JOI/USSAC NEWSLETTER

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Mysteries of the Palmer Deep Revealed: ODP Leg 178 to the Antarctic Peninsula

contributed by Eugene W. Domack and the Leg 178 Scientific Party

The Antarctic Peninsula was the first region of the polar continent to be explored. This landmass of 165,000 km^2 juts—like a crooked finger—north of the main continent towards South America and the Drake Passage which separates the two continents (Figure 1). The Antarctic Circle divides the peninsula into northern and southern regions named Graham Land and Palmer Land, respectively. Nathaniel B. Palmer was an American captain who some claim was the first person to see the Antarctic mainland in 1820 when exploring for seal rookeries. Today, a U.S. Antarctic research base (Palmer Station) and a research vessel (*N.B. Palmer*) also bear his name. A relatively small, but deep bathymetric depression was discovered in the region during early hydrographic surveys of the coast. It was informally named "Palmer Deep" due to its proximity to Palmer Station (Figure 1; *Kirby et al., in review*).

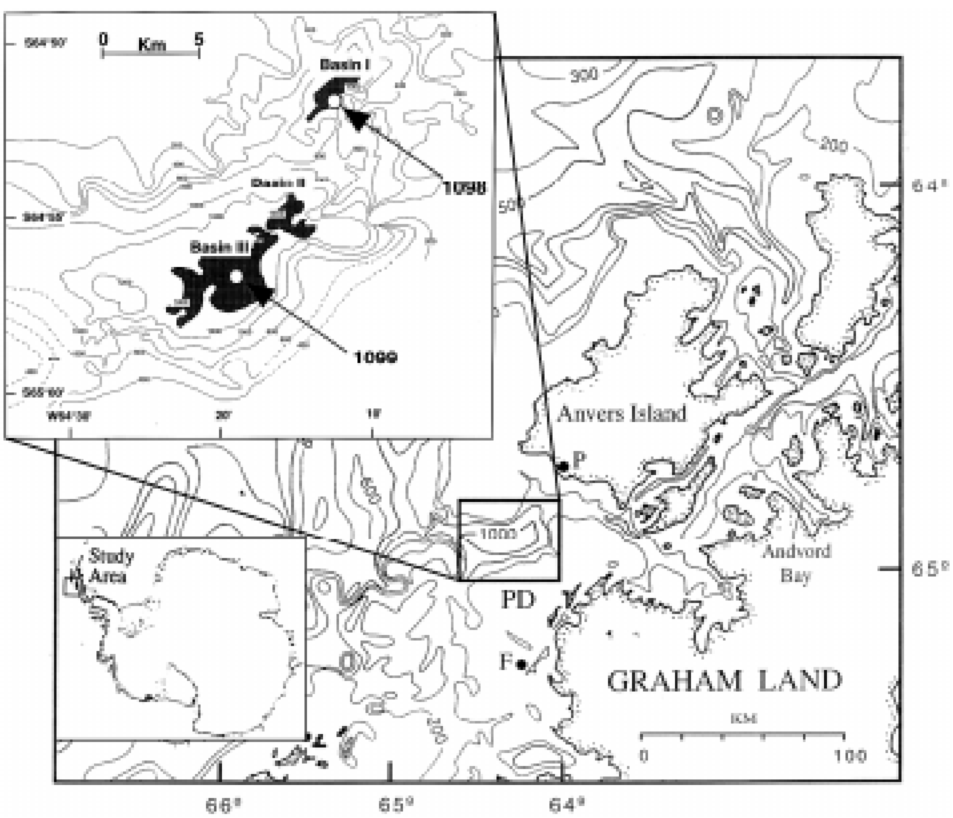

Fig. 1: Location of the Palmer Deep (PD) on the continental shelf of the Antarctic Peninsula. Locations of Palmer Station (P) and Faraday Station (F) are also shown (after *Leventer et al., 1996*). Inset shows details of the Palmer Deep in depth contours of 200 m and locations of Sites 1098 and 1099.

Palmer Deep is similar to other inner-coastal depressions found along the passive margins of the Antarctic continental shelf in that all are thought to be overdeepened by glacial erosion (*Anderson, in press*). This one, however, is unique because active, normal faulting has accentuated the preservation of an unusually thick section of unconsolidated sediments (Figure 2; *Rebesco et al., 1998*). The Palmer Deep consists of three separate depressions creatively dubbed Basins I, II, and III. Each of these has different sill and bottom depths, thus

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providing a variety of natural sediment-trap basins in a region of contrasting seasonal productivity and sediment flux (*Ross et al., 1996; Smith et al., in press*).

The Antarctic Peninsula is a transitional environment in the glacial climatic system because summer temperatures are warm enough to generate significant surface meltwater. Recent focus upon the disintegration of Antarctica's floating ice masses (ice shelves) has demonstrated the peninsula's key role in understanding the context of potential global warming in the southern continent (*Vaughan and Doake, 1996*). The peninsula's northward reach brings it into close proximity to the Antarctic Convergence making it a prime place to search for paleoceanographic changes which may have global consequences (*Broecker, 1997*). As a significant barrier to the powerful westward flow of the Antarctic Circumpolar Current, the region is important for understanding past changes in this current system—especially because such changes reflect interactions between the South Pacific and Atlantic Oceans.

For these and other compelling reasons, two sites were cored in the Palmer Deep from February 14 to April 11, 1998, during the Ocean Drilling Program's (ODP) Leg 178 (*Barker et al., in press*). Other Leg 178 objectives included studying the glacial/interglacial stratigraphy of thick sedimentary drifts along the base of the continental slope to rise as well as the glacial deposystems preserved along the edge of the continental shelf.

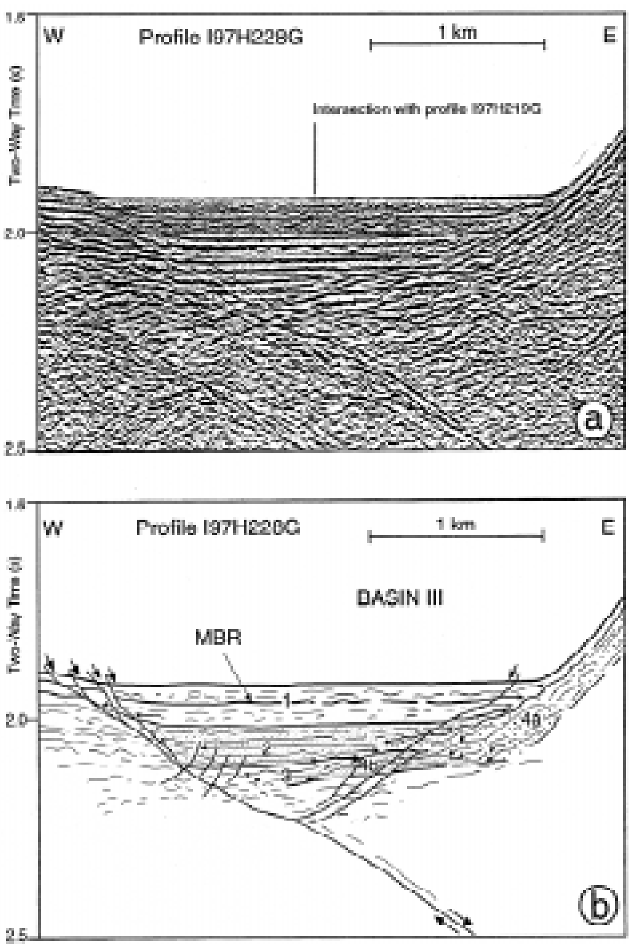

Fig. 2: (a) Seismic line across the Palmer Deep basin collected using a GI gun and single channel system. The section has been migrated using seawater velocity. (b) Line drawing of (a). After Rebesco et al., (1998).

Holes 1098A-C are located in Basin I and from them was recovered an ultra-high-resolution record of Holocene biosiliceous mud and ooze of pelagic/hemipelagic origin; Holes 1099A and B are located in Basin III to intercept the deeper, potentially older, stratigraphy within a turbidite-dominated deposystem (*Kirby et al., in review*). The following paragraphs discuss the results of this drilling which open up a new realm in the exploration of the Antarctic margin for high-resolution paleoclimate records.

Basin I, Site 1098

Site 1098 was triple APC cored to a depth of about 50 mbsf (Figure 3) where penetration was halted by compacted glacial diamicton. The diatomaceous mud/ooze recovered from the hole represents the most complete, highest resolution record of the Holocene for the entire Southern Ocean. The dominantly laminated character of this section portends great potential for season-by-season assessment of paleoproductivity. Previous studies in the basin suggest that an excellent radiocarbon chronology can be developed and tested against a marine varve sequence for at least part of the section (Figure 3; *Leventer et al., 1996*). Serious limitations of the radiocarbon method encountered in the Antarctic paleoenvironmental record may be solved, in part, by the detailed radiocarbon analyses planned for these cores. Of additional interest is the century-scale variation in paleoproductivity previously recorded in the sedimentary record (*Domack et al., 1993; Leventer et al., 1996*). Of intrigue is the observation that these cycles are quite similar to paleo-enviromental records from the Greenland Ice Core Project (GISP2), which record century- to millennial-scale changes in atmospheric circulation of near-identical character to the Palmer Deep sediment cores (*Domack and Mayewski, in press*).

Shipboard and shorebased investigators plan a coordinated study on these cores in order to extract the most information possible from the Palmer Deep record. So far, it appears that the predictions for the utility of this record are being surpassed, and we are only in the earliest stage of the analyses. The magnetic susceptibility (MS) record provides a first look at the potential of the cores (Figure 3) and demonstrates five major divisions related to:

- glacial deposition (very high MS),
- ice proximal varved record (alternating thin cycles of low and high MS),
- a re-advance section of mixed siliciclastic-biogenic ooze turbidites ("fining upward" MS intervals),
- a middle Holocene productivity maximum (laminated interval of very low MS) and,
- the Late Holocene neoglacial section (high but variable MS).

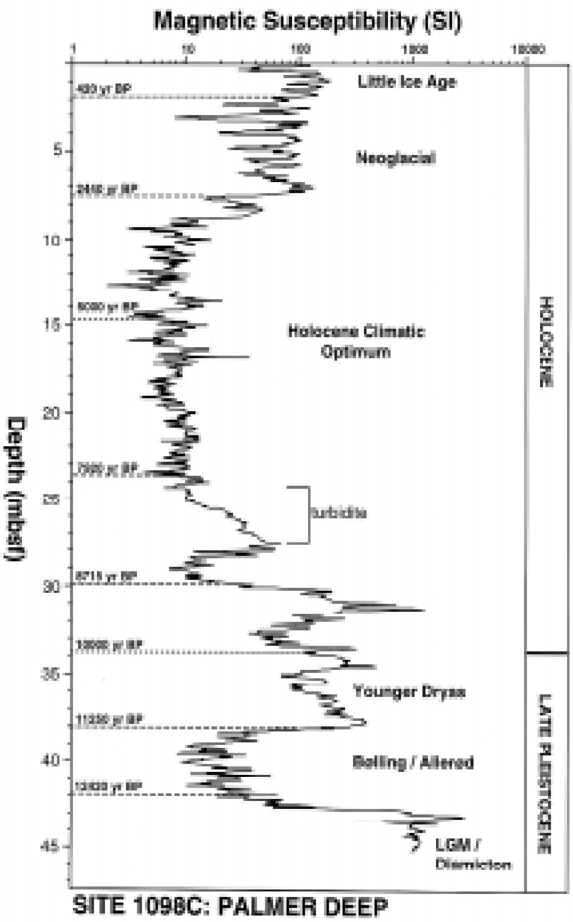

Fig. 3: Magnetic susceptibility record of Site 1098, Hole C with climate intervals identified based upon preliminary timescale. Depths are approximately the same for Holes A and B.

The excellent preservation of biogenic phases throughout the cores (near absence of organic carbon degradation) suggests that it will be possible to develop detailed productivity proxies for comparison to results of decades-long monitoring of the regional ecosystem (*Ross et al., 1996*). In addition, the clear varve-stratigraphy in the lower two thirds of the section (Figure 4) will allow us to resolve interseasonal variations in the productivity signal (*Leventer et al., 1998*) for time spans of thousands of years—a first for the Southern Ocean.

Basin III, Site 1099

Two holes were APC cored at Site 1099 to a combined depth of about 108 mbsf. The objectives here were to intercept deeper seismic reflectors (Figure 2) in order to test the working hypothesis that sediments within Basin III represent pre-Last Glacial Maximum deposition (*Kirby et al., in review; Rebesco et al., 1998*). While nearly 150 m of unconsolidated section remains below, unsampled within the basin, the results of shipboard paleontology suggest that the entire recovered section of 108 m can be correlated to the 50 m of section recorded at Site 1098. Expansion of the Site 1099 section is due to several thick sedimentary gravity flows (mud turbidites) that occurred near its base. One of these is approximately 30 m thick, a remarkable slab of diatomaceous mud and ooze that surpasses turbidite intervals on the largest of submarine fans. Subsequent radiocarbon analyses confirm the temporal match of the sections between Sites 1098 and 1099. Because of the underlying uncored section, several hypotheses remain untested. The mechanism for generating the thick sediment gravity flows and precise correlations between Sites 1098 and 1099 will be addressed in ongoing studies.

Summary

Differences in the sediment's diagenetic character between Basins I and III, as noted by shipboard investigators, provide additional focus for future study. For example, diagenetic ikaite recovered at Site 1099 is consistent with earlier reports of this hydrated calcium carbonate occurring in the deep, organic-rich muds of the Antarctic margin (*Suess et al., 1982*). Differences in organic carbon preservation also exist between the two sites, including the almost unaltered preservation of organic matter in the upper 20 m of Site 1098.

The results from Palmer Deep will eventually be compared to similar records from prior and future ODP drilling in places such as the Saanich Inlet, Santa Barbara Basin, and Cariaco Basin. Other Antarctic marginal sites have been proposed for future drilling in order to evaluate circumpolar variations in Holocene paleoceanography.

First Author:

Eugene Domack is an Associate Professor at the Dept. of Geology, Hamilton College.

References:

Anderson, J.B., *Antarctic Marine Geology*, Cambridge University Press, in press.

Barker, P. F., P.J. Barrett, A. Camerlenghi, A.K. Cooper, F.J. Davey, E.W. Domack, C. Escutian, Y. Kristoffersen, and P.E. O'Brien, Ice sheet history from Antarctic continental margin sediments: the ANTOSTRAT approach, *Terra Antarctia*, in press.

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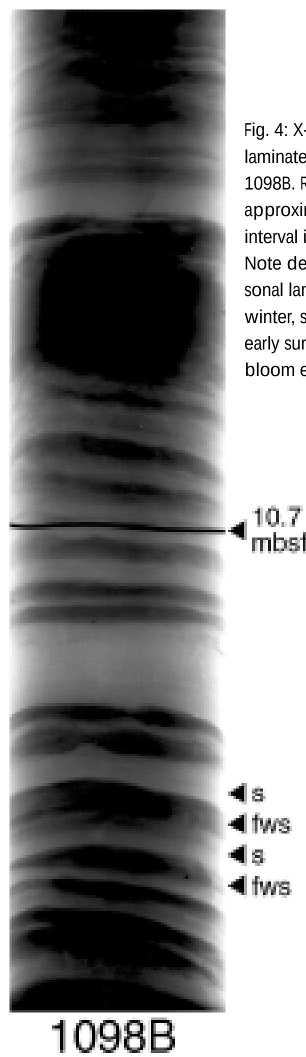


Fig. 4: X-ray radiograph of laminated intervals in Hole 1098B. Refer to Figure 3 for approximate location of the interval in the MS record. Note designation of seasonal laminations as fall, winter, spring (FWS) and early summer diatom bloom event (S).

DRILL BITS

NEW! SHIPBOARD STUDENT TRAINEE PROGRAM

An exciting and unique program is being developed by ODP to provide undergraduates with exposure to, and training in, a variety of scientific and technical activities onboard the drillship, *JOIDES Resolution.* The responsibilities of the student trainees will be defined by a shipboard mentor, in consultation with the co-chief scientists, lab officer, and trainee. Duties will depend on the trainee's background, experience, and interests, but can include assisting the shipboard scientists with laboratory work and processing sediment and rock cores. Opportunities will be few but will be available to all members of the ODP. When the program is ready for implementation, nominations for U.S. students to participate as trainees will be submitted to JOI/USSSP, in response to requests published in this newsletter, on our web site, and elsewhere. Trainee positions will be available on an opportunity basis, and will not displace any scientific, technical, or engineering positions on the drillship which are required to meet high-priority leg objectives. Stay tuned.

TWO WORKSHOPS SUPPORTED

JOI/USSSP and the International Lithosphere Program (ILP) are cosponsoring a workshop titled "Hydrogeology of the Oceanic Lithosphere" on December 11-12, 1998. Drs. Earl Davis, Harry Elderfield, Keir Becker, and Jon Martin are convening this workshop which is being hosted by Dr. Andy Fisher at the University of California at Santa Cruz. Knowledge about the hydrogeology of the oceanic lithosphere will be reviewed with emphasis on important problems that have received little recent attention. Observational and experimental strategies will also be discussed—including use of ODP facilities—to increase our understanding of the full range of variation of hydrologic regimes in the oceanic lithosphere, including those near passive and convergent continental margins.

The second workshop, which is titled "Marine Oxygen Isotope Stage 11 and Associated Terrestrial Records," is being supported by JOI/USSSP and the U.S. Geological Survey. Drs. Dick Poore, Lloyd Burckle, and Andre Droxler are convening this workshop in San Francisco on December 5, 1998, prior to the Fall AGU meeting. Formal presentations on key topics (deep sea, ice core, continental, and sea-level records) and a poster session will be followed by open discussion to establish a list of priorities for future work.

Reports of both workshops will appear in the March 1999 *JOI/USSAC Newsletter*.

NEW CD-ROM ON THE WAY

In early 1999, JOI expects to have available beta copies of its newest educational CD-ROM, "Gateways to Glaciation." This CD, which is being developed for high school and undergraduate earth science classes, uses ODP data to explore the closing of the Panama gateway as one of the possible triggers of northern hemisphere glaciation about 2.6 million years ago. Using real ODP data in virtual shipboard laboratories, students can analyze sedimentological and isotopic evidence for glaciation within the sediments, date the glacial onset through paleomagnetics and biostratigraphy labs, and explore evidence for Milankovitch cycles within the cores.

The CD culminates in a climatology lab where students explore the paleoceanographic and climatic consequences of the Panama gateway closure as interpreted from their data. Students are aided in the labs by shipboard scientists, and a co-chief scientist discusses their results with them. The format is similar to the one in JOI's "ODP: From Mountains to Monsoons" CD-ROM, which is freely available from JOI. The narrative for the "Gateways" CD-ROM was developed by principally Drs. Bob Duncan and Ellen Kappel, with input from Drs. Bill Chaisson, John Farrell and many others. Electronic Learning Facilitators, Inc. will be programming this CD.

POST-2003 PLANNING UPDATE

Serious planning is in progress for the spring COnference on Multi-PLatform EXploration (COMPLEX). The conference is scheduled to be held at the University of British Columbia, Victoria, Canada from May 26 to 29, 1999. This meeting will focus on non-riser drilling and is being organized around "statements of interest" submitted by scientists worldwide. A total of 257 statements were submitted to the JOIDES Office at last count. Many of these statements were written by multiple authors so the tally of involved scientists will be higher. Approximately, two-thirds of the first authors are U.S. scientists.

Dr. Nick Pisias, chair of the COMPLEX steering committee, reports that they will meet in mid-November to sort the statements of interest into logical categories. The next step will be to identify chairs. The chairs will help organize presentations within each category for the conference and to frame key questions to guide discussion.

The JOIDES Office is Moving

As of January 1, 1999 the JOIDES Office will be rotating from Woods Hole Oceanographic Institution to GEOMAR in Kiel, Germany. Dr. Bill Hay will head the office and chair the JOIDES Science Committee (SCICOM). Bill has served scientific ocean drilling in many ways over the years—including as President of JOI in the early 1980s. Dr. Warner Brueckmann will be second in command as the JOIDES Science Coordinator. The new JOIDES Office address will be:

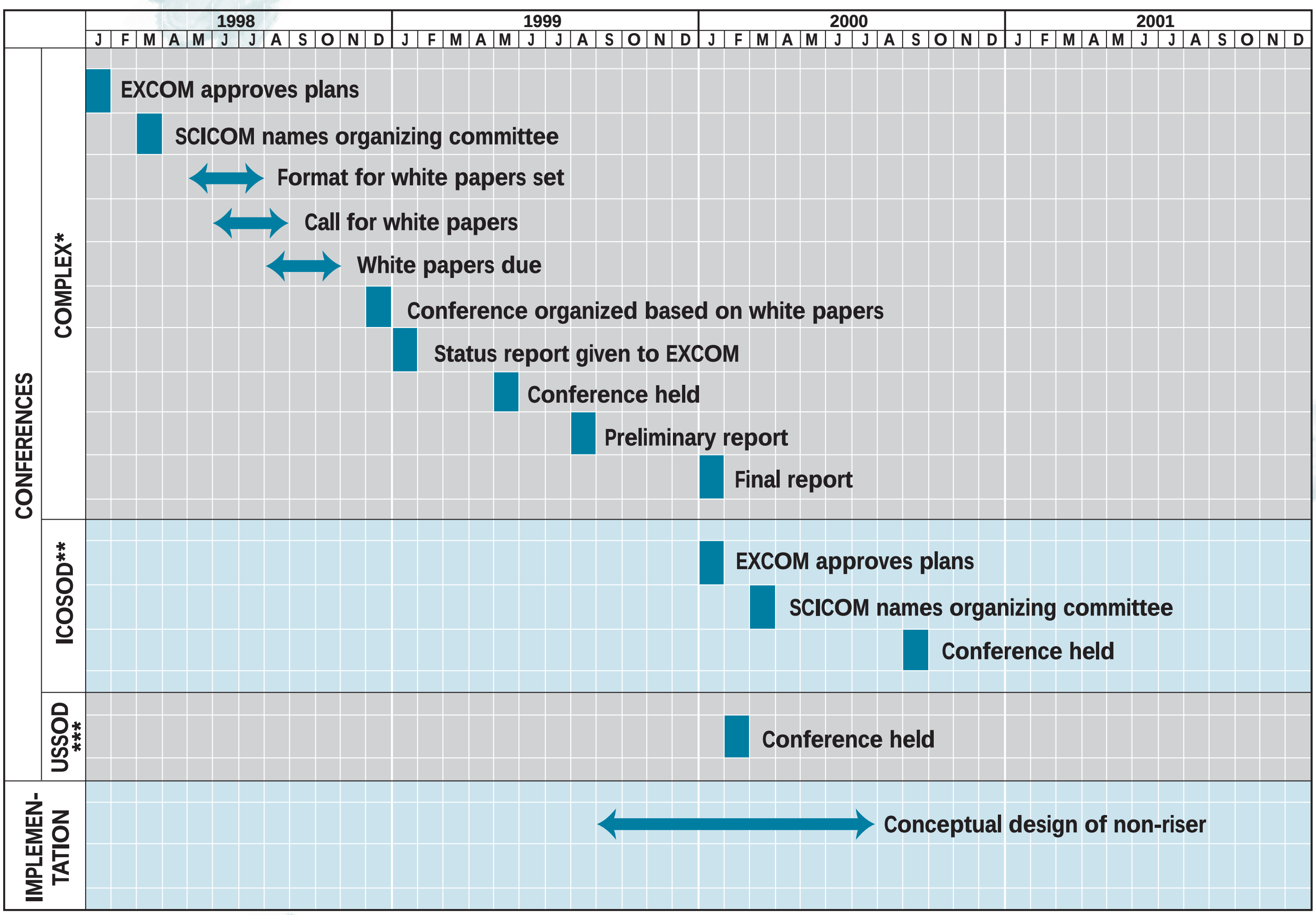
GEOMAR Research Center for
Marine Geosciences
Wischhofstrasse 1-3, Building 4
24148 Kiel, Germany
tele: (49) 431-600-2821
fax: (49) 431-600-2847
joides@geomar.de
www.geomar.de

We bid farewell to Dr. Susan Humphris who served as head of the JOIDES Office and as the PCOM/SCICOM Chair for the past two years. Susan will remain a vital participant in the JOIDES community during the exciting years ahead. During Susan's tenure, she implemented the reorganization of the JOIDES structure and actively promoted post-2003 planning for scientific ocean drilling. Susan and her able staff (Drs. Katherine Ellins and Christina Chondrogianni, and Shirley Waskilewicz) are owed many words of appreciation for successfully managing the helm during a busy watch.

U.S. Rep in the JOIDES Office

JOI is pleased to announce that Dr. Jeffrey Schuffert, a Senior Research Associate at Brown University, has recently accepted the position of U.S. Representative to the JOIDES Office when it moves to GEOMAR. For the last three years, Jeff has been working with Tim Herbert at Brown managing a geochemistry laboratory for analyzing alkenones. Recently, his research interests have focused on identifying regional variations of oceanic productivity and sea-sur-

PLANNING FOR POST-2003 SCIENTIFIC OCEAN DRILLING



*The Conference on Multiplatform Exploration **The Integrated Conference on Scientific Ocean Drilling ***The U.S. Conference on Scientific Ocean Drilling face temperature on glacial-interglacial and shorter timescales.

Previously, Jeff worked as a Research Associate at the University of South Florida, St. Petersburg and as a civilian research consultant for the Navy, following the completion of his Ph.D. in 1992 at Scripps. A veteran of numerous cruises, Jeff is active in the JOIDES community and participated on ODP Leg 178 to the Antarctic Peninsula.

Jeff begins this two-year term appointment on November 30, 1998. In this position, he will provide high-level executive support to Dr. Bill Hay, the new SCICOM Chair. His duties may include managing drilling proposals submitted to JOIDES, liaison responsibilities to one or more panels within the advisory structure, editing the *JOIDES Journal*, and assisting the SCICOM Chair in preparation of meeting agendas, agenda books, and meeting minutes. He will also attend USSAC meetings as the U.S. representative from/to JOIDES. Please welcome him in his new ODP role.

JOI Membership Expands

Joint Oceanographic Institutions, Inc. (JOI) is pleased to announce that Rutgers, The State University of New Jersey, became the eleventh member of JOI on September 1, 1998. This expansion of membership, the first in many years, reflects JOI's recognition of the fact that U.S. participation in the ODP has grown significantly beyond its initial ten institutions and that a broad base of constituency support will be necessary to create and foster a scientific ocean drilling program to succeed the Ocean Drilling Program in the year 2003. Since the Program began in 1985, U.S. participation in the ODP from JOI institutions has remained strong, but participation from non-JOI institutions has grown, partly as newly-minted PhDs from the JOI institutions disperse to other academic organizations. Over the past 13 years, about 43% of the U.S. participants in ODP have come from JOI institutions. Non-JOI academic participation is running about 49%, with 6% coming from the U.S. government (e.g., U.S. Geological Survey, Navy, Smithsonian) and the remaining 2% from industry and other organizations, such as museums. The JOI Board of Governors will further consider the issue of membership in a November 13th meeting in Washington, DC. An update on JOI membership will be presented in the March newsletter.

Gas Hydrate Update

The gas hydrate bill (S.1418, Methane Hydrate Research and Development Act) flamed brightly this summer, but ultimately burned out in October, at the conclusion of the 105th Congress, which was preoccupied with the Lewinsky matter and other weighty issues. A successful hearing was held in the U.S. Senate Energy and Natural Resources Committee on May 21 (see July newsletter for details). Support from several congressman, including Senators Ron Wyden of Oregon and Daniel Akaka of Hawaii, was encouraging. Senator Wyden urged the inclusion of NSF and ODP "as full partners in the exploration strategy discussions and science planning for gas hydrate research." The Senate passed the bill which was the first step towards establishing an interagency program to research and develop methane hydrate resources.

A hearing by the House Science Subcommittee on Energy and Environment occurred on September 15th. Testifying at the hearing were Robert Kripowicz, Department of Energy (DOE) Acting Assistant Secretary for Fossil Energy; William Dillon, USGS Research Geologist; and Arthur Johnson, Senior Staff Geologist of the Chevron USA Production Company and member of the JOIDES Gas Hydrate Program Planning Group. Their testimony focused on the development and recovery of hydrate resources as an energy source. The witnesses mentioned the DOE program of hydrate research that will begin in fiscal year 1999, and they sought House passage of this bill as an expression of congressional support.

For both hearings, JOI's President, Admiral James Watkins (U.S. Navy, retired), submitted a statement for the record outlining ODP's involvement in methane gas hydrate research and recommending that any program established use the National Oceanographic Partnership Program (http://core.cast. msstate.edu/NOPPpg1.html) framework. Despite heroic efforts, the bill was not passed by the House. The good news from this experience is: 1) hydrates, and ODP's role in exploring for and understanding them, came directly to the attention of congress; 2) ODP scientists participated in the legislative/congressional process; and 3) awareness was raised and several lessons were learned.

Additional good news is that failure to pass the bill has not slowed DOE's Fossil Energy Office from pressing onward with their program plan "A Strategy for Methane Hydrates Research & Development" (http://www.fe.doe.gov/oil_gas/methanehydrates/hydrate_strategy.html). The plan, which was published in August 1998, takes into consideration several of the comments and suggestions that you, members of the JOIDES advisory structure, submitted to JOI. ODP is mentioned in the plan, such as on page 23, "6.5.1 Federal Energy Technology Center will also fund critical elements of the program...ODP support for shipboard laboratory modifications or funding for a dedicated hydrates cruise." Stay tuned for updates.

30th Anniversary Calendar

A free anniversary calendar highlighting the scientific and technical accomplishments of thirty years of scientific ocean drilling (DSDP and ODP) will be available in December 1998. You may request copies from Aaron Woods, ODP/TAMU (aaron_woods@odp.tamu.edu).

JOI-FULL BEGINNINGS

contributed by Kate Moran, Director, Ocean Drilling Programs at JOI

Greetings, Kate Moran here. I'm pleased to introduce myself as the new ODP Director at JOI and I'm honored to be chosen. Before getting personal, I'd first like to offer heartfelt appreciation to my predecessor, Nick Pisias, for his hard work and dedicated service to the Program as the Interim Director after David Falvey's departure last December. We all owe Nick many thanks for carrying the Program through a difficult budgetary exercise this year and for setting the course for an exciting new scientific ocean drilling program beyond 2003.

Many of you may be asking yourselves, "who's this Canuck now directing OUR program?" [editor: Moran is U.S. born, raised, and educated]. Well, here goes. I came to JOI (and the wilds of DC), from the Bedford Institute of Oceanography in Halifax, Nova Scotia (the birthplace of the *JOIDES Resolution*) where I worked for the Geological Survey of Canada. Since the early '80's, my research has ranged from applied, e.g. evaluating seabed hazards for offshore pipelines and structures, to basic, such as geological studies with ODP.

With the ODP, I've studied sediment physical properties and deformation on accretionary complex legs (Barbados, Nankai, and Cascadia). The exciting discoveries of active fluid flow and overpressured fault zones have significantly advanced our understanding of accretion. I've also participated on paleoceanographic legs, first to work on problems associated with the construction of composite depth sections (Ceara Rise) and later to develop ultra-high-resolution records from Saanich Inlet. I've also sailed on three other occasions to help develop Janus, the new ODP database. I've served in the JOIDES advisory structure and on JOI committees, experiences that allowed me to learn how the program worked, warts and all. Most recently, I have been an active proponent of several JOIDES proposals, including one that plans to use an alternate platform. From all of my experience with ODP, I wholeheartedly agree with the outcomes of the many national and international review and evaluation committees over the years that have given high praise to the scientific successes and management of ODP.

I look forward to many new and interesting experiences with the Program. As Director, I am focusing on four areas. First and, most importantly, we must maintain and strengthen the central activities of NSF, JOI, TAMU, LDEO and the JOIDES Office so that only the best science is selected and then accomplished for the benefit of the international community. Developing partnerships with industry is a second major interest. Industry will help us advance the technology we'll need to meet the challenges of our science and their participation with academia will be essential in a future ocean drilling program. Third, JOI will step up and provide the support and services needed to plan a future, multi-platform scientific ocean drilling program to succeed the ODP. Finally, we are redoubling our efforts to pursue new international partners. In particular, we will woo countries that may not be able to afford a full membership, but may participate as associate members, under EXCOM's new guidelines.

I look forward to working with you all and I encourage you to contact me, or any of the JOI staff, if you have concerns, comments, or suggestions on any aspect of our management as the prime contractor for ODP. It is certainly a JOI-full beginning for me and my vision is one of a bright and exciting future for the Ocean Drilling Program and its successor.

ODP LEGS 188-193: MARKING THE MILLENNIUM

The JOIDES Scientific Committee has finished the drillship operations schedule for 2000. Condensed descriptions of Legs 188 to 193 follow and a map shows the leg locations. There is some great science here and wonderful opportunities to participate. Shipboard scientist applications are available at www-odp.tamu.edu/sciops/cruise_application_info.html. For more information, contact Dr. Thomas Davies, Manager of Science Services, ODP/TAMU (tom_davies@odp.tamu.edu)

LEG 188: ANTARCTIC GLACIAL HISTORY — PRYDZ BAY

The Antarctic ice sheet is a key component of the world's climatic system and has a major influence on global sea levels. ODP Leg 188 is the second of two Antarctic drilling legs (Leg 178 was the first) to better understand the role of the ice sheet and to test models of its behavior. Leg 188 will drill Cenozoic sedimentary sequences in Prydz Bay, and on the adjacent continental slope and rise. The purpose is to: 1) link East Antarctic Ice Sheet events with changes in the Southern Ocean, 2) recover a Plio-Pleistocene record of ice advances and interglacial deposits from the Antarctic continental slope, 3) date the earliest evidence of glacial activity in Prydz Bay, and 4) obtain information about the Paleogene environment of Antarctica. *This Leg will require an ice support vessel, and SCICOM has stipulated that the leg will proceed only if affordable ice support can be acquired*. Leg 188 will complement the Cape Roberts Project which is a joint international venture seeking to recover cores from a 1500 m thick sedimentary sequence off Cape Roberts in the southwestern Ross Sea.

LEG 189: SOUTHERN GATEWAY BETWEEN AUSTRALIA AND ANTARCTICA

The progressive high-latitude cooling during the Cenozoic which led to the development of the polar cryosphere—initially on Antarctica, and later in the northern hemisphere—may have resulted from plate tectonic changes. The opening of the Tasmanian Seaway (and the Drake Passage) progressively and thermally isolated Antarctica as the Circumpolar Current developed. These paleoceanographic changes likely played a fundamental role in the development of Cenozoic climate evolution and associated paleoenvironmental changes. The Leg 189 drilling program in the well preserved and complete carbonate-rich sequences off Tasmania will document the paleoceanographic/climatic changes associated with the tectonic opening of the Tasman gateway since the Middle Eocene.

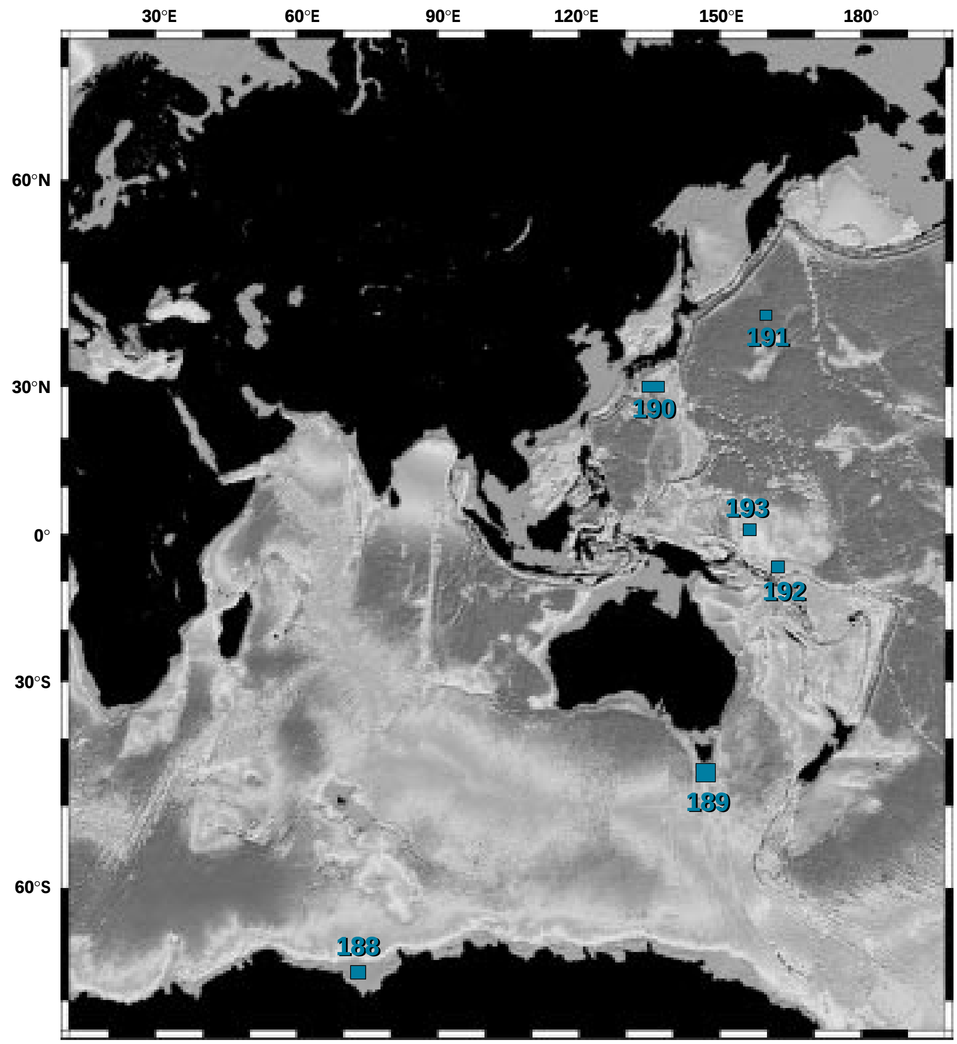
LEG 190: NANKAI TROUGH

A complex interplay of deformational, diagenetic, and hydrologic processes associated with initial mountain building processes occurs within accretionary prisms. Key questions relate to the distribution of deformation, the controls on what material is accreted and what is subducted, and the role of fluids and fluid flow in the prism's deformation. The Nankai accretionary prism—a type example of a convergent margin accreting a thick section of clastic sediments—is ideal for mechanical and hydrologic modeling of fluid-linked diagenetic and tectonic processes in a rapidly deforming accretionary wedge. Leg 190 will be the first of a two-leg program focused on the Nankai Trough, which has unparalleled seismic resolution and structural simplicity as well as data from three previous DSDP/ODP drilling legs. Leg 190 will consist of drilling and coring at three primary sites to compare two parts of the Nankai Trough with different wedge tapers and structural geometries. The second leg (not yet scheduled) is planned to include Logging-While-Drilling (LWD) at four sites, and the emplacement of CORKs at three of these sites.

LEG 191: WEST PACIFIC SEISMIC NETWORK

The International Ocean Network (ION) was founded to meet a critical need for permanent seismic observatories in the deep ocean and to fulfill two major scientific goals: 1) uniform global coverage, and 2) long-term monitoring of active processes (such as those at subduction zones). The Western Pacific is the best suited region on Earth to investigate the dynamics of subducting plates, formation and evolution of island arcs and marginal seas, as well as their relation to mantle convection. Leg 191 will drill one of the high-priority areas identified by ION in the Western Pacific. A downhole seismometer will be installed at this site to expand the observatory network. This observatory will complement a dense regional geophysical

ODP Legs 188-193



Seafloor topography map courtesy of Walter H.F. Smith and David T. Sandwell
Seafloor Topography Version 4.0, SIO, September 26, 1996, © Walter H.F. Smith and David T. Sandwell, 1996

network existing over Japan by providing unique seismic observations on the seaward side of the Japan Trench.

Leg 192: PACMANUS Hydrothermal System

Drilling active hydrothermal systems is vital to understanding the genesis of massive sulfide deposits and associated ores in ancient marine sequences. This knowledge is necessary to create a new science base for mineral exploration on the continents. Previous ODP legs have probed both volcanic-hosted and sediment-hosted deposits. A yet unexplored, but economically very important, category, is the felsic volcanic-hosted polymetallic massive sulfides and related stockworks which are abundant in the ancient geological record—ranging in age from Tertiary through the Paleozoic to Archean. These types of deposits probably formed at convergent continental margins, rather than at mid-ocean ridges. Many represent multi-billion dollar resources. Knowledge of fundamental processes such as fluid-rock interactions, hydrodynamics and structural/tectonic controls on fluid pathways, and metal and fluid sources are key to understanding chemical fluxes and ore deposition. Leg 192 will focus on the thoroughly surveyed, active, PACMANUS hydrothermal field in the eastern Manus back-arc basin. The hydrothermal field includes two focused, high-temperature "smoker" sites with Cu-Au-rich sulfide deposits, and a field of diffuse, lower temperature venting through intensely altered dacite, for which modeling indicates significant subsurface mineralization. ODP will drill below both focused and diffuse outflow zones, into a likely seawater inflow, and will also drill a reference hole. Plans call for one hole to be CORKed as a geochemical observatory.

Leg 193: Ontong-Java Plateau

Large igneous provinces (LIPs) represent immense volumes of magma erupted on the seafloor in fairly short time periods. Emplacement rates of the largest LIPs may have approached the entire magma production rate of the global mid-ocean ridge system. The Alaska-sized Ontong-Java Plateau in the western Pacific may represent the largest igneous event of the last 200 my. Leg 193 is the first leg in a proposed two-leg program aimed at understanding the formation of the world's largest plateau. A transect of holes into basement across the Ontong-Java Plateau will be drilled to determine: its age and duration of emplacement, the range and diversity of magmatism, the environment of eruption, its post-emplacement vertical tectonic history, the effects of rift-related tectonism, and its paleolatitude at emplacement.

THE SUBDUCTION FACTORY: THE GLOBAL IMPACT OF MASS AND ENERGY TRANSFER AT CONVERGENT MARGINS

contributed by Julie Morris

Subduction of oceanic plates causes earthquakes, tsunamis and explosive volcanism. It also gives rise to beneficial products, such as ore deposits, geothermal energy and the ground we live on. The "subduction factory" recycles raw materials from the subducting seafloor and overlying mantle, and creates products on the upper plate in the form of melts, aqueous fluids and gases. Convergent margin processes have profound scientific and societal consequences, and a Subduction Factory Workshop was convened to develop plans to tackle the most important research.

The workshop—related to the MARGINS Initiative—was held from June 6 to 9, 1998 in La Jolla, CA. It was funded by JOI/USSSP, the National Science Foundation (Marine Geology and Geophysics), Washington University in St. Louis, and Scripps Institution. Approximately 65 scientists, representing the many disciplines required for integrated studies of the subduction factory, attended. The workshop mandate was to build and identify community consensus for scientifically and geographically focused interdisciplinary studies of the subduction factory.

The workshop participants recognized three themes as tractable and essential:

- The role of subduction parameters (e.g. slab and mantle temperature, convergence rate, subduction dynamics and mass transport to depth) as forcing functions in regulating chemical cycling and crustal growth.
- The volatile cycle through subduction zones and its impact on physical, chemical and biological processes from the trench to the back-arc.
- Mass balance and continental growth in the middle and lower arc lithosphere and as understood through experimental studies.

In a strong, but not unanimous, consensus the following actions were endorsed:

Selecting Nicaragua/Costa Rica as a site for focused interdisciplinary studies. Here: 1) variations in subduction dynamics and mass transport to depth are matched by sympathetic chemical gradients in the volcanic output, 2) abundant carbonate subduction exists for investigating the CO_2 cycle, and 3) the deeper plutonic section is exposed. The first reason links Subduction Factory and Seismogenic Zone goals into a scientifically integrated package. In addition, work in Central America will include studies of volcanic gases and their role in hazards, climate modification, and mass balance.

Determining a counterpoint site to Central America in a non-accretionary margin where old, cold slabs are subducting, and back-arc spreading is present. In the Marianas, Izu-Bonin and Tonga margins, key forcing functions are distinctly different from Central America. Because each margin is best suited for addressing specific themes, a workshop at the December 1998 American Geophysical Union meeting will be convened to set priorities.

Conducting selected studies of the subducting input and the volcanic and plutonic products of the Aleutians. Variations in subduction parameters along-strike in the Aleutian arc present a great opportunity to examine forcing functions. A continental growth study from exposures of deeper arc crust and the hazards presented to U.S. residents and planes flying in U.S. airspace are additional reasons for working in the Aleutians. However, the relatively limited database is an issue.

The workshop attendees also recognized: 1) the need for Theoretical and Experimental Institutes to investigate the internal margin workings and to link observations across disciplines; 2) the role of InterMARGINS to coordinate international studies; 3) the importance of databases and uniform systems of sample curation and distribution; and 4) the need for well-defined studies in critical localities to ensure adequate sample sets, provide critical pieces of information or generate adequate data synthesis.

Scientific ocean drilling has been—and will continue to be—essential for studies of the subduction factory through 2003, and beyond. Much of what we know about the composition and alteration of the incoming ocean crust and the composition and mineralogy of its sedimentary veneer comes from ODP drilling. Recovery of the sedimentary section and deep penetration of the igneous basement outboard of the trench continues to be essential. Drilling, in combination with seismic imaging and geochemistry, is also essential for quantifying the fraction of sediment subducted to the depths of magma generation. In addition, scientific and technical progress has changed the way in which the ODP drillship, *JOIDES Resolution,* can be used. Casing techniques can provide better hole stability for deeper penetration and core recovery in the compressive regime of the accretionary prism, to study sediment dynamics. Logging-While-Drilling techniques provide high-quality logs for density and porosity in fore-arc sites. Pore fluid sampling and analysis provide a very sensitive look at the diagenetic, hydrologic and chemical changes in the downgoing plate during the earliest stages of subduction. New capacity for microbiological study aboard the *JOIDES Resolution* will allow investigation of subduction trenches as important habitats in the biosphere. In any study of the subduction factory, it is essential that a reference site be drilled outboard of the deformation front.

Riser drilling will ultimately allow deeper penetration, improved hole stability, and better recovery under difficult drilling conditions typical of convergent margins. Drilling through the seismogenic zone will provide samples of aqueous fluids and of accreted and subducting sediments, necessary for understanding shallow subduction processes, and their effect on the slab delivered to depth. Riser drilling could improve access to deeper fore-arc serpentinites and associated pore-fluids. It may also provide a longer record of arc evolution through deep drilling in the arc edifice or in subsiding basins that receive volcanic sediments or ash.

Legacy boreholes are increasingly important for hydrological, geochemical, microbiological and seismic studies with long-term observatories. New developments are leading to a second generation CORK that will allow multiple levels in the borehole to be isolated from each other and from seawater, so that the hydrology, chemistry and microbiology can be investigated in several different horizons. Such observatories would be particularly useful in the fore-arc of margins selected for focused study, with isolation of intervals above and below the decollement and in the basement of the subducting plate. This information will be essential for understanding the volatile cycle in the shallow subduction factory, with obvious implications for the volatile budget. The same borehole can house a seismometer and strainmeter, leading to a better array for characterizing the seismicity and regional strain of convergent margins. Mini-CORKs are being developed to serve as shallow, inexpensive, easily deployed mini-observatories. These could be linked with borehole observatories as arrays for the investigation of the three-dimensional aspects of the subduction factory, such as hydrologic process, heat flow, seismicity, regional strain, geochemical variability, and biologic processes.

Details about the Subduction Factory Workshop and its report may be found on the web: epsc.wustl.edu/admin/people/morris/factory.html. The Subduction Factory Science Plan and the workshop report will be available at the MARGINS web site: www.soest.hawaii.edu/margins.

AUTHOR

Julie Morris is a Research Associate Professor at the Department of Earth and Planetary Sciences, Washington University.

PALMER DEEP
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ANNOUN

JOI/USSSP SUPPORTED SHIPBOARD PARTICIPANTS

Leg 182: Great Australian Bight
U.S. Co-Chief: Albert Hine, U of S. FL, St. Petersburg
ODP Staff Scientist: Mitchell Malone, TAMU
Gregg Brooks, Eckerd College
Charlotte Brunner, U of S. MI
Michael Fuller, U of HI
Bryan Ladner, FL State U
David Mallinson, U of S. FL, St. Petersburg
Richard Mitterer, UT, Dallas
Roberto Molina Garza, U of NM
Joellen Russell, SIO
Juan Antonio Simo, U of WI, Madison
Peter Swart, U of Miami

Leg 183: Kerguelen
U.S. Co-Chief: Millard Coffin, UTIG
U.S. Co-Chief: Frederick Frey, MIT
ODP Staff Scientist: Paul Wallace, TAMU
Jane Barling, U of Rochester
John Damuth, UT, Arlington
Robert Duncan, OSU
Laszlo Keszthelyi, U of HI at Manoa
John Mahoney, U of HI at Manoa
Clive Neal, U of Notre Dame
Kirsten Nicolaysen, MIT
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Sherwood Wise, FL State U
Xixi Zhao, UC Santa Cruz

THE FUTURE OF MARINE GEOLOGY AND GEOPHYSICS

Report of a Workshop

December 5-7, 1996

Compiled by Paul Baker and Marcia McNutt

Available from:
Consortium for Oceanographic Research and Education (CORE)
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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 up to $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.

DEADLINES:
Shipboard work (Legs 188-193): 4/15/99
Shorebased work: 4/15/99 and 11/15/99

MORE INFORMATION:
Andrea Johnson
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) 462-8754
E-mail: ajohnson@brook.edu

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Report of a Workshop on

ADVANCED CORKS FOR THE 21ST CENTURY

Convened by Keir Becker and Earl Davis

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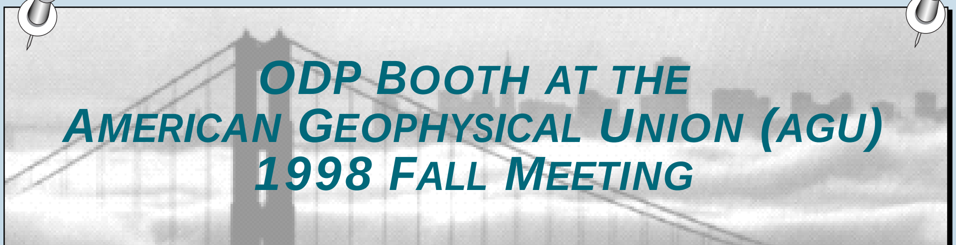
C E M E N T S



ODP Booth at the American Geophysical Union (AGU) 1998 Fall Meeting

Booths 208-210-212
Moscone Center, San Francisco
December 7-10, 1998
8:30 am - 5:00 pm

Visit the ODP booth and catch up on the latest ODP activities. Also, find out how to: get involved in ODP; sail on the *JOIDES Resolution;* undertake shorebased research; access data and publications; request core photos or samples; serve on advisory panels; propose a cruise; and much more.

See you there.

Post-2003 Scientific Ocean Drilling Town Meeting

Date: December 7, 1998

Time: 5:30 pm - 7:30 pm

Where: Moscone Center, Room 125
Fall AGU Meeting, San Francisco

The Ocean Drilling Program ends in 2003. A town meeting on the future of scientific ocean drilling will be held in December in conjunction with the Fall AGU conference in San Francisco. This meeting will be an open forum to provide an update on the post-2003 planning efforts and to hear your views on the future. Scientific ocean drilling cronies and neophytes are strongly encouraged to attend. Refreshments (the kind geologists like) will be served.

ODP Sessions at AGU

Union Session

New Evidence for Rapid Climate Change from Ocean Drilling (U10)
To Celebrate 30 Years of Scientific Ocean Drilling

Date: December 7, 1998

Conveners: L. Peterson & E. Jansen

Morning Oral Session (U11B):
8:30 am, Moscone Center, Room 133

Afternoon Poster Session (U12B):
1:30 pm, Moscone Center, Hall D

Ocean Sciences Session

Ocean Drilling in Laminated Sediments for High-Resolution Paleoenvironmental Records (OS13)

Date: December 10, 1998

Conveners:
B. Bornhold, A. Kemp, & E. Domack

Morning Oral Session (OS41I):
8:30 am, Moscone Center, Room 304

Afternoon Poster Session (OS42G):
1:30 pm, Moscone Center, Hall D

Ophiolites and Oceanic Crust: New Insights from Field Studies and ODP

contributed by Yildirim Dilek

A Geological Society of America (GSA) Penrose Conference on ophiolites and oceanic crust brought together a multidisciplinary group of 86 international geoscientists in Marshall, California, from September 13 to 17, 1998. It was jointly sponsored by JOI/USSSP, the National Science Foundation's Marine Geology and Geophysics Program, and GSA. The purpose of the conference was to: 1) reevaluate existing models of oceanic crust generation, ophiolite formation and ophiolite-ocean crust analogy; 2) explore the possibility of reaching a new consensus on the architecture of oceanic lithosphere; and 3) discuss the significance of ophiolites and oceanic crust for past and present plate tectonic processes.

The conference was organized into five major thematic sessions including invited overview talks and poster sessions. Two evening sessions on "Ophiolites and the Sedimentary Record" and "Current Thoughts on the California Coast Ranges" highlighted unresolved questions and outstanding controversies on the evolution of Jurassic ophiolites and the Mesozoic active margin tectonics of the western U.S. These sessions tied into the conference field trip to the California Coast Ranges. During daily two-hour discussions, panel members addressed questions and encouraged informal exchanges. This format promoted the active participation of all attendees and the cross-pollination of ideas among investigators with diverse approaches.

In the first session on structural and magmatic processes at oceanic spreading centers, Ken Macdonald discussed off-axis volcanic activity for melt distribution beneath mid-ocean ridges. The highly asymmetric zone of primary melting at the East Pacific Rise, as deduced from the MELT experiment, mimics the asymmetric distribution of seamount chains and seafloor subsidence in the area. Jeff Karson emphasized the complexity and the heterogeneity of the internal structure of both modern oceanic crust and ophiolites. Henry Dick compared structural and magmatic processes at spreading centers, as seen from *in situ* lower oceanic crust and shallow mantle. He discussed large variations in the stratigraphy of the ocean crust at slow-spreading ridges, reflecting along-axis transport of melt in the lower crust from a central intrusive center, and the significance of synmagmatic deformation in melt transport and igneous differentiation. Peter Kelemen addressed magmatic processes and melt transport in the mantle and the nature of crust-mantle transition; porous flow processes may control the geometry of melt transport networks beneath ridges.

In the second session, on ophiolite-ocean crust analogy and field observations, Eldridge Moores explained the significance of the scale and distribution of mantle heterogeneity and evolution for the generation of ophiolitic magmas. Tjerk Peters presented the geology of the Masirah ophiolite and discussed its evolution at a ridge-transform intersection in the proto-Indian Ocean. Jean Bédard described syntectic assimilation processes and magmatic differentiation patterns in the plutonic sequence of the Bay of Islands (Newfoundland) ophiolite and discussed their significance at all scales. Hans Schouten compared the volcanic stratigraphy drilled in ODP Hole 504B at the Costa Rica Rift and in Hole CY-1/1A in the Troodos ophiolite, Cyprus. He suggested that the kinematic histories and deformation in the lavas and sheeted dikes in 504B and near CY-1/1A may reflect their contrasting mechanical response to lava burial, rather than faulting.

In the third session, on petrology and geochemistry of oceanic crust and ophiolites, Julian Pearce summarized methods yielding geochemical fingerprints that can be related to present tectonic settings empirically and/or by using petrogenetic reasoning. He described several modern analogues for oceanic crust formation in suprasubduction zone environments and the processes affecting arc magma composition. Elisabetta Rampone gave an overview on the petrogenesis of the Ligurian ophiolites in the Apennines of Italy and discussed occurrence of the Jurassic MORB-type oceanic crust. Steve Edwards addressed melt migration and reaction in conductive mantle lithosphere with a specific reference to the Bay of Islands ophiolite. He discussed the potential of these processes to cause significant chemical modification of melt and mantle at shallow depth. Paul Robinson reviewed the structure, stratigraphy, and petrology of lower oceanic crust, formed at the Southwest Indian Ridge, that has been drilled in ODP Hole 735B, and compared its characteristics to those of well-known ophiolites.

In the fourth session, on hydrothermal alteration and mineralization of oceanic crust and ophiolites, Jeff Alt discussed the mechanism, effects, and differences of hydrothermal alteration in seafloor spreading environments as recorded in young oceanic crust and ophiolites. Rachel Haymon explored the importance of shallow crustal magma supply and delivery configuration to ridge-crest hydrothermal systems based on observations from the East Pacific Rise and the Semail ophiolite. The distribution and geochemical character of hydrothermal alteration on ridge crests are fundamentally different in magma-rich, dike-dominated segments (fast-spreading), compared to magma-starved, fault-dominated segments (slow-spreading). Debbie Kelley focused on the geochemical, isotopic, and thermal history of fluids circulating in the oceanic crust from magmatic to hydrothermal vent conditions, as well as their role in crustal development and microbial processes. Lower oceanic crust is a potentially major reservoir for abiogenic methane in submarine hydrothermal systems, and carbon-bearing fluids in gabbros may provide a critical energy source for a diverse microbial population in the sub-seafloor. Susan Humphris reviewed thermal and geochemical mass balances for the TAG active hydrothermal mound and discussed their implications for the time of formation, the size of reaction zone, growth constraints, and the heat source of a seafloor massive sulfide deposit.

The fifth and final sessionwas on active margin tectonics, orogeny and ophiolite emplacement mechanisms. Nicola Godfrey presented generalized crustal-scale cross-sections of the Great Valley in California at different latitudes and discussed the occurrence of a 600 km-long, 70 km-wide ophiolitic slab beneath the Great Valley forearc basin. Bradley Hacker reviewed recent data on the thermochronology and thermobarometry from the metamorphic sole of the Semail ophiolite which imply extremely rapid subduction (~200 km/my) beneath a very young oceanic crust. Adolphe Nicolas compared inferred microplate tectonics of the Semail ophiolite, the Easter Island microplate, and the Magellan Plateau. He discussed the kinematics of rapid rotation at spreading centers and rotation-related compressional deformation at the tip of propagating ridges. Alan Smith considered current models of ophiolite emplacement and the involvement of two distinct subduction phases during the terminal obliteration of ocean floor.

The panel sessions, in general, addressed overarching scientific questions; however, the final discussion recalled the first Penrose field conference on ophiolites in 1972 during which the definition of an ophiolite was developed. Panel members reflected on the progress made in ophiolite and ocean crust studies. The original Penrose definition of *ophiolite* has been very useful and remains effective in ophiolite-ocean crust analogy, as long as the term is used independently of its origin and/or formation of tectonic affinity.

To address the questions that arose during the panel discussions, additional integrated studies of modern oceanic crust and ophiolites are needed to foster collaboration among members of the marine geology and geophysics community and ophiolite geologists. Systematic and detailed structural, kinematic, petrological, and geophysical process-oriented studies —both in ophiolites and modern oceanic crust—are important for modeling oceanic systems. For future studies, objective criteria should be established for structural reference frames in oceanic rocks and methods should be explored to constrain pressure-temperature-time (PTt) paths for oceanic mafic and ultramafic rocks.

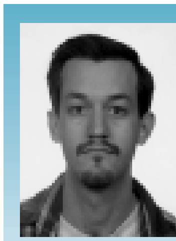
Scientific drilling in the oceans has been crucial in advancing our knowledge of the oceanic lithosphere. Coordinated efforts and collaborations in the marine geology and geophysics and ophiolite communities can focus scientific drilling programs and garner understanding and support from the broader international geological community. The priorities for future deep-earth sampling include: drilling an intact section of modern oceanic crust (preferably 3 km into the basement) using current technology; drilling the plutonic foundation of oceanic crust as well as the complete crust and crust-mantle boundary (goals of the “Mohole” project) using a riser-equipped drilling vessel; and finally, a comprehensive program to fully understand the structural and compositional variations in modern and ancient oceanic crust in relation to ophiolites.

A GSA special publication with proceedings of the conference is planned for 1999. For additional information contact Yildirim Dilek (dileky@muohio.edu).

AUTHOR

Yildirim Dilek is an Associate Professor at the Dept. of Geology, Miami University.

Zinc in Benthic Foraminifera: A New Paleoceanographic Tracer?



Tom Marchitto

Ph.D. Institution:
MIT/WHOI

Faculty Advisor:
William Curry

I am investigating ratios of zinc to calcium in benthic foraminifera shells as a potential paleotracer of deep-water circulation. Foraminiferal carbon isotopic values and cadmium-to-calcium ratios are currently used as proxies to infer the past distribution and circulation of deep-water masses, but additional tracers are needed because each has its own particular strengths and weaknesses. A multi-proxy approach offers the best means of unambiguously deciphering the geologic record.

Zinc shows promise as a paleotracer because its dissolved profile in the modern ocean is nutrient-like, with near-zero concentrations in surface waters and maximum values below 1000 m (Bruland *et al.*, 1978). Dissolved Zn closely covaries with dissolved silica, probably because both have similar rates and sites of uptake and regeneration. Deep-water formation and circulation create gradients of Zn and Si in the abyssal ocean. There is a particularly large (~sixfold) increase in Zn between the North Atlantic and Southern Ocean. This difference is much larger than the corresponding Cd gradient, and suggests that Zn may be a sensitive tracer of the interactions between Antarctic Bottom Water and North Atlantic Deep Water.

First, I calibrated the zinc chemistry of bottom waters to foraminifera in the surface sediments. I measured Zn/Ca and Cd/Ca in 29 Holocene coretops (>1500 m depth; including seven DSDP and ODP cores) and compared the results to modern concentrations of Zn in bottom waters. The Zn was estimated from nearby hydrographic stations (GEOSECS) from the Si data and the Zn:Si relationship ($r^2 = 0.98$) below 1000 m. The results from *Cibicidoides wuellerstorfi* and *Uvigerina* spp. are shown in Figure 1A. The Zn/Ca data correlate well with predicted [Zn] ($r^2 = 0.73$), indicating that these two taxa record bottom-water [Zn].

Note, however, that some data fall below the trend suggested by the Atlantic cores. This pattern may be explained by decreased apparent Zn distribution coefficients (D_{Zn}=[Zn/Ca]$_{foram}$/[Zn/Ca]$_{water}$) in waters undersaturated with respect to calcite—an effect that has been observed previously for Cd, Ba, and Sr (McCorkle et al., 1995). Apparent D_{Zn} is strongly correlated with saturation (ΔCO_3) below ~20 µmol mol^{-1} ΔCO_3. These data reflect a simple relationship, allowing me to predict seawater [Zn] (ZnW) from foraminiferal Zn/Ca and seawater ΔCO_3. The resulting foraminiferal ZnW values correlate very well with predicted seawater [Zn] ($r^2 = 0.90$; Figure 1B, confirming that *C. wuellerstorfi* and *Uvigerina* spp. precisely record bottom-water [Zn]. Because calcite undersaturation seems to affect D_{Zn} differently than D_{Cd}, there is hope of using Zn/Ca and Cd/Ca together to deconvolve circulation and apparent ΔCO_3 changes.

Next, I will generate downcore records, from the Holocene to the last glacial maximum (~22 ka) of Zn/Ca and Cd/Ca in the eastern equatorial Pacific (ODP Site 849) and in the South Atlantic.

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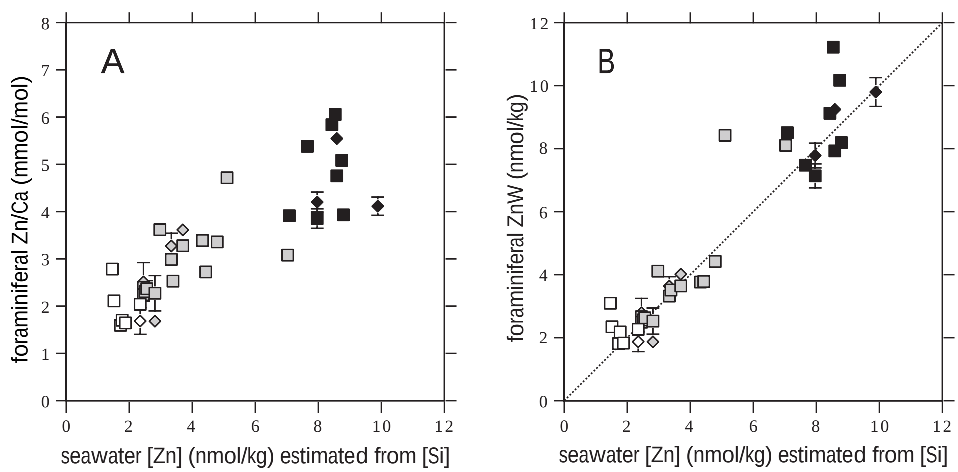


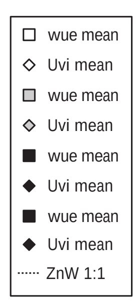
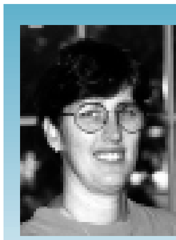


Fig. 1: A) Coretop calibration of Holocene benthic foraminifera *C. wuellerstorfi* (squares) and *Uvigerina* spp. (diamonds) Zn/Ca versus dissolved Zn concentrations in bottom water estimated from Si data. Values increase from the North Atlantic (open symbols), through the tropical and South Atlantic (shaded), and into the Indian and Pacific (filled). B) Bottom water Zn concentrations derived from coretop benthic foraminifera (ZnW) vs. Zn concentrations estimated from Si data. Symbols are as in (A). Dotted line is the 1:1 line.

Carbonate Minerals in Gas Hydrate-Bearing Sedimentary Sections: ODP Leg 164



Nancy M. Rodriguez

Ph.D. Institution: UNC Chapel Hill

Faculty Advisor: Charles K. Paull

I investigated the influence of high methane concentrations, and gas hydrates, on carbonate diagenesis. Early diagenesis in marine sediments is generally dominated by organic matter decomposition through microbially-mediated reactions (sulfate reduction, methane oxidation, and methane production) (e.g., Reeburgh, 1983). Huge volumes of methane are stored as gas hydrates in marine sediments such as those sampled on the Blake Ridge by ODP Leg 164. Gas hydrates are unstable at surface conditions and thus have poorly understood present and paleo-distributions.

My primary goal was to relate the vertical distribution of authigenic carbonates to pore fluid chemistry and fluid movement in gas hydrate-enriched sedimentary sections. Pore water geochemical data, including Sr isotopes, suggest that there is a downward diffusive exchange of fluids between the seafloor and the top of the gas hydrate zone in Blake Ridge sediments at Sites 994, 995, and 997. At Site 996, upward advection of methane-rich fluids along fault conduits supports a chemosynthetic community over the Blake Ridge diapir.

Despite the prediction that sulfate reduction generates conditions conducive to carbonate precipitation, no solid phase record of carbonate diagenesis was found above the base of the sulfate reduction zone (Figure 1). The onset of significant carbonate diagenesis in Blake Ridge sediments occurs at the sulfate-methane interface where microbially-mediated anaerobic methane oxidation (AMO) is inferred to be active. Authigenic calcite and dolomite forms at, or just beneath, this boundary. The extent to which these authigenic carbonates are concentrated appears to depend on how long methane oxidation is acting on a particular sedimentary horizon. Thus, the diagenetic record is sensitive to sedimentation rates (Raiswell, 1988). At greater depths, changes in pore water chemistry lead to formation of authigenic siderite just above and within the gas hydrate zone (200-450 mbsf). Over the Blake Ridge diapir, authigenic calcite and aragonite nodules with depleted $\delta^{13}C$ values, and $\delta^{18}O$ values in isotopic equilibrium with bottom waters, form at or very near the seafloor by AMO (Figure 2). The high methane flux results in a shallowing of the sulfate-methane interface, significantly higher rates of AMO, and precipitation of methane-derived carbonate cements.

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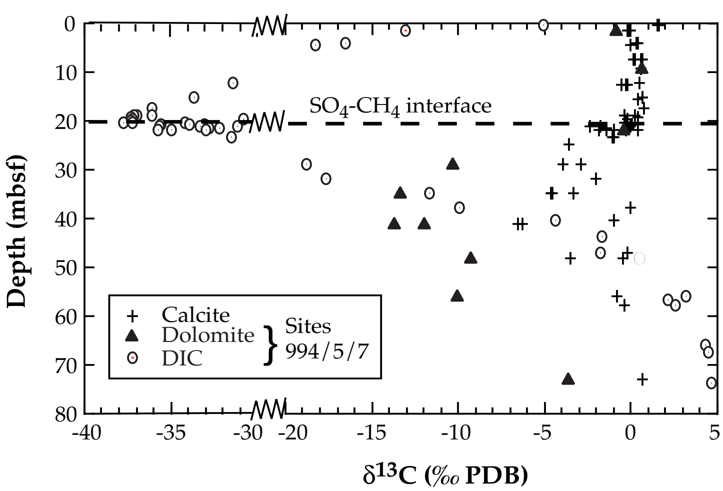

Fig. 1: The SO_4^{-2} - CH_4 interface (SMI) marks a biogeochemical interface where underlying methane is consumed with sulfate by microbially-mediated AMO. Decreases in $\delta^{13}C$ values of dissolved inorganic carbon (DIC) and $CaCO_3$ at the SMI indicate that AMO is active. The extent to which carbonate $\delta^{13}C$ values fall below a typical biogenic carbonate (~0 ‰) baseline, reflects the contribution of authigenic carbonate from AMO to the total carbonate pool.

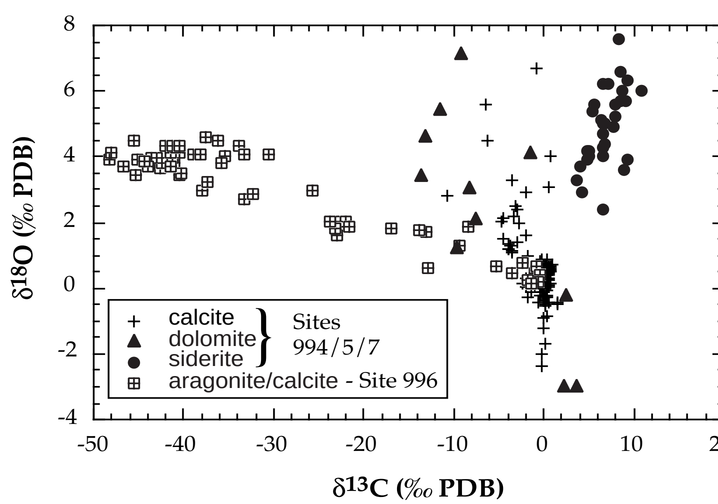

Fig. 2: Stable isotope values for carbonates from Sites 994/5/7 (diffusive processes dominate) are compared to aragonite/calcite values from Site 996 (upwards advection of methane-rich fluid occurs). Biogenic calcite has $\delta^{13}C$ and $\delta^{18}O$ values of ~ 0 ‰. Authigenic carbonates with negative $\delta^{13}C$ values may reflect carbon from AMO. Positive $\delta^{13}C$ and $\delta^{18}O$ siderite values reflect an origin within, and just above, the gas hydrate-bearing section.

Reaching Out for Earth-Science Community Input

Michael Arthur is Professor at the Department of Geosciences, Pennsylvania State University

If you've been reading this column regularly, you're aware that USSAC has been setting an agenda and planning for a new program of scientific ocean drilling (SOD), post-2003. Our future-oriented efforts are entirely appropriate because of the tremendous lead time required to 1) identify and assemble the scientific justification for a new program, 2) ensure that appropriate funding, funding mechanisms and management structures are in place, and 3) acquire new technology required to carry out our scientific goals.

Prior to the COnference on Multi-PLatform EXploration (COMPLEX)—scheduled for May 26 to 29, 1999 in Vancouver, Canada—USSAC will have engaged in a broad campaign of public awareness within the geoscience community. We will have published articles and editorials in a number of newsletters (e.g., the multi-authored front-page editorial in the August 4 issue of AGU's *Eos*) and journals (e.g., Rick Murray's piece in the July issue of *J. of Sed. Res.*). We will have also sponsored public forums and booth displays at the international meetings of two major geoscience societies.

By the time you read this column, the first forum will have been held, on October 28, at the Geological Society of America (GSA) meeting in Toronto, Canada. GSA approved a "Hot Topics at Noon" session titled "Does Scientific Ocean Drilling Have a Future?" I am convening this one-hour session with a distinguished panel of drilling *congnoscenti*, including Nick Pisias (Oregon State Univ.), Jamie Austin (Univ. of Texas), Kate Moran (Joint Oceanographic Institutions), Roy Hyndman (Canadian Geological Survey), and Kathy Gillis (Univ. of Victoria, British Columbia). Our premise for the "Hot Topics" session is:

Scientific ocean drilling (Deep Sea Drilling Project and Ocean Drilling Program) has contributed immensely to our understanding of earth system history and processes. In 2003, the current program will end, necessitating a hard look at the accomplishments to date and the scientific issues that remain. Are there sufficient compelling problems that can and should be attacked by ocean drilling? What tools and sources of funding are required to solve these problems? Is our understanding of fundamental earth processes only limited by available technology? The panel of ocean scientists will discuss these issues and entertain questions from the audience regarding the future of SOD.

As I write, it is our fond hope that this session will attract a large group of scientists interested in ocean drilling but who have not traditionally been involved in ODP.

The second forum will be a "town meeting" at the 1998 Fall American Geophysical Union (AGU) meeting in San Francisco. It is scheduled for 5:30 pm on Monday, December 7, 1998 at the Moscone Center, Room 125. For more information, look for signs at AGU or visit the ODP booth (numbers 208, 210, and 212 in the exhibit hall). This meeting has been dubbed "Suds for SOD" by one of my favorite proponents of SOD, which should suggest something to you regarding the tenor of the forum. We will use this opportunity to inform the AGU community about the planning process, provide updates, and to engage attendees in discussion of their perceptions regarding scientific issues and technical necessities. We are reserving a large room and we encourage your participation.

In late July 1998, USSAC convened a subcommittee to develop a plan—from the U.S. perspective—that details the structure and conduct of a post-2003 SOD program, including a U.S. national component analogous to the present U.S. Science Support Program (USSSP). This activity was in response to a request from NSF/OCE Director, Mike Purdy, that "USSAC provide more detailed recommendations on the scope, mechanisms, and procedures for implementing the scientific programs which will be required for the multi-platform program endorsed by the [COMPOST-II] report."

The subcommittee's membership and the text of their recommendations, which were approved by USSAC at our late September meeting, are printed on the pages that follow. USSAC urges you to read and consider these recommendations. They should be the catalyst for further discussion within our community. We welcome any constructive feedback. Please send your comments directly to me (arthur@geosc.psu.edu); I assure you that they will be vetted through USSAC as will all of the input we receive through our community forums.

Sincerely,

Michael A. Arthur
Chair, USSAC

REPORT OF THE AD HOC USSAC COMMITTEE

THE STRUCTURE OF THE U.S. COMPONENT OF A FUTURE SCIENTIFIC OCEAN DRILLING PROGRAM

State College, PA • July 21-22, 1998

PREAMBLE

An *ad hoc* subcommittee of U.S. Science Advisory Committee (USSAC) members and other representatives of the scientific community met to consider several issues related to structuring the U.S. component of a new, post-2003 scientific ocean drilling (SOD) program. This meeting was mandated by USSAC in March, in response to a formal request from G. M. Purdy, the Director of the NSF Ocean Sciences Division. Although the group discussed some options for drilling platforms, we attempted to structure a U.S. component that is platform-independent.

Because of the need for individual scientists to feel "ownership" of the program and to infuse new ideas that might not surface in initiative-based proposals, our first premise is that a future SOD program should strike a balance between scientific objectives determined by individuals (through specific drilling proposals) and those promoted by major scientific initiatives. We recognized a disjunction between the scientific objectives outlined by communities associated with major initiatives (e.g., MESH, MARGINS, RIDGE) and the drilling program carried out by ODP, despite attempts to tie some of the initiatives into the program through membership on JOIDES advisory panels. We also discussed how such a future program could accommodate the evolution of initiatives in addition to MESH, MARGINS, and RIDGE. As these come on-line, how would they contribute to the SOD planning process? How do we keep community interest in SOD as broad as possible and still give the community a sense of "ownership"?

We also considered funding aspects of pre- and post cruise science in the spirit of our second adopted premise—implementation of the "cascade of ocean drilling" recommended by COMPOST II (www.joi-odp.org). Currently, it's a challenge to procure funding to: 1) carry out the site characterization (e.g., geophysical imaging) required in advance of drilling, and 2) continue work on recovered material once the "Leg" impetus has peaked. Thus, both the source and procedure for funding of science related to SOD are at issue; can we envision new and adequate funding streams to ensure that high quality pre- and post cruise science is performed?

In ODP, the scientific process can stall post cruise, when support from USSSP winds down. Because of the leg-based emphasis, some scientists exit the structure prematurely. We also note that, perhaps for a variety of reasons, there may be insufficient effort spent on synthesizing results, evaluating success or failure, and then plugging these lessons back into the planning of future drilling. To address these concerns, we considered several ways to enhance the evaluation of the long-term scientific program, to assess its impact, and to feed the results of these analyses back into the planning process.

Finally, in order to embrace a new vision of integrated SOD and broader representation of U.S. institutions in ODP, the group supported USSAC's March, 1998 stance (motion 98-3-1) to expand the management

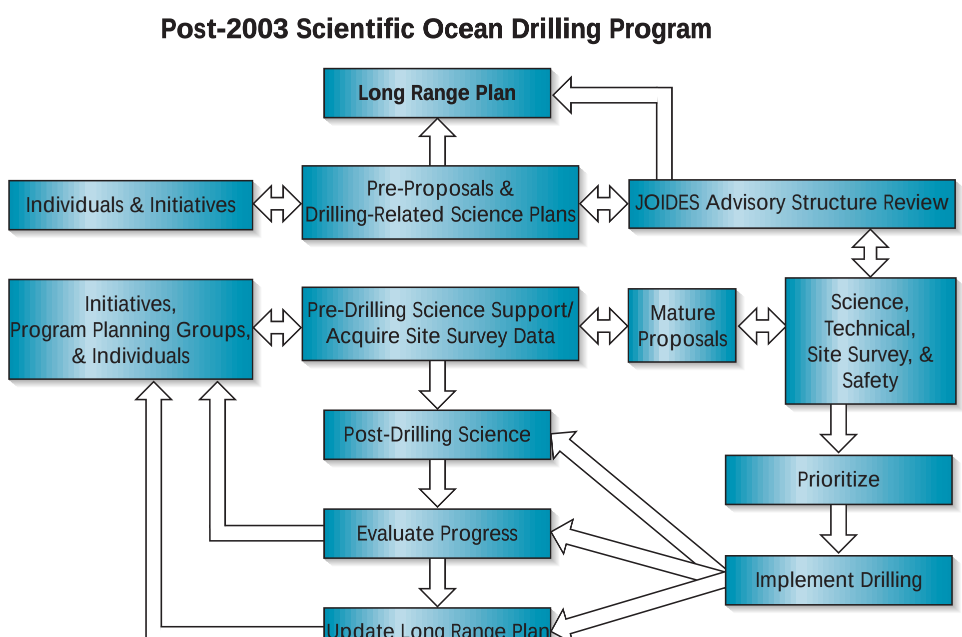

Fig. 1: Proposed structural elements, tasks, and functional relationships integral to a future scientific ocean drilling program.

input to drilling activities. This could take place either by expanding membership in JOI Inc. or by setting up a new corporate entity. We briefly considered the criteria for effective management of scientific ocean drilling and its implications for "ownership" of a scientific drilling program.

Recommendation 1: Structure of Program

Our goal was to identify a structure and procedures for the U.S. community that will facilitate operation of a future SOD program independent of drilling platform(s). Our intent was to foster proposals by individuals, while also serving broader scientific objectives identified collectively as "initiatives." We recognize that there is presently no clear avenue for the scientific objectives outlined by communities of individuals associated with major initiatives (e.g., MESH, MARGINS, RIDGE) to be accommodated in the drilling program carried out by ODP other than by submitting drilling proposals to JOIDES. Figure 1 illustrates functional relationships among the various elements and tasks outlined below.

"Initiatives" are defined as entities with a specific scientific focus that have 1) international stature, 2) an internal advisory structure, and 3) the ability to fund workshops and generate programs and proposals. We anticipate that initiative-based science will continue to grow within NSF-OCE MG&G and will garner a larger proportion of its funds. Under the new structure we envision, initiatives would:

A) Generate a rationale for their scientific objectives and disseminate it to the broader community;
B) Prioritize drilling objectives and provide input to a SOD long-range plan (LRP) reviewed by the JOIDES structure;
C) Submit "mature" drilling proposals which would include specific means of collecting the relevant regional and site-survey data;
D) Identify and communicate specific technological needs to JOIDES panels;
E) Regularly evaluate progress on the long-range plan and priority drilling objectives. This will require post-mortem analysis of specific programs and will help to maintain a "corporate" memory.

We think the JOIDES advisory structure has the following responsibilities:

A) Writes the LRP for drilling, incorporating priorities of the scientific community, including existing and new "initiatives," after suitable review;
B) Solicits and evaluates research proposals and programs;
C) Facilitates technical advice and outlines technical requirements for drilling;
D) Prioritizes drilling-based science;
E) Reviews/analyzes progress relative to LRP objectives. This activity should be done in tandem with initiatives to identify possible problems and successes.

We are reluctant to offer a more detailed structure, but, at a minimum, it should have the following characteristics:

A) Willingness to commit to long-term projects;
B) Responsiveness to the scientific and industrial communities;
C) Representation of the broad spectrum of disciplines that drilling serves;
D) Participation in the decision-making process by the broadest community possible;
E) Ability to provide expertise/advice on site survey issues for envisioned drilling;
F) Ability to provide safety oversight.

Recommendation 2: Organization of a USSOD Workshop

USSAC acknowledges the need to hold a small (40-50 participants) workshop of U.S. investigators in early 2000 to evaluate the international plans from the riser (CONCORD, July 1997) and riserless (COMPLEX, May 1999) conferences in terms of their relevance to U.S. SOD objectives/long-range planning. This workshop should be composed of representatives from U.S./JOIDES, U.S. science initiatives (MESH, MARGINS, RIDGE, …) and the "at-large" scientific community. The workshop attendees will examine (a) the reports from CONCORD and COMPLEX, (b) science plans of designated U.S. initiatives, (c) the current ODP LRP, and (d) any other relevant science planning documents, such as those that will come out of the JOIDES technology meeting in Houston, in November 1998. The group should assess the contribution of a post-2003 SOD program for U.S. science, as input to both NSF planning and to the third international COSOD, also scheduled for 2000.

Recommendation 3: Mechanisms for Funding Drilling-Related Science

Members of this *ad hoc* USSAC subcommittee perceive a critical need to enhance post-cruise science support for the post-2003 SOD program tentatively dubbed "Integrated Ocean Drilling Program" (IODP). Such enhancement must directly address the disconnection that we perceive among ongoing pre-cruise survey and planning activities, shipboard activities, and post-cruise research.

We envision two mechanisms to support post-cruise science activities. First, the successor program to USSSP should continue to provide modest post-cruise science support grants to U.S. participants based on peer-reviewed proposals. The small, rapid-turnaround grants (~$20K plus one month salary support, in addition to the three months of salary support currently provided for shipboard participation) provide complete funding for small projects associated with meeting the short-term scientific objectives of the leg, and for seed funding for larger efforts. Second, we recommend that substantial new resources, targeted for drilling-related science, be made available through the NSF peer review process for post-cruise science support. The retreat committee discussed possible homes for these new funds (e.g., MG&G versus ODP at NSF) and the degree to which community initiatives would steer or influence prioritization of post-cruise project funding. While there are no unambiguous answers to these questions, a general and broad consensus emerged, that:

A) We must link IODP science as strongly as possible with the overall goals of the MG&G and with the broader geoscience communities. Accordingly, new funds for post-cruise science support should reside within the MG&G program at NSF, but would be identified for research related to SOD.

B) Mechanisms must be developed whereby community-based initiatives, such as those identified in the COMPOST II documents (e.g., MARGINS, MESH, RIDGE) can provide timely advice on program priorities and proposal/project relevance to initiative objectives and to the ODP LRP. Such mechanisms must include regular evaluations of individual leg outcomes and the changing status of progress towards achievement of initiative objectives. Initiative priorities should influence post-cruise science funding, but not at the expense of individual proposals that merit funding.

C) Peer-review remains the mechanism for funding proposals, both initiative and non-initiative based. Program managers should ensure that program funds are accessible to competition from individual investigators, irrespective of their links to established initiatives.

D) Many of the proposed initiatives that comprise key elements of the new drilling program also have non-drilling elements. To prevent perceived disconnects between scientific drilling support and core MG&G support, and to maintain funding for individual investigators-initiated research, overall MG&G budgets should increase in concert with enhanced ODP support.

Recommendation 4: Structure and Funding of Pre-Drilling Site and Regional Surveys

The need for pre-drilling scientific studies, including site-specific surveys as well as more regional studies, will be significantly greater for a multi-platform program, especially for riser drilling holes. If the U.S. community is to participate fully in an enhanced SOD program, the support for pre-drilling site characterization must be expanded substantially. That is, the program will require significantly more funding.

Two sources of funding for U.S. scientists were identified for this work: co-mingled IODP funds and NSF program funds (MG&G/EAR/OPP as appropriate). Provisions should be made within the structure of IODP for co-mingled funds to be used for highly specific site surveys, e.g. those required for safety or geotechnical requirements as opposed to those expressly for scientific purposes. In cases where these surveys require high-resolution, 3-D imaging experiments beyond the current capabilities of the academic community, the option of contracting these surveys to industry should be available. Funds for less site-specific, drilling-related scientific studies, including integration and synthesis of existing data, as well as collection of new data, should be available to individual U.S. scientists through NSF program funds including major U.S. geoscience initiatives (e.g., MARGINS, RIDGE, MESH) whose goals are closely linked to/or require SOD.

Recommendation 5: Future Program Management

Several guidelines are presented here to aid in the development of the IODP management and in the selection of the prime contractor. First, we hope that significant elements of the program management and operation fall within U.S. institutions and/or corporations in order to maintain a high level of U.S. presence and leadership within a future drilling program. Second, the management structure and the managers need to be responsive to the broadest possible user community, to work closely with the U.S. funding agencies, and to provide broad outreach of the program's successes and research contributions. We commend the recent efforts to broaden both the membership of JOI, Inc. and the drilling program advisory structure, and we believe that any future management structure should do the same. Third, we think that a future program would be best served if management were separate from the operational subcontractors because of the need to maintain checks and balances. Finally, we think that management should have great flexibility for subcontracting and hiring in order to find needed technical expertise and deliver important scientific support services in a timely manner.

Committee Members

Mike Arthur (Chair), USSAC Chair
Jamie Austin, USSAC
Bill Curry, USSAC
Rob Dunbar, USSAC
Rick Murray, USSAC
Bob Detrick, Chair, JOIDES EXCOM
Ted Moore, Chair, JOIDES ESSEP
Dennis Kent, at large
Nick Pisias, at large
Eric Barron (day 1), guest observer

Liaisons:

Bruce Malfait, NSF
Paul Dauphin, NSF
Jamie Allan, NSF
Kate Moran, JOI
John Farrell, JOI

Finance and the Future

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

As this article is being written, President Clinton has not yet signed the fiscal year 1999 budget for the National Science Foundation, but we hope this will happen soon. Congress passed a conference bill that provides NSF with a total appropriation of $3.672 billion for fiscal year 1999. This is $243M or 7.14% more than the FY 1998 level. For research and related activities, the conferees agreed to provide $2.770 billion—an increase of $224M or almost 9% above the FY 1998 level. How will this be reflected in the funding level for the Geosciences Directorate or the Division of Ocean Sciences (OCE)? The answer remains to be seen, but the prospects are definitely positive.

While Congress and the President spar over the budget, we at NSF continue to perform our duties. A significant challenge in OCE these days is preparing for the period post-2003 which should see the transition to an enhanced drilling program that will use more than one platform. One envisioned platform would have well-control capabilities employing riser technology to drill deep crustal holes. It would also provide entry into other difficult or inaccessible environments, such as convergent accretionary margins, which require hole stabilization not available on non-riser drillships like the *JOIDES Resolution*.

The other major platform envisioned for the new program is a much enhanced non-riser vessel. The non-riser science will be discussed at a coordinated international conference dubbed COMPLEX (Conference On Multi-PLatform EXploration) scheduled for May 26-29, 1999 at the University of British Columbia in Vancouver, B.C., Canada. For more information, contact Drs. Nick Pisias (pisias@oce.orst.edu) and Asahiko Taira (ataira@ori.u-tokyo.ac.jp) who will co-convene COMPLEX on behalf of the JOIDES advisory structure.

In addition to all the scientific, technological, and management planning required to implement a multi-platform drilling program, significant thought must be devoted to the relationship such a program will have with other programs and initiatives within the geosciences. To be successful, it will need to maximize science return and the efficiency by which it complements and enhances these other programs.

One can envision that the necessary full characterization of riser sites will make each hole a major project. Site preparation will require such things as three-dimensional seismic imaging and conventional non-riser drilling. Because of the magnitude of effort required, each site needs to be carefully chosen for maximum scientific impact. Close coordination will be required among those planning scientific ocean drilling and those associated with initiatives such as MARGINS, MESH, and the International Continental Drilling Program. Wider community involvement will be needed—with the JOIDES SEIZE (Seismogenic Zone) Program Planning Group perhaps being a model for how such projects will be planned.

In addition to optimally integrating a portfolio of geosciences programs and initiatives with a future multi-platform drilling program, adequate and appropriate support must be provided to allow the U.S. scientific community to participate in this major international effort. Drawing on the positive elements of the present, highly successful, ODP, and identifying those areas that could be improved is perhaps a place to start. Determining the ideal support structure for U.S. participation in a new, complex scientific drilling program and maintaining a proper balance within the geosciences will be a real challenge. We have asked the Scientific Advisory Committee (USSAC) to the U.S. Science Support Program (USSSP) to begin addressing these issues. We are open to suggestions and invite your comments on these issues, as well as on all other issues related to planning this bold, exciting enterprise of the 21st Century. We want to continue scientific ocean drilling's history of compelling successes. We invite you to participate in the ODP "Town Meeting" at the Fall AGU meeting and to take that opportunity to let your voice be heard.

THE U.S. SCIENCE ADVISORY COMMITTEE

MEMBERS

Dr. John M. Armentrout
Mobil E&P Technical Center
300 Pegasus Park Drive
Dallas, TX 75265-0232
tele: (214) 951-2865; fax: (214) 951-2265
john_m_armentrout@email.mobil.com

Dr. Michael Arthur, Chair*
Department of Geosciences
Pennsylvania State University
503 Deike Building
University Park, PA 16875
tele: (814) 863-6054; fax: (814) 863-7823
arthur@geosc.psu.edu

Dr. Rodey Batiza*
Department of Geology and Geophysics
University of Hawaii
POST Building
Honolulu, HI 96822
tele: (808) 956-5036; fax: (808) 956-5512
rbatiza@soest.hawaii.edu

Dr. Tim Byrne
Department of Geology and Geophysics
University of Connecticut
345 Mansfield Road
Storrs, CT 06269-2045
tele: (806) 486-1384; fax: (806) 486-1383
byrne@geol.uconn.edu

Dr. Steve Carey
University of Rhode Island
Graduate School of Oceanography
South Ferry Road
Narragansett, RI 02882
tele: (401) 874-6209; fax: (401) 874-6811
scarey@gsosun1.gso.uri.edu

Dr. Nicholas Christie-Blick
Lamont-Doherty Earth Observatory of Columbia University
Palisades, NY 10964-8000
tele: (914) 365-8821; fax: (914) 365-8150
ncb@ldeo.columbia.edu

Dr. Margaret Delaney*
Ocean Sciences Department
University of California, Santa Cruz
1156 High Street
Santa Cruz, CA 95064-1077
tele: (831) 459-4736; fax: (831) 459-4882
delaney@cats.ucsc.edu

Dr. Robert B. Dunbar*
Geological and Environmental Sciences
Stanford University
Stanford, CA 94305-2115
tele: (650) 725-6830; fax: (650) 725-0979
dunbar@stanford.edu

Dr. Gregor Eberli
Marine Geology and Geophysics
University of Miami/RSMAS
4600 Rickenbacker Causeway
Miami, FL 33149
tele: (305) 361-4678; fax: (305) 361-4632
geberli@rsmas.miami.edu

Dr. Tim Herbert
Department of Geological Sciences
Brown University
Providence, RI 02912-1846
tele: (401) 863-1207; fax: (401) 863-2058
timothy_herbert@brown.edu

Dr. Marvin Lilley
Box 357940
School of Oceanography
University of Washington
Seattle, WA 98195
tele: (206) 543-0859; fax: (206) 543-0275
lilley@ocean.washington.edu

Dr. Richard Murray
Boston University
Department of Earth Sciences
685 Commonwealth Avenue
Boston, MA 02215
tele: (617) 353-6532; fax: (617) 353-3290
rickm@bu.edu

Dr. David Naar
University of South Florida
Marine Science Department
140 Seventh Avenue, South
St. Petersburg, FL 33701-5016
tele: (727) 553-1637; fax: (727) 553-1189
naar@marine.usf.edu

Dr. Lisa Tauxe
Scripps Institution of Oceanography
University of California
Geosciences Research Division
La Jolla, CA 92093-0220
tele: (619) 534-6084; fax: (619) 534-0784
ltauxe@ucsd.edu

Dr. Mike Underwood
Department of Geological Science
University of Missouri
101 Geology Building
Columbia, MO 65211
tele: (573) 882-4685; fax: (573) 882-5458
geoscmbu@showme.missouri.edu

Membership term is three years

* USSAC Executive Committee

LIAISONS

Dr. J. Paul Dauphin
Associate Program Director
Ocean Drilling Program
National Science Foundation
4201 Wilson Boulevard, Room 725
Arlington, VA 22230
tele: (703) 306-1581; fax: (703) 306-0390
jdauphin@nsf.gov

Dr. John Farrell
Program Director, JOI/USSSP
Joint Oceanographic Institutions
1755 Massachusetts Avenue, NW, Suite 800
Washington, DC 20036-2102
tele: (202) 232-3900 x211; fax: (202) 232-8203
jfarrell@brook.edu

Dr. Thomas Davies
Manager, Science Services
Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, TX 77845-9547
tele: (409) 862-2283; fax: (409) 845-0876
tom_davies@odp.tamu.edu

JOI/USSAC NEWSLETTER

Editors: John Farrell and Andrea Johnson
Layout and Design: Johanna Adams

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JOI/USSAC NEWSLETTER

Joint Oceanographic Institutions
1755 Massachusetts Avenue, NW, Suite 800
Washington, DC 20036-2102 USA

SCHEDULE FOR ODP LEGS 182-193

LEG	REGION	CO-CHIEFS	DEPARTURE PORT	DEPARTURE DATE	SCIENTIFIC OBJECTIVES
182	Great Australian Bight	Feary Hine	Wellington	10/98	To document this carbonate platform's evolution since 65 Ma and to study global sea-level fluctuations, physical and chemical paleocean dynamics, biotic evolution, hydrology and diagenesis.
183	Kerguelen	Coffin Frey	Fremantle	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.
184	E Asia Monsoon	Prell, Wang	Fremantle	2/99	To investigate the interrelationships among uplift, monsoon evolution, and global cooling.
185	Mariana-Izu	Ludden Plank	Hong Kong	4/99	To investigate crustal recycling by determining the net fluxes of material at the Mariana-Izu subduction zone by mass balance of inputs and outputs.
186	W Pac Seismic Net/Japan Trench	Sacks Suyehiro	Tokyo	6/99	To establish long-term borehole geophysical observatories in the western Pacific to provide information about subduction zone earthquakes and the mechanics of the subduction process.
186T	Transit	-----	Tokyo	8/99	----------
-----	Dry Dock	-----	TBN	8/99	----------
186E	HD Engineering	-----	TBN	10/99	----------
187	Aus-Ant Discordance	Christie TBN	Sydney	11/99	To investigate relationships of crustal and mantle composition, spreading, and magma supply rates in an area suspected to have unusual mantle dynamics and profound magma supply differences.
188	Prydz Bay	TBN TBN	Fremantle	1/00	To link Antarctic Ice Sheet events with Southern Ocean changes, to recover a record of Antarctica's Plio-Pleistocene glacials and Paleogene environment, to date the first glacial evidence in Prydz Bay.
189	Southern Gateways	TBN TBN	Hobart	3/00	To document paleocean/climatic changes related to the tectonic opening of the Tasmanian Seaway and Drake Passage which thermally isolated Antarctica and spawned the Circumpolar Current.
189T	Transit	-----	Hobart	4/00	----------
190	Nankai	TBN TBN	Guam	5/00	To model of fluid-linked diagenetic and tectonic processes in a rapidly deforming accretionary prism by comparing two different wedge tapers and structural geometries within the Nankai Trough.
191	W Pacific Ion	TBN TBN	Tokyo	7/00	To emplace a permanent observatory (downhole seismometer) in the tectonically active Western Pacific at a high-priority area identified by the International Ocean Network (ION).
192	Manus Basin	TBN TBN	Guam	8/00	To understand the chemical fluxes, fluid pathways, and ore deposition of felsic volcanic-hosted polymetallic massive sulfides by probing the active PACMANUS hydrothermal system.
193	Ontong-Java	TBN TBN	Guam	10/00	To determine the Ontong-Java Plateau's age, paleolatitude, emplacement duration, vertical tectonic history, the effects of rift-related tectonism, and the range and diversity of magmatism.