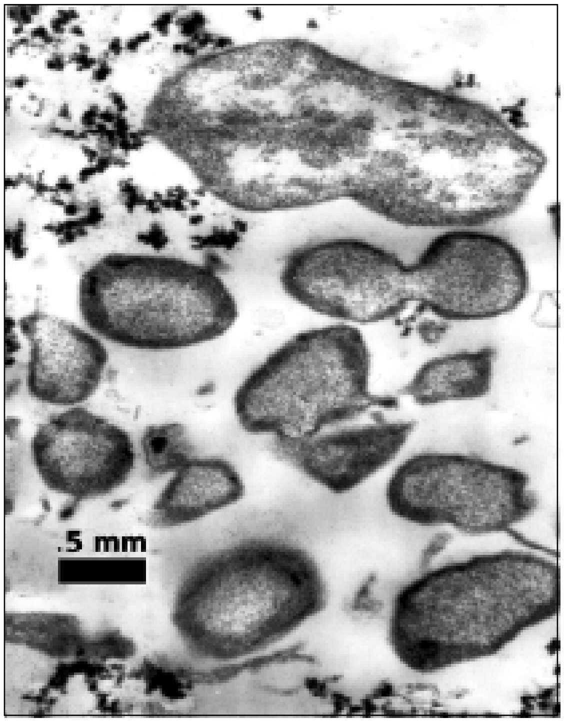

Fig. 3: Electron micrograph of microbes cultured from the North Gorda event plume. These microbes were grown anaerobically at 70°C in a growth medium containing .03% (w/v) formate, acetate, propionate, and citrate, as well as .01% yeast extract.

It is clear that understanding the ecology of the subseafloor microbial habitats associated with volcanism is very complex and involves insight into decade-long questions about the nature and dynamics of the heat source, rock and magma chemistry, cracking behavior, hydrothermal fluid circulation, crustal porosity and thermal gradients. The interrelationships between these variables and microbial communities are not known other than that individually they constrain the ability of microorganisms to colonize and grow in the subseafloor. The verification of a vast subseafloor biosphere will require interdisciplinary measurements and models, and particularly at new eruption sites and drillholes strategically located near ridges.

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ANNOUN

SEIZE

THE SEISMOGENIC ZONE EXPERIMENT

Tentative dates: June 3-6, 1997
Tentative venue: Kona, Hawaii
Convenors: Greg Moore, Casey Moore, Tom Shipley, Miriam Kastner

Subduction zone thrusts produce the largest and potentially the most destructive earthquakes and tsunamis on our planet by shear along converging plate boundaries. Despite the societal and economic importance of great earthquakes on the subduction zone megathrust, little is known about the seismogenic zone that produces them. An International Lithosphere Program Workshop on Dynamics of Lithospheric Convergence, held in September, 1995 in Japan highlighted the importance of an interdisciplinary international effort to effectively investigate this seismogenic zone. Although the problem has been well outlined, the field techniques and geographic areas for field studies require considerable community input. We will be funded by the U.S. National Science Foundation and the JOI/U.S. Science Support Program (JOI/USSSP) to hold a workshop to address these issues.

Important research objectives of SEIZE are: (I) to establish the relationships between earthquakes and: (1) structural geometry, (2) distribution of stress and strain, (3) thermal structure, and (4) nature and fluxes of the fluids and solids in and across key seismogenic zones; and (II) to formulate and test quantitative models of how the shallow subduction cycle works, including the complex interactions among the multiple processes. Investigations will require observations of active tectonic, seismic, and geochemical processes that occur from milliseconds to decades and document their accumulated geologic record. These characterizations will help define the conditions and materials that control earthquake cycles and improve evaluation of natural hazards.

The purpose of this workshop is to bring together a group of scientists who will broadly represent the greater community studying the seismogenic zone. We will discuss the kinds of experiments that are necessary to achieve the objectives listed above. An important component will be to identify the best geographic areas in which to carry out experiments.

The workshop addresses all interested scientists and engineers, in the U.S. and abroad. Funding will be available for approximately 25 U.S. participants. The total number of attendees should be limited to approximately 50 in order to keep the workshop at a manageable size.

Participants will be chosen by the U.S. MARGINS Steering Committee, based on scientific expertise and potential contribution to the workshop. Interested individuals should send a one-page letter outlining their potential contribution as soon as possible to the MARGINS Office via: e-mail to margins@rice.edu; fax to (713) 285-5214; or mail to Dr. Dale Sawyer, MARGINS Planning Office, Department of Geology and Geophysics, MS 126, 6100 South Main St., Houston, Texas 77251, USA.

SCHLANGER OCEAN DRILLING FELLOWSHIP PROGRAM

JOI/USSAC is seeking graduate students of unusual promise and ability who are enrolled in U.S. institutions to conduct research compatible with that of the Ocean Drilling Program. Both one- and two-year fellowships are available. The award is $22,000 per year to be used for stipend, tuition, benefits, research costs, and incidental travel, if any. Masters and doctoral degree candidates are encouraged to propose innovative and imaginative projects. Research may be directed toward the objectives of a specific leg or to broader themes.

PROPOSAL DEADLINE

Shorebased Work (regardless of leg) 11/15/97

For more information and/or to receive an application packet please contact Andrea Johnson at:

Schlanger Ocean Drilling Fellowship Program
Joint Oceanographic Institutions
1755 Massachusetts Ave., NW, Suite 800
Washington, DC 20036-2102
Tel: (202) 232-3900 x213
Fax: (202) 232-8203
E-mail: ajohnson@brook.edu

CONCORD

CONFERENCE ON COOPERATIVE OCEAN RISER DRILLING

Date: July 22-24, 1997
Place: National Olympics Memorial Youth Center
Tokyo, Japan

The workshop's goal is to formulate the main scientific objectives outlined in the ODP Long Range Plan that require riser drilling, and to define the strategies and technology needed to achieve these goals. The workshop report will summarize and document the main problems and goals but will not specify the research-implementation plan which will be proposal-driven.

Approximately 25 members of the U.S. scientific community will be chosen to attend. Expenses will be supported by the JOI/U.S. Science Support Program. For more information contact the CONCORD Steering Committee Secretariat at:
JAMSTEC e-mail: tenakata@jamstec.go.jp
or ORI e-mail: suyehiro@ori.u-tokyo.ac.jp

JOI/USSSP SUPPORTED SHIPBOARD PARTICIPANTS

LEG 172: NW ATL. SED. DRIFTS

U.S. Co-Chief: L. Keigwin, WHOI
ODP Staff Scientist: G. Acton
W. Borowski, U of North Carolina
B. Clement, Florida International U
W. Chaisson, UC Santa Cruz
R. Flood, SUNY Stony Brook
B. Haskell, U of Minnesota
M. Horowitz, MIT
E. Laine, Bowdain College
S. Lund, U of Southern California
M.-S. Poli, U of South Carolina
M. Reuer, WHOI/MIT
D. Winter, Florida State U

LEG 173: IBERIA MARGIN

ODP Staff Scientist: P. Wallace
J. Beard, VA Mus. of Nat. History
K. Kudless, Ohio State U
S. Smith, U of Houston
M. Tompkins, Purdue U
B. Turrin, Berkeley Geochron. Ctr.
R. Wilkens, U of Hawaii
S. Wise, Florida State U
X. Zhao, UC Santa Cruz

MarineCAM

Marine Coring at Margins

Shallow water sediments contain unique information about nearshore processes, sediment stability/transport, paleoclimate, diagenesis, and the history of sea level. Sampling these sediments forms a key component of the ODP Long Range Plan plus the ONR STRATAFORM and NSF Margins initiatives. However, the technology required to recover samples from tens to hundreds of meters below the seafloor in shelfal water depths is not widely recognized or exploited within the scientific community. A workshop initiated by ONR STRATAFORM will be held May 1-2 at the Lamont-Doherty Earth Observatory to promote dialogue between potential scientific users and commercial providers of shallow-water sampling technologies: vibra-coring, wireline coring from floating platforms, and coring and logging from jack-up rigs. The meeting will frame the scientific justification for such sampling. Case histories will be examined. Available sampling technologies will be presented and discussed, and the cost and performance of these methods will be compared to desired scientific objectives. Technological developments that may be needed to achieve these objectives will also be identified. The goal will be to prepare a written strategy intended to culminate in high-recovery coring and logging tens of meters into the shallow-water seabed.

MarineCAM is cosponsored by JOI/USSSP and ONR. For additional information contact the convenor, Gregory Mountain, LDEO, Palisades, NY 10964 (mountain@ldeo.columbia.edu).

JOIDES SCIENCE COMMITTEE U.S. MEMBERSHIP

Susan Humphris, WHOI, SciCom Chair
Gerard Bond, LDEO *(Greg Mountain, LDEO)*
Kevin Brown, Scripps (*Lisa Tauxe, Scripps)*
Emily Klein, Duke (*John Bender, UNC, Charlotte)*
Roger Larson, URI (*Steve D'Hondt, URI)*
Ken Miller, Rutgers *(Greg Mountain, LDEO)*
Casey Moore, UC Santa Cruz (*Jim Zachos, UC Santa Cruz)*
Greg Moore, U of Hawaii (*Patty Fryer, U of Hawaii)*
Jonathan Overpeck, NOAA (*Larry Peterson, RSMAS)*
Maureen Raymo, MIT (*Ed Boyle, MIT)*
(*SciCom alternates)*

Letters of nomination for U.S. membership on SciCom were solicited from the scientific community. The U.S. SciCom members were nominated by the JOIDES Nomination Committee (J. Kennett, Chair; M. Leinen; M. McNutt; D. Clague) and approved by the JOI board of Governors.

JOIDES SCIENCE STEERING AND EVALUATION PANEL U.S. MEMBERSHIP

EARTH'S ENVIRONMENT

Jamie Austin, UTIG
Peter deMenocal, LDEO
Steve D'Hondt, URI
Jeff Gee, SIO
Jon Martin, U of Florida
Ted Moore, U of Michigan
Brian Popp, U of Hawaii
Ana Ravelo, UCSC
Ellen Thomas, Yale/Wesleyan
Mike Underwood, U of Missouri

EARTH'S INTERIOR

Nathan Bangs, UTIG
Garry Karner, LDEO
Debbie Kelley, U of Washington
John Mahoney, U of Hawaii
Craig Manning, UCLA
Julie Morris, Washington U
Carolyn Ruppel, Georgia Tech
John Tarduno, U of Rochester
Doug Wiens, Washington U
TBN

Letters of nomination for U.S. membership on the SSEPs were solicited from the scientific community. The U.S. SSEP members were selected by the JOI/U.S. Science Advisory Committee.

New ODP sample distribution policy

The rumors are true. A new ODP sample distribution policy will soon go into effect. This policy, a fundamental rewrite of the old one, is designed to maximize the scientific return from sample distribution in a responsive and flexible manner.

Last year, JOI/ODP personnel decided that curatorial and core sample distribution procedures should be reviewed in light of community suggestions, recent advances in shipboard laboratories and scientific approaches, as well as in procedures (e.g., new publication policy and changes in the JOIDES advisory structure) and thematic directions (e.g., the 1996 ODP Long Range Plan). In response, JOI hosted a workshop in Washington, D.C. on November 18-19, 1996. It was attended by 20 participants* from the international scientific community, representing ODP/TAMU, several JOIDES panels, JOI, and other groups. The participants reviewed extant policy, discussed its scientific and programmatic implications, and ultimately decided to fundamentally revise the policy. The participants drafted a new set of procedures which was endorsed by the Planning Committee at their December 1996 meeting. After a second round of minor editing, the policy was presented to, and approved by the Executive Committee this past February. The final edits are being made and then, once NSF approval is received, the policy will go into effect. It will be posted on the curation page of the ODP/TAMU web site at: http://www-odp.tamu.edu/curation.

Major differences between policies

ISSUE: curatorial supervision and authority
Old: ultimately resided with ODP Curator, who received advice and guidance from the Information Handling Panel, now disbanded.
New: ODP Curator will supervise and implement the new policy. As we go to press, the interim Curator at ODP/TAMU is Dr. John Firth. Ultimate curatorial and sampling authority will reside with a Curatorial Advisory Board (CAB), a standing body, which will serve as an appeals board and will consist of the ODP Deputy Director of Services (Dr. Jack Baldauf), the ODP Manager of Science Services (interim Manager is Dr. Jamie Allan), and two JOIDES-appointed members of the scientific community (serving four-year terms). These two will be selected by the new Scientific Measurements panel (SCIMP). On a leg-by-leg basis, sampling will be determined by a Sampling Allocation Committee (SAC). One will be formed for each leg and will consist of the two Co-Chief Scientists, the ODP Curator/Curatorial Representative, and the ODP Staff Scientist. Because the SAC best understands the scientific needs of their leg, they will be vested with the authority and responsibility of making leg-specific decisions on sampling. This includes considering sampling requests from the scientific party, both before and during the leg. The SAC will disband and its authority will end at the conclusion of the moratorium, which extends from the beginning of the leg (i.e., when the ship sails), to 12 months after it ends (i.e., the ship returns to port). SAC decisions may be appealed to the CAB. Evenly split votes in the SAC and the CAB will be decided by the ODP Curator and the ODP Deputy Director of Services, respectively. SCIMP will be the guardian of the new policy and will provide advice and guidance as necessary.

ISSUE: sample limits
Old: 50 cc/meter (lifetime) in non-igneous materials, and 100 shipboard igneous samples per person per leg.
New: no preconceived set limit; will depend on scientific objectives, availability of material, and the SAC.

ISSUE: archive core
Old: half of every DSDP and ODP core (except from rarely cored “dedicated” holes) was conserved and preserved in the repositories as archive material and has rarely (if ever) been sampled.
New: policy defines a “minimum archive” for each site, which will often be significantly less than is currently archived. This minimum can be expanded, depending on the intentions of the SAC. This policy change will immediately increase the volume of core material accessible to sample requesters and may reduce coring time by requiring fewer holes. New policy will also permit sampling of the archive, under certain circumstances, and with CAB authorization.

ISSUE: “Sampling Strategy”
Old: evolved informally as the Scientific Prospectus was written, and fortuitously during (and sometimes after) the leg.
New: will formalize the development of a “Sampling Strategy.” JOIDES proposal proponents, and ultimately the SAC, will be charged

with the responsibility of constructing a sampling plan that is coordinated with drilling and logging strategies. This plan will be flexible and will evolve as scientific objectives solidify before, and even during the leg, depending upon core recovery. The strategy will consider all aspects of sampling, such as what core material will be designated "working" versus "archive" (beyond the required minimum), the anticipated number and frequency of samples to be taken by investigators and whether the samples will be taken on ship or shore, special sampling methods, needs, and storage. The purpose of developing a specific strategy is to best meet scientific needs.

ISSUE: post-cruise sampling (within the moratorium)
Old: occurred on a case-by-case basis
New: will be strongly encouraged when sampling demand is high (e.g., paleoceanographic legs). This will promote the best possible use of core and more judicious distribution of sample.

* Patricia Fryer, Brian Huber, Warner Brueckmann, Kate Moran, Tom Janecek, Kathy Gillis, Mitch Lyle, Jean-Pierre Valet, Alan Kemp, Kay Emeis, Rick Murray, Damon Teagle, Eve Arnold, Jamie Allan, Russ Merrill, Chris Mato, John Firth, Ellen Kappel, Dave Falvey, and John Farrell

The debut of Janus, the new kid on the boat

Name: Janus
DOB: January 8, 1997
Weight: eight terabytes, six gigabytes (and growing)
Height: DEC AlphaServer 2100 with 64-bit hardware

Like new parents, we're proud to announce the birth of Janus, the new ODP computer database system. Of course, as with any baby, the prenatal period was fraught with planning, interaction with experts and soothsayers (hence Oracle), and even a little hand wringing. However, thanks to the hard work of the dedicated delivery team of ODP/TAMU and Tracor Inc. personnel, this baby was successfully delivered (not contractually speaking of course) on the *JOIDES Resolution* in Barbados, at the beginning of ODP Leg 171B. All went well, despite the fact that the ship's doctor was busy conducting radio patches, and sparks flew when the cord was cut (on the old S1032 database).

The baby's not bad looking, as babies go, but it's still just a baby. It'll grow and do more with time. Patience is required. At this stage of development, Janus is doing a great job of capturing data through both manual and instrumented interfaces. This makes the lives of shipboard scientists easier because it reduces errors and the entry of redundant data and it decreases data collection time. Data from the following areas are being directly entered into the Oracle relational database: drilling, operations, core/sample, paleontology, multi-sensor track, physical properties, chemistry, and x-ray. A new visual core description package, Applecore, is now in use for digital capture of these data and an interface to Janus from Applecore is under development. Additional applications are being written to enter data from: age-depth models (new), sediment and hard rock description, color reflectance, thin sections, paleomagnetics, thermal conductivity, and the Adara tool. For details, see the article "Janus in January" in the most recent issue of the *JOIDES Journal* (vol. 23, no. 1) or at http://www-odp.tamu.edu/janus/joi/janus.html.

As babies grow and discover, so do their parents. ODP/TAMU personnel, shipboard scientists, and shorebased investigators accessing Janus online, will have to learn how to use this powerful research tool. Entering data into Janus is one thing, getting data out, and in a useful manner, is another thing, but that's where the power of a relational database becomes apparent. ODP/TAMU is rapidly providing reporting tools for easy access to Janus data. These reports provide simple steps for a shipboard scientist to pull data from Janus, in a relational fashion (e.g., "give me all the weight percent carbonate data and the dry density data from Miocene intervals drilled in the Atlantic at water depths between 3 and 3.3 km"). Currently, ODP/TAMU is developing reports using Java-based scripts that directly query the database. The most intriguing interface being examined at this moment is using JanusWeb/Netscape, a web browser approach.

Stay tuned. We'll provide a Janus update in the next issue of this newsletter, focusing on digital images, visual core description, and other developments from the toddler phase.

Fluid sampling in basement boreholes: Facts and prospects

contributed by Joris M. Gieskes

Joris Gieskes is Professor of Oceanography at Scripps Institution of Oceanography. He is an avid sea-goer on drillships (Legs 15, 25, 35, 64, 92, 102, 110, 131, 152, 169) or any other ships, particularly those on the Quixotic Quest for borehole fluids.

In memory of Marcus Langseth whose visions have led to many innovations in oceanic borehole science.

Introduction

Scientific interest in fluid circulation through marine sediments and oceanic crust has increased significantly during the past 20 years as researchers have realized that flowing water plays an essential role in global geochemical cycles and geothermal budgets. Perhaps the most spectacular example of flow is hydrothermal circulation associated with the creation of new oceanic crust. This flow results in the expulsion of hydrothermal fluids at ridge crests affecting oceanic mass balances of the elements to a significant degree. Scientists now know that hydrothermal fluid flow through off-axis basaltic basement continues for periods of time that can span well over 20 million years. This interpretation is based on measurements of heat flow anomalies and on changes in the geochemistry of pore fluids in the overlying sediments.

Despite this recent recognition of the importance of fluid circulation, recovery of liquids from active circulation systems has generally been hampered by our technological inability to retrieve *in situ* formation fluids directly from the sediments and basalts. Most of the fluid samples recovered from sediments are obtained shipboard, by squeezing pore waters from core samples. The only *in situ* sampling methodology currently possible, and only in soft sediments, is by means of the Water Sampling Temperature Probe (WSTP) (e.g., Barnes [1988]). *In situ* recovery of formation fluids has been difficult to impossible in basaltic basement, or in harder sediments, with low porosities (< 30%) or characterized by fracture porosities.

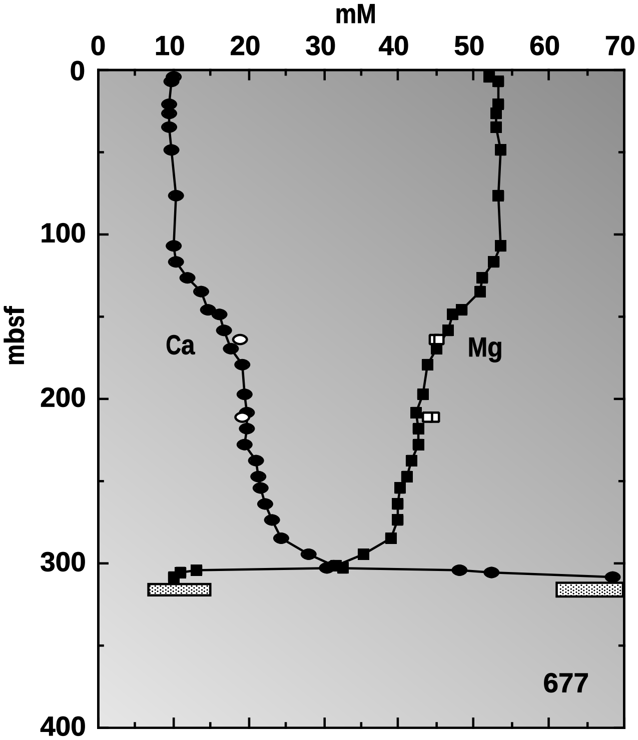

Fig. 1: Pore water chemistry at Site 677 on the Costa Rica Rift Flank. Curvature at 180-200 mbsf is probably due to lateral advection of fluid. Near basement change in calcium and magnesium concentrations, just below 300 m, are the result of diffusive exchange with fluids circulating in the top of basement. Hatched boxes indicate depth of basement.

Accurate estimates of chemical exchange between the ocean and the basaltic basement depend on direct measurements of basement formation fluids. Until such measurements are accomplished by borehole reentry techniques, as discussed below, we will continue to rely on the indirect information extracted from the pore fluids from the overlying sediments.

Fluid sampling in oceanic crust through borehole reentry

The challenges of sampling of fluids in basement and in sedimentary rocks were discussed in detail during a JOI/USSSP sponsored workshop, “Science Opportunities Created by Wireline Reentry of Deep Sea Boreholes” [*Langseth and Spiess*, 1987]. Workshop participants considered two modes of sampling: “active,” which involves the use of packers that isolate a portion of the borehole and directly sampling formation fluids (e.g., by suction into an evacuated chamber); and “passive,” by sampling and analyzing “open” borehole fluids and indirectly inferring the nature of *in situ* basaltic formation waters. Although several Deep Sea Drilling Project attempts were made to sample actively in Hole 504B on the Costa Rica Rift, all efforts failed to recover true formation fluids [*Mottl and Gieskes*, 1990]. Since the beginning of the ODP, only passive sampling has been attempted during borehole reentries, whether from *JOIDES Resolution* [*Magenheim et al.*, 1992, 1995; *McDuff*, 1984; *Mottl and Gieskes*, 1990; ODP Legs 168 and 169], or from tools lowered from other platforms [*Gable et al.*, 1992; *Spiess et al.*, 1992].

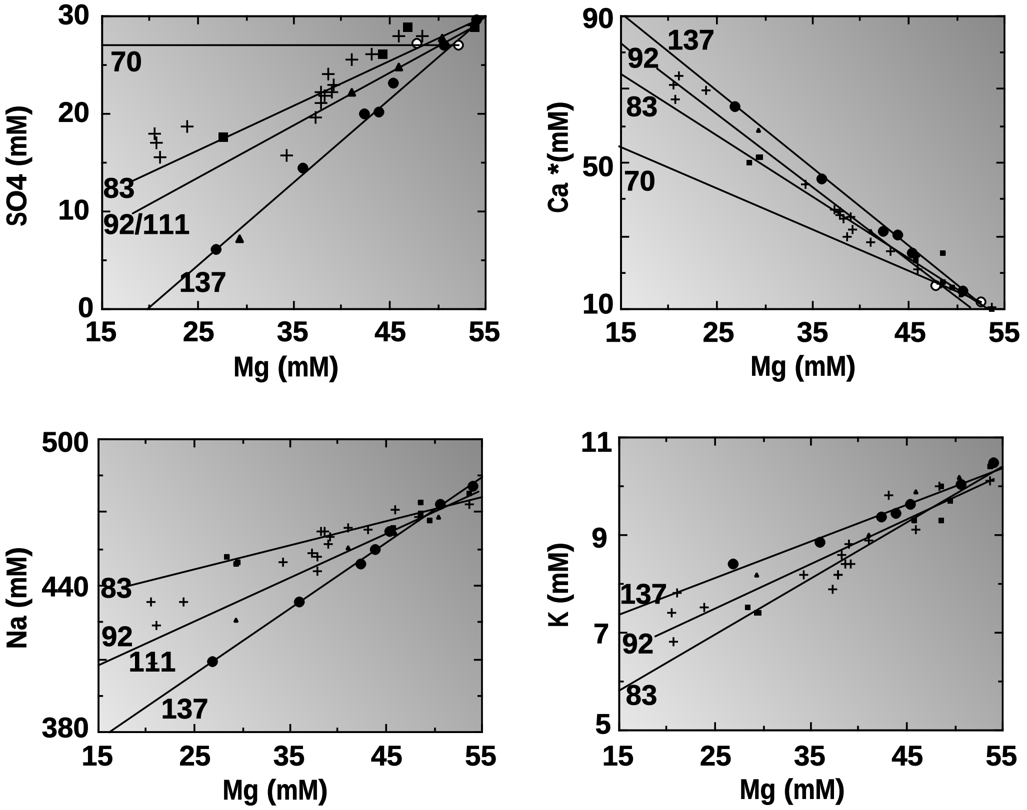

Fig. 2: Comparison of element vs. Mg mixing lines of borehole fluid components from Hole 504B [c.f., Magenheim et al., 1995]. Trends towards lower Mg concentrations (perhaps to zero concentration) are expected in hydrothermal interactions. Note the progressive changes in Na+ (larger decreases as the bottom of the hole gets hotter) and K+ (smaller decreases with increasing temperatures). Observations are compatible with experimental data of Bischoff and Seyfried [1978] and Seyfried and Bischoff [1979]. Numbers refer to drillings legs dedicated to re-entruies of Hole 504B. Temperatures at bottom of the hole: Leg 70: 80°C; Leg 83: 112°C; Leg 92/111: 145°C; Leg 137: 162°C. Ca* indicates calcium concentration corrected for calcium sulphate precipitation.

One of the major scientific objectives of subsurface fluid research has been to establish the nature of fluid flow through ocean crust basaltic basement. In practical terms, this requires representative sampling from a borehole. Nevertheless, the act of drilling a hole for access, ends up perturbing the very system we wish to study, and this introduces a series of complications that must be accounted for. Among these are: flow into the formation as a result of underpressure in the upper part of basement as a result of cracking of the formation during cooling (prior to drilling); mixing in the hole caused by thermal and physical instabilities; and mixing downhole caused by the lowering of large instrument packages into the hole. Undaunted, I press on, and present here a summary of results that were obtained from the Costa Rica Rift region. Fluid flow in the upper reaches of basement in Hole 504B was inferred from heat flow values that were lower than expected [*Langseth et al.*, 1988] and from pore water variations in dissolved calcium and magnesium (Figure 1) from nearby Site 677 [*Mottl,* 1989].

Unfortunately, the upper part of basement at Hole 504B has a history of accepting inflow of bottom water down the hole and mixing with the *in situ* waters. This precluded us from sampling pristine basement formation waters, which we expect will have a composition that is markedly different from abyssal waters, based on the pore water profiles observed at nearby Site 677 (Figure 1).

On an encouraging note, borehole fluid samples from deeper portions of Hole 504B did indeed show substantial changes in composition. Progressive trends in chemical composition were observed from deeper samples during revisits to extend the drillhole [*Mottl and Gieskes,* 1990; *Magenheim et al.,* 1995]. Examples of these trends are presented in Figure 2. Because downhole gradients are disturbed, e.g., through sampler problems, downhole mixing, trends versus the concentration of magnesium are used for comparative purposes (e.g., Magenheim et al. [1995]). The progressive trends in the geochemical changes are attributed to alteration of basaltic rubble in the bottom part of the hole at increasing temperatures. Potential fluid exchange with formation waters at the extremely low porosities of the deeper parts of the hole are considered unimportant.

Despite the problem of seawater flowing into many open drillholes (this has been observed in Holes 333A, 395A, 396A, 504B), there have been cases where water has been found to be flowing up, out of the holes, e.g., Hole 858G in the Juan de Fuca Ridge Area [*Davis and Becker,* 1994]. A major problem in high temperature holes, however, has been the partial functioning of downhole water samplers under extreme conditions of temperature and pressure [*Lysne,* 1991; *Magenheim et al.*, 1995]. This became apparent during a recent reentry attempt of Hole 858G during ODP Leg 169, in which case fluids flow upward from the basement with temperatures as high as 272° C (c.f., Zierenberg et al. [1996]). Therefore, the development of appropriate downhole water samplers remains a priority.

The principal question to be addressed by the fluid sampling program remains: “Can geochemical evidence be gathered on exchange processes between formation waters and borehole fluids, which indicate the chemical composition of formation fluids and the processes that have led to these compositions?” Results obtained hitherto have been tantalizing, but a much more systematic approach will be necessary to obtain information on geochemical processes occurring in areas where fluid processes are considered to be of primary importance.

The next opportunity for wireline borehole reentry will be in the OSN-I Hole off Hawaii in late 1997/early 1998. Both downhole logging and fluid sampling will be carried out.

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ODP’s Greatest Hits

ABSTRACT VOLUME

JOI/USSSP is pleased to announce that well over 85 abstracts have been received for the “ODP Greatest Hits” volume. Many thanks to those who took the time to submit their abstracts. This volume should prove a valuable asset in the renewal process for scientific ocean drilling. It will be available to all for free upon publication.

A list of the abstract authors and titles has been placed on the JOI web site at http://www.joi-odp.org/joi/usssp/greathits/abstracts1.html. Please take the time to look at the list and give us your opinion on the volume contents — if you have any comments, contact the JOI/USSSP Director, Ellen Kappel, at ekappel@ brook.edu. We expect the volume to be completed in June.

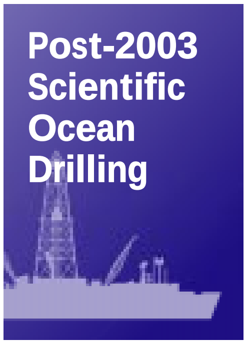
Ocean drilling's future grows from COMPOST-II

The natural rhythms of Earth's climate, plate motions, and volcanism vary on a variety of timescales; understanding the reasons for such changes poses an urgent challenge. Ocean drilling, used to confirm the theory of plate tectonics and to document changes in ocean circulation and climate, is now also needed as part of a larger global strategy to solve pressing problems facing humankind. The Deep Sea Drilling Project (DSDP), the International Phase of Ocean Drilling (IPOD), and the Ocean Drilling Program (ODP) together span more than a quarter century of scientific achievements that are impressive by any standard. Through scientific ocean drilling, paleoceanographers have begun to document changes in the ocean's carbon budget, oscillations in rates of formation, depth of penetration, and chemistry of deep water masses, and abrupt shifts in climate response to orbital forcing. ODP has drilled into active hydrothermal systems in the oceanic crust, where volcanic- and sediment-hosted sulfide mineral deposits are forming, to provide insight into the development of these deposits which may aid in land-based mineral exploration efforts. In subduction zones, drilling scientists are using innovative techniques to understand processes of rock deformation and the role of fluids in faulting and seismicity. Most recently, ODP has uncovered spectacular evidence of the cataclysmic meteorite impact that may have led to the demise of the dinosaurs at the end of the Cretaceous. Yet, unraveling phenomena such as long-term ocean and climate change and the nature of the deep oceanic lithosphere (which comprises more than half of Earth's surface) will require a global observational framework and new technological developments. We must take a more expansive, ambitious approach to ocean drilling for study of many of the active geologic processes, like earthquakes, volcanic eruptions, and sea-level changes that will help to shape the future of humankind on Earth.

RECOMMENDATIONS

The scientific objectives envisioned by the U.S. community for the 21st century, as outlined in the 1993 National Research Council (NRC) report entitled "Solid-Earth Sciences and Society," the 1996 JOIDES Long Range Plan (LRP), and other recent scientific planning documents (many of which are summarized in this report), can only be addressed through an integrated approach, of which a drilling program is a critical component. Accordingly:

1. COMPOST-II, acting on behalf of the U.S. community, affirms its commitment to a new international scientific ocean drilling program post-2003 to solve outstanding scientific problems of a global nature.
2. COMPOST-II thinks that scientific ocean drilling in the 21st century must be defined more broadly, to include predrilling site assessment, drilling and sampling, and post-drilling observations and experiments. Scientific ocean drilling represents a cascade of diverse activities and investments, from the formulation of scientific hypotheses to post-drilling analysis, integration and publication. If the U.S. community is to participate fully in an enhanced scientific ocean drilling program, we must expand and integrate:
    - site-appropriate predrilling characterization (e.g., high-quality 2-D and 3-D geophysics, piston coring, multibeam bathymetry and side-scan sonar, submersible/ROV characterization of the seafloor, etc.);
    - post-drilling utilization of boreholes for observation, monitoring, and testing of active processes and studies of whole-Earth structure; and
    - post-drilling support of scientific experiments and personnel, which results in data synthesis and formulation of new hypotheses.
3. COMPOST-II endorses the LRP multi-platform approach to the accomplishment of U.S. scientific objectives. This will require a capability to drill and sample in water depths from the beach to the abyss, including:
    - complete recovery of continuous, undisturbed, high-sedimentation-rate sections across a diverse suite of geologic environments and ages;
    - improved recovery and penetration of difficult-to-sample lithologies (e.g., young, fractured basalts) and geologic environments (e.g., overpressured sections); and
    - new capability to reach subseafloor depths in excess of 2 km.
4. COMPOST-II recognizes that the U.S. community remains committed to investigator-driven science. While 21st century scientific ocean drilling will often be allied with major geoscience initiatives, JOIDES or its succeeding advisory structure must be responsive to new ideas from individuals as well as from these collectivized efforts.
5. COMPOST-II supports education and outreach programs that aim to advance the understanding of earth processes through drilling-related efforts for K-12, undergraduate and graduate learning programs. Specific efforts include:
    - CD-ROM and web-based learning exercises;
    - distinguished lecturer series, with integrated earth-studies opportunities seminars; and
    - private, public, and industry-sponsored fellowships to advance exceptional masters and doctoral candidates.
6. COMPOST-II encourages development of active partnerships with diverse sectors of the U.S. business community (e.g., petroleum, computing, communications), which will focus on direct participation in scientific ocean drilling:
    - as proponents of drilling proposals;
    - through industry funding of drilling- and science-related activities;
    - by means of data exchange for site augmentation, drillsite design, etc.; and
    - through cooperative development and testing of new technologies.



This article was reprinted from the Executive Summary of the COMPOST-II draft report.

COMPOST-II, the U.S. COMmittee to Consider POST-2003 Scientific Ocean Drilling, met in Miami, Florida, on February 16-17,1997. COMPOST-II was tasked with defining the role ocean drilling will play to help fulfill the scientific objectives envisioned by the U.S. community for the 21st century. COMPOST II is a USSAC Subcommittee.

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NSF asks U.S. community to assess future needs

Contributed by J. Paul Dauphin, Associate Program Director, NSF/ODP

As I write this article, spring has arrived in Washington, and the cherry trees are about to go through their annual transformation, bursting into bloom. ODP has also been undergoing a major transformation in preparation for Phase III (1998-2002), including a restructuring of the JOIDES advisory structure and a major reorganization of ODP at Texas A&M University. There is a sense of renewed vigor, enthusiasm, and challenge associated with these changes. The hope is for a Program that will more efficiently deliver the exciting science envisioned in the 1996 ODP Long Range Plan (LRP).

The February 1997 meeting of the international ODP Council, our international partners expressed optimism that the decision to continue participation in ODP for the next five years would be a positive one. They will provide official notification this summer when the Council meets again.

Well it’s official, not that we expected anything different, but renewal of the U.S. Science Support Program (USSSP) for ODP has been approved by NSF’s National Science Board (NSB) for another three-year period. The NSB was very enthusiastic about the USSSP, and ODP in general. As I stated in an earlier article, the NSF blue ribbon panel which reviewed the USSSP, prior to seeking NSB approval, also had very positive comments to make about the USSSP. Much of the credit for the success of the USSSP lies with the efforts of the U.S. Science Advisory Committee (USSAC) and in particular to the hard work and dedication demonstrated by Ellen Kappel as the Program Director at JOI.

In the previous newsletter, I said that I would provide some details in this newsletter on FY 97 funding levels for the USSSP, the ODP and the Division of Ocean Sciences at NSF. These can be viewed in the table below. The USSSP is funded at the level of $5.65 million for FY 97, an increase of 5.6% over FY 96. Part of this increase is intended to fund participation of U.S. scientists attending the Conference on Cooperative Ocean Riser Drilling (CONCORD) workshop this July in Japan (see the ad on page 12). This workshop is one of many steps towards developing a scientific ocean drilling program for the year 2003 and beyond.

NSF - OCEAN SCIENCES DIVISION

	Actual FY 96 $M	Current FY 97 $M	Requested FY 98 $M
Ocean Science Research	**106.5**	**109.3**	**112.2**
Oceanographic Facilities	**47.5**	**52.3**	**52.3**
Ocean Drilling Program	**39.6**	**40.3**	**41.8**
Ocean Sciences Division	**193.6**	**201.8**	**206.2**

NSF - OCEAN DRILLING PROGRAM

	Actual FY 96 $M	Current FY 97 $M
Operations and Management	**27.7**	**27.4**
U.S. Science Support Program	**5.4**	**5.7**
Unsolicited Proposals	**6.0**	**5.9**
Other Foundation Activities	**0.5**	**1.3**

Another crucial step, in preparation for the future, was taken by USSAC at NSF’s request. NSF asked USSAC to assess the needs and expectations of the U.S. scientific community for scientific ocean drilling beyond 2003. A subcommittee of USSAC prepared a report (COMPOST II) which USSAC is revising prior to its delivery to NSF. This report will be published on the world wide web and widely available to anyone wishing copies. The draft Executive Summary of this document is printed

POSITION AVAILABLE

Associate Program Director, Ocean Drilling Program/National Science Foundation

NSF's Division of Ocean Sciences is seeking qualified applicants for the position of Associate Program Director in the Ocean Drilling Program. This position will be filled under the Intergovernmental Personnel Act (IPA) in the spring/summer 1997. IPA applicants must be permanent, career employees of their current employer for at least 90 days prior to entering into a mobility assignment agreement with a federal agency. Duration of the assignment is one year, although it may be extended for a second year. Reimbursement of salary and other related costs are negotiated between NSF and the individual's institution.

The Associate Program Director has primary responsibilities which involve proposal evaluation, project development and support, program planning and budgeting, and related administrative duties.

Applicants for this position must have a Ph.D. or equivalent experience in marine geology or geophysics or a related disciplinary field. Four or more years of research experience beyond the Ph.D. and a broad understanding of the current status of the relevant U.S. academic scientific community and its relationship with NSF, other federal agencies, and international planning efforts are also required. Previous involvement with ocean drilling would be an advantage, but is not required.

Interested applicants must submit a letter of recommendation and a curriculum vita to the National Science Foundation, Division of Human Resource Management, Attn: Catherine Handle, 4201 Wilson Blvd., Suite 315, Arlington, VA 22230. For technical information, call Dr. Bruce Malfait, Ocean Drilling Program, (703) 306-1581. Hearing-impaired individuals should call TDD at (703) 306-0189.

NSF is an equal opportunity employer committed to employing highly qualified staff that reflects the diversity of our nation.

on page 19 of this newsletter. When this document is published we strongly encourage comments and suggestions from the scientific community, so that we may develop, as accurately as possible, an understanding of the needs and rationale for future scientific ocean drilling.

At a December 1996 meeting in Ashland, Oregon, sponsored by NSF, a representative cross section of the marine geosciences met to discuss the "Future of Marine Geosciences" (FUMAGES). One conclusion which emerged from this group was that scientific ocean drilling figured prominently in most visions of the future. The need for multiple drilling platforms was very clear. Some segments of the community felt that a continuing need for a platform, like the *JOIDES Resolution*, which allows them to take long cores from a variety of environments, would be essential. The solid earth groups expressed a need for a vessel with riser-type capabilities that would allow them to sample generally inaccessible lithologies, to control hole stability, and to drill deep holes.

At the February 1997 meeting of ODP's Executive Committee, our Japanese colleagues reported on developments with their proposal to build a riser-drilling vessel to augment international scientific ocean drilling in the future. Consonant with that proposal and the LRP, we are pursuing the funding and commitments required for a two ship program in which Japan and the U.S. would be equal partners. In addition, NSF and Japan have agreed to work together in seeking additional partners for the future program.

On a different matter, we have reopened the search for a rotator in the Ocean Drilling Program at NSF (see the ad above). If you qualify and think you would like to experience the Washington scene, or if you know of anyone who might be suited to this position, let us know.

A letter from the Chair

ODP's latest and greatest hits

Dr. Roger Larson is Professor of Marine Geophysics, Graduate School of Oceanography, University of Rhode Island.

The last few times I wrote here it was on organizational matters, such as including non-JOI representation on PCOM/SCICOM and my "two cents worth" on the new JOIDES Advisory Structure. Furthermore, USSAC, as the U.S. "national committee" for JOIDES, spent the majority of our last meeting selecting U.S. representatives for the new Advisory Structure, a job that previously was relinquished to PCOM. All of this has temporarily bored me with organizational matters, and I would rather return to the science itself. Bruce Heezen once told me that ODP (then DSDP) was an organization that got science done, while JOIDES was an organization that kept science from getting done. Well, that's a bit extreme, but Bruce cared only about the science, and had no interest in committee memberships or organizational wiring diagrams. In that spirit then, let's have a look at ODP's latest and greatest scientific hits.

We won't have far to look. Last month, Leg 171B returned from the Blake Nose off South Carolina where they recovered three spectacular sections of the K/T boundary by APC/XLB coring only 180 m deep into the section (see p. 24 of this newsletter). In true Bruce Heezen fashion, this happened by serendipity, and not as a planned major leg objective. To quote Jim Ogg who was onboard, "Our coring of the K/T boundary yielded a spectacularly complete and superbly preserved dramatic record of the impact event. Shock wave, 15 cm of glass spherules, fallout dust layer, Strangelove ocean — a museum-quality illustration of the death and destruction." Jim wasn't exaggerating; the Smithsonian is interested in the possibility of publicly displaying one of these sections.

Off the west coast of the U.S. last Fall, Leg 169 scientists opened two new hydrothermal vents with the drillstring, thus reactivating a dormant hydrothermal system on the Juan de Fuca Ridge. This gives us the unprecedented opportunity in future years to study the hydrological evolution of a deep-sea vent system from inception, with its attendant mineralization and biological evolution. The latter will be of great interest in learning how deep-sea vent communities are colonized, somewhat like the coral colonization studies of World War II ships sunk in Truk Lagoon in 1942. The mineralization studies can be benchmarked with the discovery of huge, ore-grade deposits of iron, copper, zinc and other heavy metals associated with other vents.

But we all know ODP is no "flash in the pan" operation. Solid, broad-based, global science has always characterized scientific ocean drilling, maybe due in part (even Heezen might admit) to panels and committees reviewing proposals and planning ahead. In preparation for the U.S. renewal of ODP from 1998 through 2002, JOI is publishing a volume of "ODP's Greatest Hits," a compendium of illustrated, one-page abstracts suitable for consumption by NSF's National Science Board. I first worried that this would fall far short of the Top 40 Tunes on my country radio station, but the list has now grown to over 85 abstracts, and about 20 more are promised. They document how ODP has recovered unique evidence for scientific phenomena ranging from the Pliocene onset of glaciation to Paleocene global warming to Cretaceous large igneous provinces. Hydrothermal circulation through mid-ocean ridges and their flanks is as pervasive as cyclostratigraphy throughout the sedimentary record. This volume will be a real measure of the strength and diversity of the Program, and recalls to me a remark by Orville Wright: "Isn't it astonishing that all these secrets have been preserved for so many years, just so that we could discover them."

Roger

Roger L. Larson
Chairman, USSAC

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***USSAC Executive Committee**

Membership term is three years.

Fall 1997

MEMBERSHIP ROTATION

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David Naar, USF
Lisa Tauxe, Scripps

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Roger Larson*
Jim Ogg
Bernd Simoneit

*** Mike Arthur will take over the USSAC Chairmanship from Roger Larson.**

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JOI/USSAC
NEWSLETTER
Joint Oceanographic Institutions, Inc.
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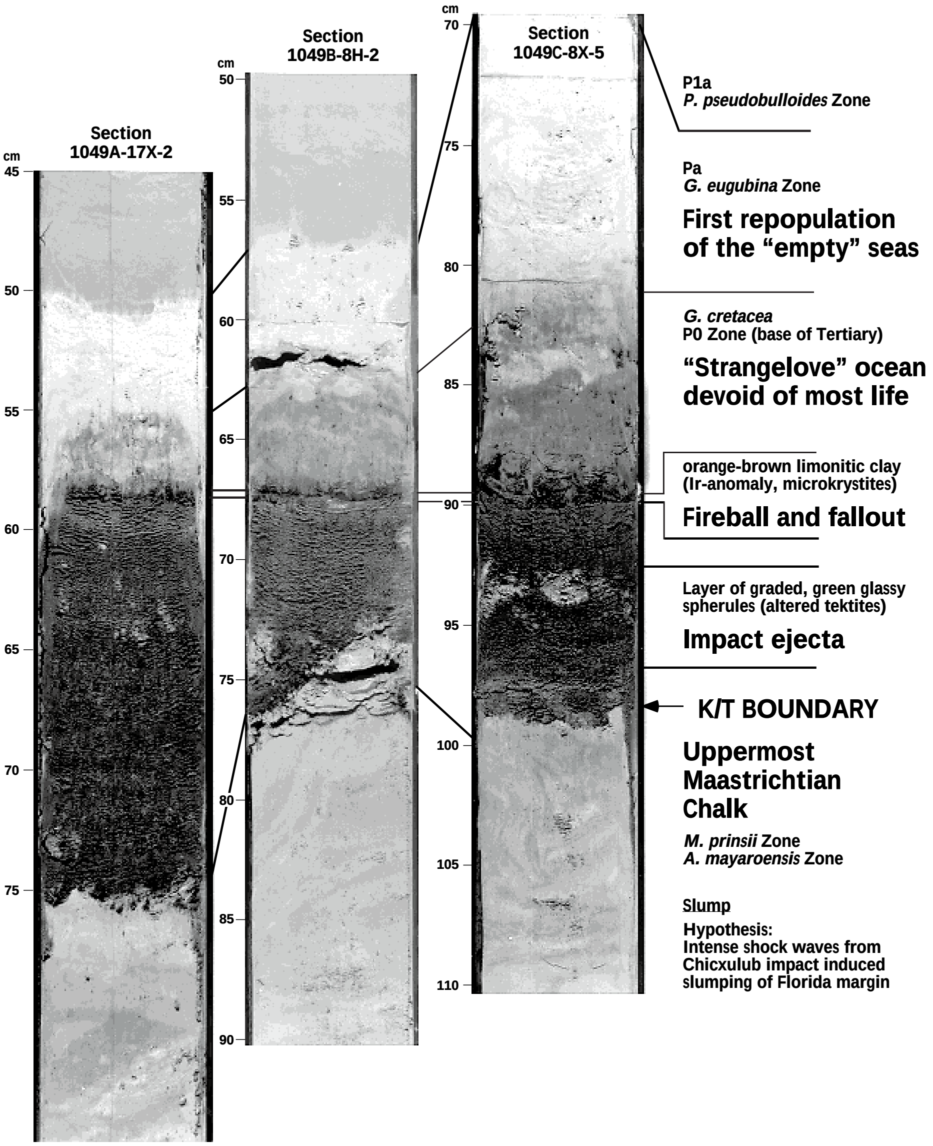
Meteorite impact at Cretaceous/Tertiary boundary (~65 Ma)

Cores from Atlantic margin of Florida (ODP Leg 171B)



Photograph and interpretation of three cores spanning the K/T boundary provided by the Ocean Drilling Program Leg 171B shipboard scientific party. The ODP press release quotes Co-Chief Scientist, Dr. Richard Norris (WHOI), as saying, "We recovered three cores spanning the last 65 million years that include not only a fantastic record of the meteorite's impact and resultant debris that was blasted into the upper atmosphere, but also a 2 to 4 inch thick sedimentary record of global repopulation of microorganisms in the ocean during that time period." Dr. Dick Kroon (University of Edinburgh), the other Co-Chief, commented that the highly disturbed sediments immediately below the debris layer "could be a result of an impact-related earthquake. We envision a massive tidal wave breaking over the Florida platform and stirring up enormous quantities of sediment along the Atlantic seaboard."

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