JOI/USSAC NEWSLETTER

News from the Joint Oceanographic Institutions/U.S. Science Support Program associated with the Ocean Drilling Program • Fall 1999 • Vol. 12, No. 2

DOES GRAIN SIZE DETERMINE ACOUSTIC BACKSCATTER ON THE NEW JERSEY CONTINENTAL SHELF? SOMETIMES!

J. A. Goff, H. Olson, C. S. Duncan, G. Moss, and J. A. Austin, Jr.

In September, 1998, with Site Survey Augmentation funding from JOI/USSSP, we collected ~300 sediment grab samples along the New Jersey "Mid-Atlantic Transect," in the vicinity of three proposed jack-up drilling sites that have been surveyed with both swath mapping (Goff et al., 1999) and multichannel seismic reflection profiles (survey by G. Mountain et al.) (Figure 1). The samples have been analyzed for grain-size distribution, and their micropaleontology was studied this summer. Ultra-high resolution chirp seismic reflection data were collected in June 1999. The purpose of the work is threefold: (1) to provide additional site characterization for future placement of jack-up rigs; (2) to "ground truth" the sidescan sonar backscatter data; and (3) to better understand bedform evolution in inner- and mid-shelf settings. We have intermittently established an unprecedented level of correlation between grain size and backscatter intensity. This finding generally supports our hypothesis that bedforms in ~20-45 m water depth are responsive to the present day hydrodynamic environment, although the larger ridges may be partially relict from an interval of lower sea level. However, the observed correlation of grain size to backscatter can be degraded if the sediments include even a few extra weight percent of the largest grain sizes (>4 mm), typically shell hash.

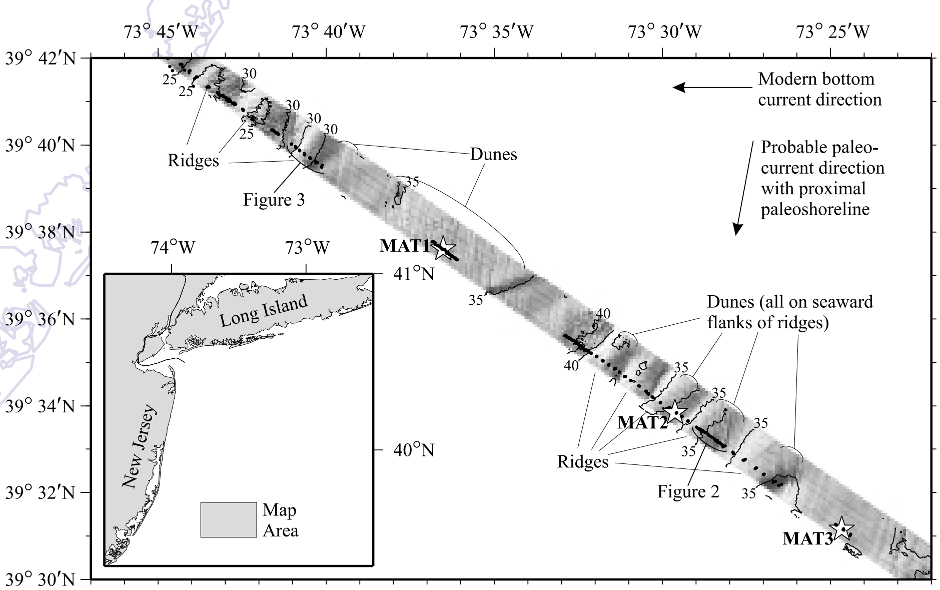


Fig. 1: Simrad EM1000 multibeam bathymetry along part of the Mid-Atlantic Transect, New Jersey inner shelf (location in inset), artificially illuminated from the northwest. Contours are shown in meters. Dots indicate grab sample locations. Stars indicate approximate proposed locations for jack-up drilling.

GROUND TRUTHING BACKSCATTER

Sidescan backscatter has long been used as a qualitative seafloor mapping tool, a "sonic photograph" of the seafloor. Backscatter intensity variations can arise from bottom topography, from varying acoustic properties of seafloor material, or from both. The holy grail of acoustic swath mapping is to use backscatter more quantitatively; that is, to transform the image into estimates of seafloor properties (e.g., grain size, density, composition). "Ground truthing" the sidescan data, that is, sampling and analyzing seafloor material within the survey area to correlate backscatter properties to bottom properties, is the key to the quantitative approach. In a purely sedimentary seafloor environment,

INSIDE

where variations in backscatter and sediment properties can be subtle, this is a difficult task because there are many sources of uncertainty: (1) navigational inaccuracies of sonar and sampling surveys, (2) noisiness of backscatter data, (3) difficulties in estimating *in situ* sediment properties from samples, and (4) the complexity inherent in ascertaining whether a sample is representative of a larger region (pixel size is ~5 m by 5 m).

Grain size is thought to be a principal determinant of backscatter intensity for sedimented seafloor. However, this assumption has only been demonstrated previously for sandy and coarser sediments, and then only fairly broadly (i.e., coarse vs. medium vs. fine sands; e.g., Davis et al., 1996). The correspondence between backscatter and mean grain size demonstrated in Figure 2 is remarkable because of the subtlety of the variations. Backscatter variations here fall within the pixel-to-pixel noise level; they are visible in profile only after careful filtering. Corresponding mean grain sizes range only from ~0.3 to 0.4 mm, entirely within the medium sand category. We can attribute part of this correlation to improvements in data acquisition techniques; i.e., consistent use of differential GPS navigation, large sample sizes (~300 g), and careful filtering of sidescan data. However, this level of correlation is not seen everywhere in our study area; in fact, in some locations on the New Jersey inner and middle shelf we can find no correspondence at all. Our best correlations appear when the grain-size distribution is unimodal, and particularly when the sediments are well sorted (low variance). Even a small extra percentage of large grain sizes (> 4 mm), commonly shell hash, degrades the correlation because, although backscatter is disproportionately affected by these larger grain sizes, their proportion is difficult to measure accurately without even larger and more areally extensive sample sizes. Nonetheless, our results indicate that backscatter from sandy shelf sediments is predominantly responsive to variations in grain-size distribution. This information will be important for future siting of jack-ups on the New Jersey inner shelf.

Sand Ridge Evolution

Sand ridges are among the largest and most pervasive bedforms on the mid-Atlantic continental shelf, yet they are also the most enigmatic. The puzzle comes from the fact that they are oriented obliquely (~20° to 40°) to the direction of formative bottom current flow. Sand Ridges are most vigorously active along the shoreface (e.g., Swift and Field, 1981), although there are five competing models for their formation (see Goff et al., 1999, for summary). The fate of ridges when sea level rises is also poorly understood: do they become "moribund," or do they continue to evolve, and if so, how? The implications go beyond understanding bedform evolution. In this sediment-starved shelf environment, reworking of transgressive sand deposits could alter the paleobathymetry derived from the micropaleontologic record by mixing nearshore and offshore faunas; this has potentially important implications for the interpretation of sea-level history from drilling records.

In the portion of the New Jersey inner shelf surveyed (Figure 1), there are two clusters of ~NE-SW-oriented ridges, each several meters high and ~1-3 km wide. Numerous smaller dunes are oriented ~N-S, generally <1 m in amplitude and <200 m in width. Bottom current directions in the surveyed portion of the inner shelf are evidently ~W (Vincent et al., 1981; Figure 1), a deviation from the ~S to SW, contour parallel currents that are more

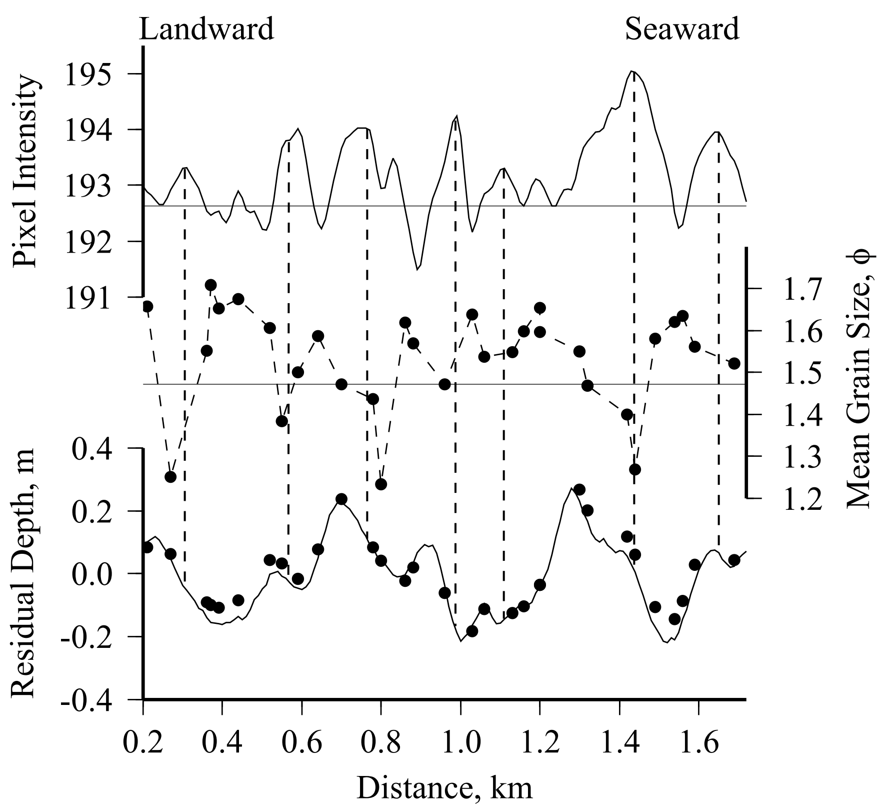


Fig. 2: Coincident backscatter (top), mean grain size (middle) and residual depth (bottom) across a series of inner shelf dunes (see Figure 1 for location). Backscatter has been stacked (averaged) along the dune trend and additionally filtered along the profile to reduce noisiness. One pixel value corresponds to 0.5 db in backscatter strength. Dots indicate grab sample locations projected along the dune trend onto the profile line. Mean grain size is given in values of $f = -\text{Log}_2(S)$, where *S* is grain size in mm; smaller values of *f* thus correspond to larger grain sizes. Residual depth is formed by removing a best-fitting trend from the bathymetric profile. Vertical dashed lines demonstrate correspondence between high backscatter, larger grain sizes, and seaward (east) facing (up-current) dune slopes.

typically observed in the Mid-Atlantic Bight. In contrast, when sea level was lower and the shoreline was closer, currents through this region were likely constrained to be shore parallel, or ~SSW (Figure 1) as determined by regional contours. This change in current direction over the past ~10,000 years is important because it helps us to distinguish modern from relict bedforms.

The grain-size pattern over the dunes, coarser on the E flanks (Figure 2), is consistent with formation transverse to the modern current because the eroding, upcurrent flanks should have a coarser residue. But are larger ridges also responding to the modern current? Their ~NE-SW ridge orientation is what we might expect if these had been formed oblique to a ~SSW paleoshoreline. However, their slope asymmetry contradicts this interpretation. Nearshore, the seaward flanks, in the lee of a SSW-directed alongshore flow, are steeper (e.g., Swift and Field, 1981). Offshore in our study area, landward flanks tend to be steeper (Figure 3), suggesting a response to a seaward current direction. The backscatter and grain-size pattern over these ridges is complicated. In the displayed example (Figure 3), backscatter and grain size are generally higher on the seaward flank. This would support its interpretation as an upcurrent slope, but there is also a large grain size and backscatter spike at the base of the landward slope, which is a common feature seen in nearshore ridges (Swift and Field, 1981).

The slope break on the seaward ridge flank (Figure 3), another common feature of these ridges which gives them a somewhat trapezoidal cross section, is an added complexity. Similar shapes have been observed in sand waves in tidal regimes and interpreted as resulting from alternation between primary and secondary current directions (e.g., Swift et al., 1978). Like the tidal bedforms, these ridges may have formed under the influence of more than one current direction. We hypothesize that they originally formed in a nearshore paleoenvironment under a ~SSW-directed flow when sea level was lower, and have subsequently been heavily modified, but not entirely deconstructed, at their present water depth by the modern, ~W bottom currents. Forthcoming chirp seismic data, which will image the internal structure of the ridges, should test this hypothesis.

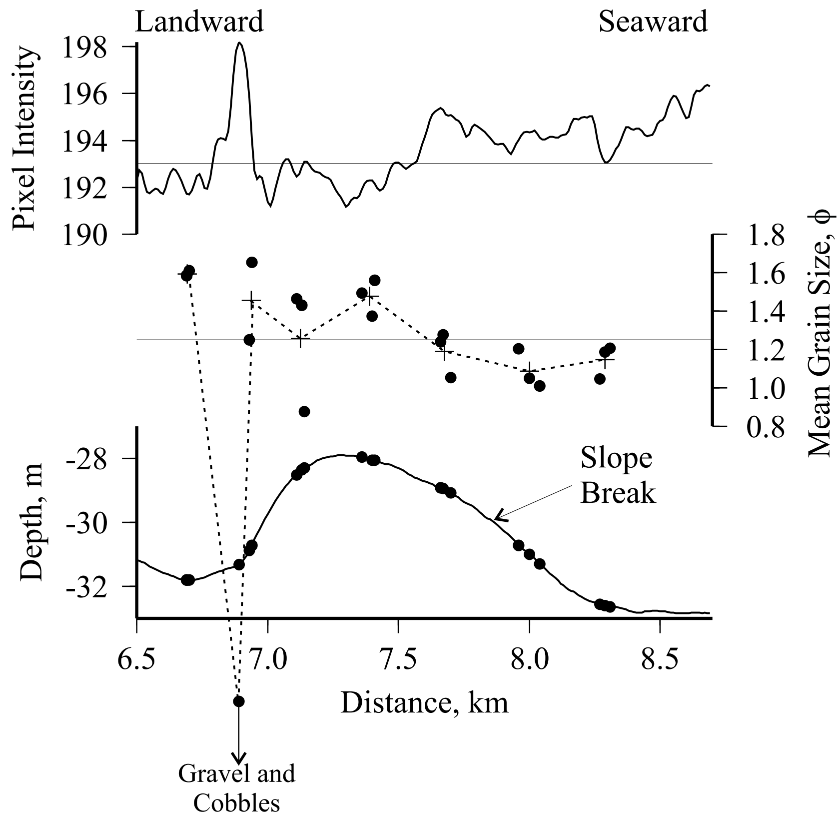


Fig. 3. Coincident backscatter (top), mean grain size (middle) and bathymetry (bottom) across an inner shelf ridge (see Figure 1 for location). Backscatter has been filtered both across and along the profile to reduce noisiness. One pixel value corresponds to 0.5 db in backscatter strength. Dots indicate grab sample locations projected onto the profile line. Mean grain size is given in values of f = -Log$_2$(S), where S is grain size in mm; smaller values of f thus correspond to larger grain sizes. Crosses indicate group averages. The overall pattern of higher backscatter and larger grain sizes on the seaward slope is complicated by a strong spike in both measures at the base of the landward slope.

The Authors

John A. Goff, Research Scientist; Hilary C. Olson, Research Associate; C. S. Duncan, Doctoral Graduate Student; G. Moss, Postdoctoral Researcher; and James A. Austin, Jr., Senior Research Scientist; are all at the University of Texas Institute for Geophysics. They are collaborating in the Office of Naval Research's STRATAFORM program for which one of the natural labs is the New Jersey shelf. The ONR and ODP efforts are closely linked both in science and in funding.

References

Davis, K. S, et al., Acoustic backscatter and sediment textural properties of inner shelf sands, northeastern Gulf of Mexico. *Geo-Mar. Letters, 16*, 273-278, 1996.

Goff, J. A., et al., High resolution swath sonar investigation of sand ridge, dune and ribbon morphology in the offshore environment of the New Jersey margin. Submitted to *Marine Geology*, 1999.

Swift, D. J. P. and Field, M. E., Evolution of a classic sand ridge field: Maryland sector, North American inner shelf. *Sedimentology, 28*, 461-482, 1981.

Swift, D. J. P., et al., Evolution of a shoal retreat massif, North Carolina shelf: Inference from areal geology. *Marine Geology, 27*, 19-42, 1978.

Vincent, C. E., Swift, D. J. P. and Hillard, B., Sediment transport in the New York Bight, North American Atlantic shelf. *Marine Geology, 32*, 369-398, 1981.

DRILL BITS

DRILLSHIP RETURNS TO SEA

The *JOIDES Resolution* is at sea again after spending two months in a scheduled drydock in Singapore. As contractually stipulated, NSF spent over $6 M to upgrade the ship. She received new capabilities for dynamic positioning, improvements to the thrusters and hull, a new active heave compensation system, refurbished quarters, and an expansion of the laboratory stack, including additional space for logging and for a new microbiology lab.

HONORING DON HEINRICHS

Don Heinrichs will retire from the NSF at the end of 1999 after serving the oceanographic community for nearly 30 years. He began his administrative career in 1971 with the Office of Naval Research and moved to NSF in 1975. Spending the next decade as Program Director of the Submarine Geology and Geophysics Program, he provided important continuity for an expanding and increasingly technical research enterprise. In 1985 he became head of the Oceanographic Centers and Facilities Section with responsibility for ships, facilities and the ODP. Drs. Bruce Malfait (NSF) and Debra Stakes (MBARI) have organized two special sessions at the Fall 1999 AGU Meeting to honor Don and his many contributions to ocean science. A morning poster session and an afternoon oral session will be held on December 14 and will recognize Don's distinguished career and commitment to advancing scientific research.

CONCEPTUAL DESIGN COMMITTEE LAUNCHED

To meet the objectives of a post-2003 ocean drilling program, the scientific community has consistently emphasized that both riser (well-control) and non-riser drilling capabilities will be required. Japan is building a large (ca. 210 m, 50,000 ton) riser vessel meant to address some of these needs. As amply demonstrated at the COMPLEX meeting, a non-riser vessel, with enhanced capabilities, is also needed. NSF has said that it would seek the necessary resources to bring such a vessel to a future program. This vessel would constitute a major capital asset of the future Integrated (riser and non-riser platforms) Ocean Drilling Program (IODP). To accomplish this, the operational and scientific capabilities of this drilling vessel need to be carefully identified. NSF has requested that USSAC assist with this effort. In response to this request, USSAC has formed the Conceptual Design Committee (CDC). The CDC is chaired by Peggy Delaney and is comprised of Tim Byrne (U. Conn.), Steve Clemens (Brown U.), Susan Humphris (WHOI), Roger Ingersoll (Mobil), and Tom Janecek (Florida State U.). The CDC is also being assisted by a consultant, Brian Taylor (Jacques Whitford and Associates). Jamie Austin (UTIG) is the liaison to CDC from IPSC. Their final report is due to NSF on March 1, 2000.

BON VOYAGE JOHANNA

JOI/USSSP bids a fond farewell to Johanna Adams, JOI's graphics artist. The appearance of this newsletter—and every other document JOI has produced for nearly a decade — bears testimony to Johanna's skill. We thank her for her past contributions and wish her well in her future adventures as she seeks new challenges in San Francisco.

ADIEU PAMELA

In July, Pamela Baker-Masson resigned her position as Director of Public Affairs for the ODP at JOI. She's continuing her career in the ocean sciences as Director of Communications for JOI's sister company, the Consortium for Oceanographic Research and Education (CORE). Pamela now works under CORE's new Vice President and Executive Director, Dr. Robert Winokur. JOI thanks Pamela for raising the profile of scientific ocean drilling in both national and international arenas, and we wish her well at CORE.

WELCOME TAD

In July, Tadeusz "Tad" Gladczenko joined JOI as a Technical Program Associate. In September, Tad completed his Ph.D. in geophysics/geology from the University of Oslo, Norway and the University of Texas at Austin. Tad has brought JOI much-needed computer expertise and is helping with web site administration, data management, problem solving and computer-aided communication.

MARGINS WORKSHOP: SOURCE TO SINK

Continental margins are the principal locus of sediment accumulation on Earth. The pathways followed by sediments on their journey from source to sink have major impacts on human beings, ranging from natural hazards, to pollutant transport, shoreline erosion, and resource preservation. NSF, JOI/USSSP, and MARGINS sponsored an interdisciplinary workshop to discuss the most important directions for future research; to recommend research strategies; and to consider candidate sites for detailed field studies. About 50 participants attended this workshop held September 28 to October 1, 1999 at Lake Quinault, Washington State. The science plan generated from the meeting is expected to provide a blueprint for taking geomorphologic, sedimentary and stratigraphic processes to a substantially higher level of understanding. Workshop participants discussed the entire spectrum of onshore and offshore topics, including theoretical, experimental, and field-oriented research. For further information, see http://www.soest.hawaii.edu/margins/sedstrat.html.

Mimicking Mother Nature

Two replicas of ODP K/T boundary cores were produced for use by the ODP community in 1998. One was used in March 1999 by UTIG for a local science fair and has since remained with UTIG for use in a museum exhibit. The demand for such cores continues to increase, and ODP Curator Paula Weiss has come to the rescue. Using her superb pottery skills, Paula took time during Leg 186 to create several additional faux cores. The goal is to have a series of cores that represent some of ODP's most significant findings available for exhibits. Stop by the ODP booth at AGU to view examples of Paula's work.

ODP Cores on Tour

Two real ODP cores were borrowed by the American Natural History Museum in New York City. The sections on loan are from the Caribbean (165-1002C-1H-4) and from offshore west Africa (108-659A-20H-6). Plans are also in the works to loan ODP cores to The North Carolina State Museum of Natural Sciences which opens in April 2000. The geology theme in the exhibit will focus on oceanic crust and the post-Triassic genesis of the Atlantic Ocean. The museum has requested a seafloor pillow basalt, and a radiolarian chert.

A Big Splash in Yokohama

The *JOIDES Resolution* visited Yokohama for a port call between ODP legs 185 and 186 from June 15-19, 1999. During VIP events on June 16, ODP hosted 171 guests aboard the ship throughout the day for personalized tours. Handouts and posters explaining ODP science, ship operations, and plans for post 2003 were presented. The guests included five members of the Japanese Diet, high-ranking university and funding agency officials, academics, industry representatives, and science and technology representatives from several embassies/consulates. The media were also invited to tour the ship and interview scientists. Japan's Ocean Research Institute (ORI) also hosted a reception where remarks were given by Director of ORI (K. Taira), Vice President of U. Tokyo (M. Kobayashi), STA (S. Murakami), NSF (E. Murdy, Tokyo Office), ODP (J. Baldauf), Kanpai by Prof. N. Nasu, Leg 185 Co-chief (T. Plank) and Leg 186 Co-chiefs (K. Suyehiro and S. Sacks).

Over 1,350 visitors toured the ship during the Open Ship Day on June 17. Visitors included students, academics, and the general public. This high volume of visitors may have set a new record for the number of guests to visit the ship in a single day. The Japanese Port Call Committee was chaired by Dr. Asahiko Taira, composed of ORI and JAMSTEC staff, and supported by ODP Public Affairs.

IWG Office Mobilizes

NSF and the Japanese Marine and Science Technology Center (JAMSTEC) have requested that JOI Inc. provide administrative support to the International Working Group (IWG) and related entities (e.g., the JOIDES IODP Planning Subcommittee) in the form of an interim support office. The office will be co-located at JOI, in Washington, DC, and begins operation in November for a two-year period. The office will consist of representatives from JAMSTEC and JOI as well as two office support staff personnel. Operational costs for the office and the support staff will be divided equally between JAMSTEC and NSF. The office will provide administrative and financial support for planning activities required to define the post-2003 scientific ocean drilling program. The office will also coordinate communication among U.S., Japanese, and other potential partners as they identify and develop options for support and operation of the future program.

ODP Public Affairs Director

JOI seeks applicants for Director of Public Affairs to develop and manage the public affairs activities that promote the achievements of the ODP to the scientific community, industry, funding agencies and the general public. Applicants should have a BA or equivalent in communication/journalism, 7 years professional experience, excellent communications skills, and previous experience in developing and implementing a public information strategy. The position requires someone who is resourceful, well-read, and able to work comfortably with contacts in a wide variety of organizations and settings. Travel required. Science background a plus. For more information on the position and application process visit: www.joi-odp.org.

Trainee Program Sets Sail

The ODP has initiated an Undergraduate Student Trainee Program which is open to students from ODP partner countries, including the U.S. The new program provides a rare and exciting educational opportunity to participate in a scientific cruise aboard the drillship, *JOIDES Resolution.* To be eligible, participants must be undergraduate students at the time of the leg.

The first Undergraduate Student Trainee was Ericka Olsen from the University of Pennsylvania. Ericka's participation on Leg 186 was a positive experience for all involved, and for her senior project, she is working on samples she collected during the leg. The next scheduled opening for an Undergraduate Student Trainee will be on Leg 191, West Pacific Ion. It is likely that Trainee positions will be available in 2001 on Legs 195, 196, 197, and 200. More information on the program and the new schedule for legs beyond Leg 193 are available at the JOI website: www.joi-odp.org.

The COMPLEX Meeting: Conference On Multiple PLatform EXploration

contributed by Larry Mayer

Over 30 years ago, the *GLOMAR Challenger* retrieved its first samples from the seafloor thus initiating an era of scientific ocean drilling that has evolved from the Deep Sea Drilling Project (DSDP) into today's Ocean Drilling Program (ODP). Because ODP ends in 2003, the international scientific community has been exploring new options for, and approaches to, future scientific ocean drilling. The Japanese have proposed a bold plan for a riser-equipped drilling platform capable of drilling very deep holes in previously inaccessible environments, and an international meeting has already been held to explore the scientific opportunities presented by this new platform (CONCORD, 1998). Many scientific problems still remain however, for which this exciting new drilling vessel is not the most appropriate platform. In light of this, a second meeting (Conference for Multi-Platform Exploration — COMPLEX) was held in May 1999 to outline the key scientific issues facing the Earth science community and to develop multiple platform strategies to address them. Participants were encouraged to discuss planning and scientific issues free of the constraints that have limited previous drilling programs. They were encouraged to develop a truly integrated approach to planning global experiments and to define the technologies needed to conduct multi-platform programs.

Lest there be any doubt of the importance of scientific drilling to the international community, the response to the COMPLEX meeting was remarkable. More than 350 scientists travelled to Vancouver bringing phenomenal enthusiasm to plan an exciting future. The meeting results, soon to be published, outline a new approach to planning global Earth science experiments that integrates a variety of tools to best meet the needs of a particular problem. These tools range from deep or standard drilling platforms to small coring rigs deployed in special environments where other sampling tools cannot go. The experiments articulate tests of specific hypotheses posed by modeling and integrate scientific ocean drilling with other tools like ocean observatories and continental drilling. The key to this approach is a clear vision of the fundamental problems, a long-term and global strategy for addressing them, and most critically, a program that allows the flexibility to bring to bear the tools most appropriate for meeting specific scientific objectives.

An Evolving Approach

Early scientific ocean drilling was exploratory, addressing basic questions of the nature and age of the seafloor. Despite limited capabilities, early drilling led to a number of new and fundamental discoveries. With advances in technology came new capabilities, new approaches and new insights, but also the realization that many seafloor regions that contain the most critical sections are inaccessible with current drilling technology. Nonetheless, the results of the first 30 years of drilling have provided essential pieces in a growing knowledge base that is changing our outlook on, and understanding of, critical Earth processes. Paralleling, and often directly resulting from, developments in scientific ocean drilling has come an increasing recognition that the Earth is a large, complex, interactive, and interconnected, dynamic system. The individual components of the system that often define discrete fields of study, are inextricably linked through complex and still poorly understood pathways and feedback mechanisms.

With this growing observational database and a recognition of these complex Earth System links have come rapid advances in our ability to model various components of the system. These models, though far from perfect, add an important dimension to our ability to formulate scientific questions and test hypotheses; they add a powerful new tool to our quest to understand the nature of Earth system variability.

While our conceptual understanding of the Earth system is rapidly increasing, and the nature of drilling is becoming more focused, we are still at a point where drilling can lead to unexpected major new discoveries. Two recent discoveries have forced us to rethink our current understanding. The first and probably most exciting finding has been the discovery of living organisms at great depths below the Earth's surface, which extends the biosphere into the upper lithosphere and raises fundamental questions about the origins of life. The second discovery has been the recent recognition of the far-reaching ramifications that the vast deposits of subsurface frozen methane (gas hydrates) can have on the global carbon budget.

With these new discoveries, a growing observational database, our evolving conceptual paradigms, and more sophisticated Earth system models, we have greatly enhanced our ability to formulate key Earth science questions and to develop new strategies to answer them. As these strategies evolve, however, it is becoming increasingly clear that we are often limited in our ability to address these questions by the current capabilities of our drilling platform. Just as astronomers learned after their initial exploration of space with telescopes, new questions demand new approaches. In the Earth sciences, new sampling technologies and strategies (our "bigger telescopes") as well as our improved ability to model Earth systems, now set the stage for new investigations to probe even further into Earth's secrets.

Thus as we near the end of the ODP, we find ourselves well-positioned to define a new phase of ocean drilling that integrates novel technologies and approaches in a strategy that will directly address many of the remaining fundamental Earth system problems. The COMPLEX meeting was a direct result of the recognition by the Earth science community of the confluence of these events and the opportunities that await.

COMPLEX Structure

The COMPLEX meeting was held at the University of British Columbia, in Vancouver, Canada on May 25-29, 1999. It was hosted by JOI, who along with UBC volunteers, provided wonderful on-site logistical support. All JOIDES partners were well represented (PRC= 7; ESF= 20; France= 12; Germany= 34; Japan= 23; PACRIM= 27; UK= 13; USA= 190) plus representatives from non JOIDES countries, India, New Zealand and Russia.

The meeting opened with a plenary session that introduced the participants to the overall objectives of COMPLEX and the status of post-2003 drilling planning from the perspectives of both the U.S. NSF, and the Japanese. This was followed by a series of brief presentations that set the scene for planning future multi-platform experiments by providing an introduction to technologies not normally associated with scientific ocean drilling. These presentations included: riser drilling with well control, shallow water drilling, continental drilling, Arctic drilling, future surveying technologies, and ocean observatories. Finally, an excellent presentation on the potential for future collaborations between the academic world and industry was made by USSAC's John Armentrout of Mobil.

After the plenary session, the participants divided into smaller sessions. These were structured around 315 abstracts that had been submitted to JOIDES in response to a call for input from the community. From these abstracts (available upon request from JOI), the conference organizing committee (co-chaired by Nick Pisias and Asahiko Taira and including Larry Mayer, Marcia McNutt, Hisatake Okada and Rainer Zahn) divided the meeting into 16 sessions (listed below). Participants were assigned a primary session, but they were free to move among sessions. Most sessions were subdivided into smaller breakout sessions by their chairs, but several times a day plenary sessions were convened for updates on the progress of the individual sessions, and so key points could be discusses by the group as a whole.

A specific goal of the organizers was to reach scientists not traditionally associated with ODP, who might be able to address research questions in their fields if no longer constrained to the current platform. The large number of meeting attendees who had little or no previous involvement in the ODP implies that this objective was achieved. However, it was also clear from the meeting that there is still room for embracing a greater subset of the larger scientific community.

While a consensus among such a large and diverse group is virtually impossible, the driving force behind the structure of the meeting was to provide a mechanism by which each participant would feel that they had the opportunity to express their views and to contribute to the end result. We believe this was accomplished.

The final report is being prepared for publication in early 2000. It consists of contributions submitted by session chairs, rapporteurs and others, that have been reviewed and reworked by the organizing committee and made available to participants via the web for final comments. The report will be structured along three themes:

continued on page 14

COMPLEX Conference Sessions

Scientific Sessions

- Extreme Climates
- Climate Variability
- Constructing Oceanic Lithosphere
- Subduction Factory and Convergent Margin Processes
- Geological Processes Relating to Rifting
- Climate Forcing on Long Time Scales – Tectonics and Climate
- Climate Forcing on Short Time Scales – External and Internal Mechanisms
- Evolution of the Crust and Lithosphere
- Seismogenic Zone
- Basin and Passive Margin Evolution
- Dynamics of the Earth's Interior
- Catastrophic Events
- Understanding the Earth's Biosphere
- Gas Hydrate

Other Sessions

- Education and Enabling Technologies
- Non-Assigned papers

ODP PUSHES THE MICROBIAL FRONTIER

contributed by R.W. Murray and the Leg 185 Shipboard Scientific Party

When the tugboats eased the *JOIDES Resolution* off the pier in Hong Kong harbor to begin Leg 185 on April 18th, she had a brand new "passenger" partially hidden on top of her laboratory stack. Unlike the stowaways who slinked aboard merchant ships in olden days, this passenger was a welcome member of the ship's community, having received the blessings of the ship's operators.

The passenger was none other than the new microbiological laboratory, housed in a three-by-six meter van located forward of the downhole measurements laboratory atop the lab stack. The van was bolted in place in mid February, during the Fremantle portcall. On Leg 184, the ship's crew began outfitting the van with electricity, plumbing, ventilation, air conditioning, counters, cabinets, and other basic necessities. In Hong Kong, and during the transit to Leg 185's first site, ODP technicians and SEDCO personnel labored night and day in the tropical heat to finish the facility. Working under trying conditions, they installed cutting-edge equipment to initiate an exciting era of ODP science—a laboratory to meet the needs of the growing deep biosphere research community.

How did the ODP reach this point? The deep biosphere is among the most challenging and least probed avenues of research. The search for the most extreme physical and chemical limits to life goes hand-in-hand with research on major topics such as the origin of life; how life adjusts to extreme conditions; understanding metabolic pathways; how microbial activity affects global chemical transfer; and whether life might be capable of existing on other planets.

For the past five to ten years, a dedicated group of marine geomicrobiologists, many of whom have been affiliated with Dr. John Parkes's laboratory in Bristol (UK), have sailed on occasional ODP legs in the quest to learn more about the biosphere hidden deep in ocean sediments. Other groups, including those at the University of Bergen, Oregon State University (OSU), and the Scripps Institution of Oceanography (SIO), have focused on the microbial communities in the deep ocean volcanic crust.

When the new JOIDES organizational structure was considering different foci for their Program Planning Groups (PPGs), it was only fitting that one should target the growing field of geomicrobiology. Thus, the Deep Biosphere PPG was launched. This was also another step in implementing the deep biosphere "pilot project" outlined in the 1996 *ODP Long Range Plan*. The new PPG, chaired by Dr. Parkes, set as one of its objectives the performance of rigorous contamination tests to differentiate between *in situ* bacteria and bacteria introduced by drilling operations. The PPG suggested that, given the deep-water and deep ocean-crust penetration planned for Leg 185, this leg would be a logical platform from which to begin. The scientists anticipated recovery of unlithified sediments, sedimentary rock, and, importantly, a deep igneous sequence. In conjunction with members of the JOIDES panels and persons from various marine laboratories, including Dr. Andreas Teske at Woods Hole Oceanographic Laboratory and Dr. Steven D'Hondt at the University of Rhode Island (URI), the Science Services division at ODP/TAMU expanded the capacities of the laboratory for Leg 185 beyond those initially proposed by the PPG, with the result that first-rate biosphere research on-board the *JOIDES Resolution* is now a reality.

The microbiological laboratory is currently equipped with an anaerobic glove box,

Fig. 1: External view of van housing the microbiology laboratory. View is looking over the starboard side of the *JOIDES Resolution*, with the rig floor aft of photo. (Photo by Burney Hamlin, ODP/TAMU.)

Fig. 2: David Smith (left) pipetting in the laminar flow hood, while Marty Fisk (center) and Shelley Haveman (right front) are using the anaerobic chamber in the microbiology laboratory during Leg 185. (Photo by Roy Davis, ODP/TAMU.)

laminar flow hood, sterilizer, rock splitter, and constant temperature incubators. A gas chromatograph, liberated from the organic geochemistry laboratory, has also been added with a computer. These have been set up to analyze the perfluorocarbons that were used in a series of tracer tests. A -80°C freezer has also been purchased and moved into the lab. In addition to preparing for the contamination tests, the lab is also being used to initiate a number of bacterial cultures associated with rocks, sediments, and water, and to store rocks in pressurized containers for shorebased studies.

The testing plan developed by the PPG and the Leg 185 shipboard microbiologists consisted of several independent programs. Fluorescent microspheres (at a size of 0.5 μm each, similar in size to deep biosphere microbes) were placed in a Whirl-Pak bag (little plastic bag with a wire-twist top) at the bottom end of the core barrel. The idea is that this bag bursts upon coring and the beads are released into the "core stream." This method was used for both rock and sediment cores, and was based on similar tests of terrestrial coring methodologies performed by Dr. T. Phelps of the U.S. Department of Energy, also a member of the Deep Biosphere PPG. The shipboard scientists, ODP, and SEDCO personnel also set up a perfluorocarbon pump in the ship's mud-pump room. This pump injects perfluorocarbons into the drilling fluids at a constant concentration of approximately 1 ppm. Upon retrieval of the cores, the microbiologists examined them for the presence and concentration of perfluoro-carbons. Additional tests are also being performed. Background levels of microbes in Hole 801C will be determined by testing water recovered from the hole prior to and after drilling. The success of these tests, indeed of the entire deep biosphere initiative, depends on the help of the drillers and core technicians who have been keen to aid the scientific party. Look for the results of these tests to be presented at scientific meetings in the very near future.

In addition to these tests, the team of shipboard microbiologists are conducting coordinated research to further expand our knowledge about the deep biosphere. Martin Fisk of OSU (and a member Deep Biosphere PPG member) is extending his study of microbes in deep-sea basalts in rocks as old as 167 Ma, and recovered from greater depths in the ocean crust than ever before. This study may demonstrate that our largest biosphere, in terms of total mass, is located deep in the Earth. David C. Smith (URI) will extract DNA from the sediment samples in order to determine the diversity of the microoganisms that inhabit this extreme environment. In addition, he will estimate total microbial abundance and biomass in the sediment column using microscopy and total adenosine triphosphate (ATP) concentrations, respectively, and he is working with Art Yayanos of SIO to preserve high-pressure microbial communities through immediate pressurization following core recovery. Shelley Haveman, from the Dept. of Cell and Molecular Biology at Göteborg University in Sweden, is concentrating on the microbiology of the basement and will attempt to culture microbes from various basement lithologies. DNA extraction for examination of microbial diversity and microscopy for determination of microbial abundance will complement the culturing results. Hubert Staudigel (SIO), also in collaboration with Art Yayanos (SIO), is preserving potential piezophilic (pressure-loving) microbes to study the relationships between high-pressure microbial communities and the chemistry of water-rock interaction, in environments with pressures exceeding 650 atmospheres and temperatures well above 25°C. In addition, Fisk and Staudigel are studying the physical effects of microbial activity on rock alteration, through the study of abiotic and biotic textures of alteration.

What's next? Ocean drilling offers the ability to explore vast ranges of environments that are biologically unknown territory, yet are likely to harbor life. Clearly, the long-standing and diligent efforts by individual scientists, the Deep Biosphere PPG, the JOIDES panels, TAMU/ODP, and SEDCO, have paid

continued on page 14

ANNOUNC

SCHLANGER OCEAN DRILLING FELLOWS

Jennifer Latimer
Indiana-Purdue University
The influence of dust inputs on biogeochemical cycles in the Southern Ocean, ODP Leg 177
(one year, shorebased)

Michelle Shearer
Rice University
Quaternary carbonate preservation and dissolution in the Caribbean Sea, ODP Leg 165
(one year, shorebased)

Next fellowship deadline: April 15, 2000
For info see: http://www.joi-odp.org/usssp/Fellowship/Fellowship.html

JOI/USSSP SUPPORTED SHIPBOARD PARTICIPANTS

Leg 186: W Pac Seismic Net/Japan Trench
U.S. Co-Chief: Selwyn Sacks, Carnegie Inst.
ODP Staff Scientist: Gary Acton, TAMU
Logging Scientist: Alan Linde, Carnegie Inst.
German Mora, Indiana Univ
Jingfen Li, Florida State Univ.
Michael Acierno, Carnegie Inst.
Paul McWhorter, Carnegie Inst.
Benoy Pandit, Carnegie Inst.
Student Trainee: Ericka Olsen, Univ. Penn

Leg 187: Aus-Ant Discordance
U.S. Co-Chief: Dave Christie, OSU
ODP Staff Scientist: Jay Miller, TAMU
Vaughan Balzer, Oregon State U.
Douglas Pyle, Oregon State U.
Christopher Russo, Oregon State U.

OCEAN DRILLING SEMINAR SERIES

To celebrate 30 years of excellence in ocean research and exploration, the Ocean Drilling Seminar Series is presenting ODP science topics that are relevant to societal issues. The lectures are being held on Capitol Hill, Washington, D.C. and are open to the public.

November 16, 1999 — Dr. Alan C. Mix
"Understanding Past Global Climate Change"
3:15-4:45 pm, Room B-369, Rayburn Bldg., U.S. House of Representives

December 7, 1999 — Dr. John M. Hayes
"Exploring the Earth's Deep Biosphere"
3:00-4:00 pm, Room 708, Philip A. Hart Senate Office Building

January 10, 2000 — Dr. W. Steven Holbrook
"Gas Hydrates: Linking Energy, Climate and the Biosphere"
3:00-4:00 pm, Room 708, Philip A. Hart Senate Office Building

February 16, 2000 — Drs. John M. Armentrout & Theodore C. Moore
"Science and Drilling Technologies for the Future"
6:00-8:00 pm at the Canadian Embassy, Washington D.C.

For more information, visit: http://www.oceandrilling.org/odss/default.html

JOI/USSAC DISTINGUISHED LECTURE SERIES: 2000-2001

Brochures for the 2000-2001 series are now available from JOI. The deadline to apply for a speaker is April 7, 2000.

Dr. Timothy Bralower, UNC, Chapel Hill
"It was the best of times, it was the worst of times": Biotic consequences of the Late Paleocene Thermal Maximum

Dr. Eugene Domack, Hamilton College
Late Quaternary sedimentation in Antarctica's Palmer Deep

Dr. Martin Fisk, Oregon State University
Microbes beneath the ocean floor and the possibility of extraterrestrial life

Dr. Garry Karner, LDEO
The paradox of low-angle crustal faulting and rupturing of continents

Dr. Delia Oppo, WHOI
Millennial scale climate variability in the North Atlantic

Dr. John Tarduno, Univ. of Rochester
Motion of the Hawaiin hotspot during formation of the Emperor Seamounts

CEMENTS

JOI EXPANDS

JOI recently increased its membership to 14, with 3 new institutions:

University of Michigan
University of Florida, Gainesville
University of California, Santa Cruz

Welcome Aboard!

WELCOME PEGGY!

Effective Oct. 1, 1999, Peggy Delaney, UCSC, began her reign as the new USSAC Chair. JOI/USSAC wishes her well as she leads the U.S. scientific community in planning efforts for the next drilling program.

ODP ACTIVITIES AT THE AMERICAN GEOPHYSICAL UNION (AGU) 1999 FALL MEETING

POST-2003 SCIENTIFIC OCEAN DRILLING TOWN MEETING

Tuesday, December 14, 1999
5:30 pm - 7:30 pm
Moscone Center, Room 120
Come for refreshments and a discussion of future ocean drilling.

ODP BOOTH

Booths 210-212-214
Moscone Center, San Francisco
December 14-16, 1999
8:30 am - 5:00 pm

Stop by for a demonstration of the new JOI/USSSP educational CD ROM (Gateways to Glaciation), the latest information about post-2003 planning, and a rest on the couch.

SCHEDULE FOR ODP LEGS 186-193

LEG	REGION	CO-CHIEFS	DEPARTURE PORT	DEPARTURE DATE	SCIENTIFIC OBJECTIVES
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.
187	Aus-Ant Discordance	Christie Pedersen	Fremantle	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	Cooper O'Brien	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	Kennett Exon	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	-----	Townsville	4/00	--
190	Nankai	Moore Taira	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	Sager Kanazawa	Yokohama	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	Ontong Java	Mahoney Fitton	Guam	8/00	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.
193	Manus Basin	Binns Barriga	Guam	10/00	To understand the chemical fluxes, fluid pathways, and ore deposition of felsic volcanic-hosted polymetallic massive sulfides by probing the active PACMANUS hydrothermal system.

HIGH-RESOLUTION ACOUSTIC SURVEYS OF TWO PROPOSED DRILL SITES USING A CHIRP SONAR

contributed by Lloyd Keigwin, Ben Gutierrez, Ed Laine, Neal Driscoll, and David Piper

Recent availability of sophisticated technologies such as accelerator radiocarbon dating and high-resolution time series of paleoclimate data; such as from Greenland ice cores; has led to increased interest in high-resolution studies of sediments recovered by the Ocean Drilling Program (ODP). Considering the cost of ODP drilling or APC coring a site, and the tremendous analytical demand on high-deposition-rate sediments, there has not been a commensurate level of interest in applying the latest state-of-the-art geophysical surveying technologies. For example, the highest-resolution acoustic stratigraphy available for most ODP sites is still the venerable old 3.5kHz sonar developed for military purposes during the Cold War.

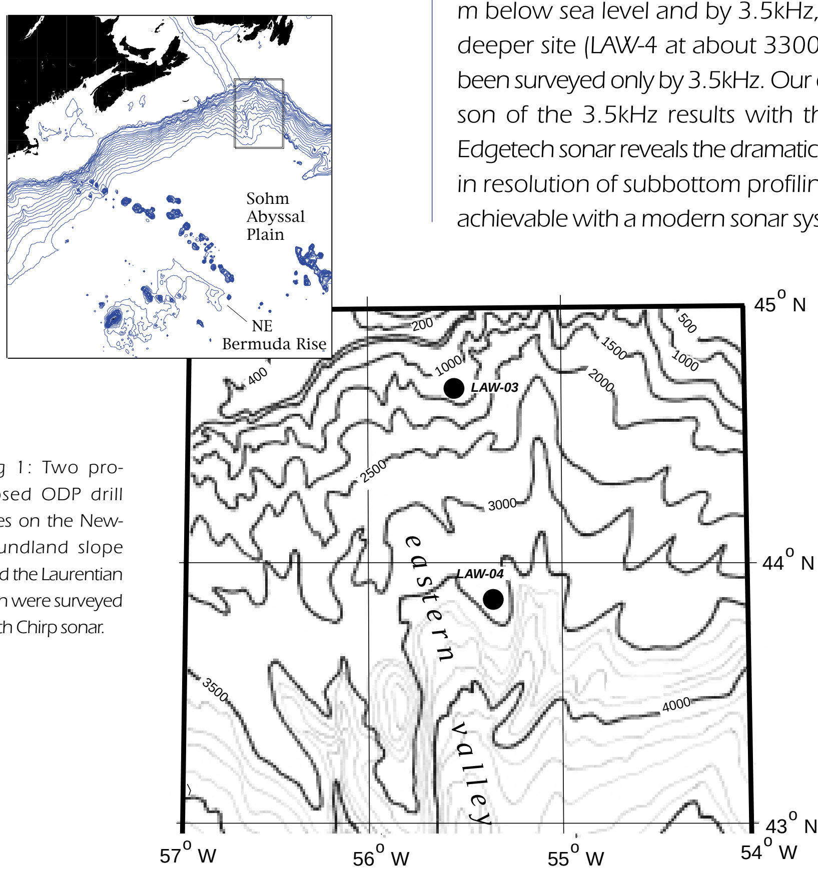


Fig 1: Two proposed ODP drill sites on the Newfoundland slope and the Laurentian Fan were surveyed with Chirp sonar.

In July 1998, we tested, with JOI/USSSP site augmentation funding, a swept frequency ("chirp") sonar that was developed by Edgetech for surveying nearshore continental shelf environments. We used an Edgetech 0512 sonar system that chirps across a variety of frequencies; during our survey, we selected to sweep across 1-7 kHz. The resolution of FM systems, like the Chirp, is governed by 1/Df times sound velocity, where Df is the swept frequency. So, our maximum potential resolution was about 25 cm. We chose two locations for our survey which are proposed ODP drill sites on the Newfoundland slope and the Laurentian Fan (Figure 1). The relatively shallow site (LAW-03 at about 1300 m) had been surveyed previously with the Huntec boomer system towed at about 200 m below sea level and by 3.5kHz, but the deeper site (LAW-4 at about 3300 m) had been surveyed only by 3.5kHz. Our comparison of the 3.5kHz results with the 0512 Edgetech sonar reveals the dramatic increase in resolution of subbottom profiling that is achievable with a modern sonar system.

Our survey of the shallow site on R/V *Oceanus* and the earlier CSS *Hudson* survey were along the same track across the heavily dissected margin to the east of the Laurentian Channel at 1300-1400 m water depth (Figure 1). Reflection horizons from the 3.5kHz sonar at LAW-03 return from as much as 40 m subbottom and, although they are fuzzy, about six are distinguishable (Figure 2a). Acoustic penetration is about the same with the Chirp, but the reflectors are more distinct and about eight are resolvable at the site as defined (Figure 2b). However, farther to the southwest (left side of Figure 2B) the 0512 Chirp penetration is slightly greater (where the rate of sedimentation is probably higher), and at least fourteen reflectors are visible. These reflectors, which occur on the decimeter scale, are not well imaged by the 3.5kHz system. At LAW-03 the 4 m gravity core collected onboard *Oceanus* is all Holocene and lithologically uniform except for a turbidite at 280 cm. That turbidite may account for the first reflection observed below the seafloor at this site, and we infer that the upper ~6 m at this site are Holocene from the acoustically transparent nature of the sediment. (This inference is supported by research in progress at Bedford Institute of Oceanography.)

In deeper waters, the superiority of 0512 Chirp over 3.5kHz is equally dramatic. Proposed drill site LAW-04 is located at ~3300 m water depth on the Laurentian Fan. At this location (Figure 1) the 3.5kHz results show two groups of diffuse reflectors within about 20 m depth below the seafloor (Figure 3a). Our Chirp line is along a NW to SE track, and the penetration is about the same as for 3.5kHz (on a W-E track), but because of a tape drive failure the Chirp line shown in the figure is slightly to the south of LAW-04 (Fig-

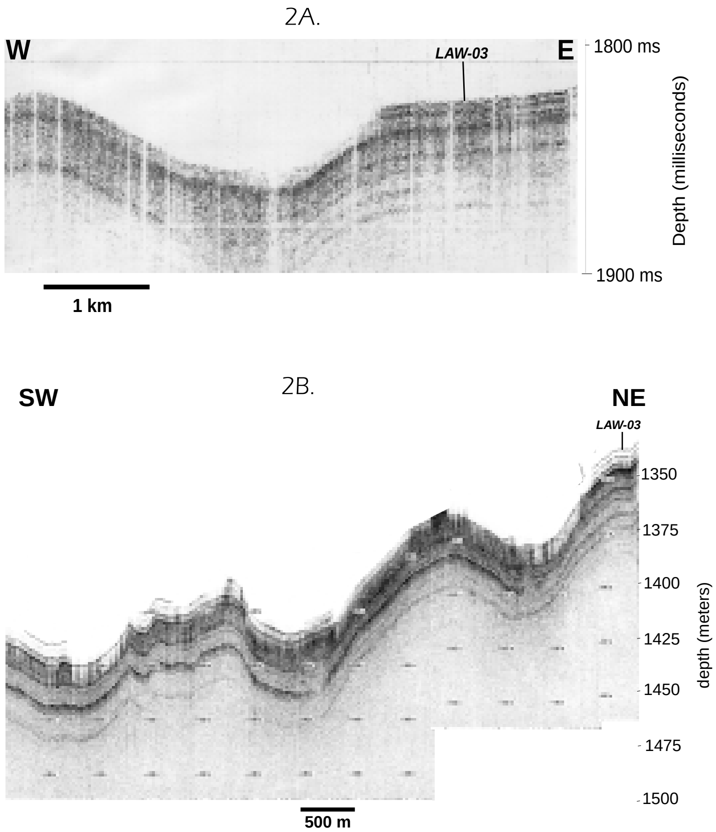


Fig 2: At site LAW-03, a 3.5kHz sonar survey (2A) shows six fuzzy reflectors and the 0512 Edgtech "chirp" sonar survey (2B) shows eight clear reflectors. To the left (SW) side of Figure 2B, in deeper water, fourteen reflectors are visible.

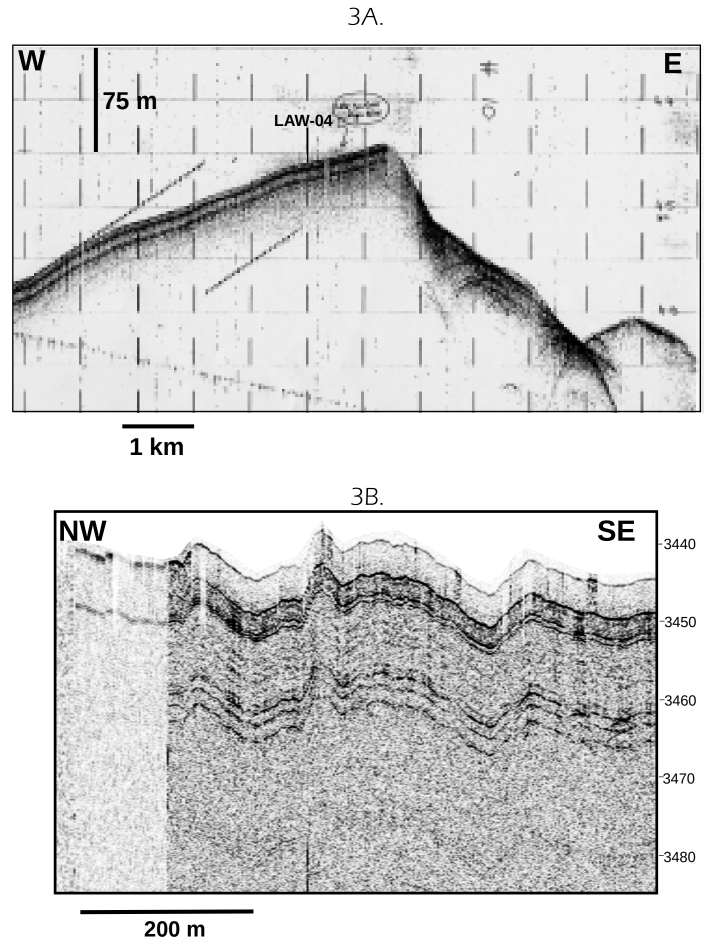


Fig 3: At site LAW-04, a 3.5kHz sonar survey (3A) shows two groups of diffuse reflectors and the Chirp line (3B) shows two groups of three to four reflectors each.

ure 3b). However, the two sets of reflectors appear to have a regional distribution, and in the Chirp data they are better resolved and have three to four reflectors each. Our *Oceanus* gravity core at this site (411 cm long) is all Holocene, and the *Hudson* piston core from this site has deglacial sediments between about 5 and 9 m subbottom. Thus, at this site we interpret the surface transparent layer as postglacial, the upper bundle of reflectors as deglacial (when most of the ice rafting occurred) and the middle transparent layer as glacial maximum fine-grained red lutites. With the rates of sedimentation implied by this scheme (~30 cm/ky), the lower set of reflectors may correspond to Heinrich Event 2 and associated thin turbidites. This interpretation is supported by recent results on nearby IMAGES core MD95-2029 (Piper, D.J.W., and Skene, *K.I., Paleoceanography, 13*, 205-214, 1998).

Although Chirp seismic data in deep water is impressive, there are other technologies available (e.g., Huntec system) which should also outperform the old 3.5kHz sonar. In addition, the broad frequency band of new Chirp systems not only improves the subbottom imaging resolution, but also allows researchers to examine different frequency bands during post-cruise processing. Seismic systems operating at different frequencies reveal different reflection patterns, not only because higher-frequencies have greater resolving capability, but also because reflections are often caused by complex interference patterns between closely-spaced stratigraphic horizons and outgoing signals. Understanding the frequency dependence of seismic reflectors is the first step toward determining the origin of seismic reflectors; quantifying reflection coefficients; and assessing the spatial variability of reflectors. We recommend that where possible, these new systems be used in identifying ODP and other sites for developing the highest-resolution acoustic stratigraphies. Many of these high-resolution geophysical surveys have turn-key operations and advanced user-friendly software for automated data analysis, which will enable researchers to acquire high-resolution seismic images. High-resolution geophysical surveys will establish a more regional framework within which to interpret core data and ODP drilling data and help locate the optimum sites for achieving high-resolution records of climatic variability.

The Authors

Lloyd Keigwin, Ben Gutierrez, and Neal Driscoll are at Woods Hole Oceanographic Institution; Ed Laine is at Bowdoin College; and David Piper is at the Bedford Institute *of Oceanogaphy.*

COMPLEX, CONTINUED FROM PAGE 7

- "*New foci for scientific ocean drilling*" that discusses the deep biosphere, gas hydrates, and the Arctic Ocean;

- "*Integrated Strategies to Address Fundamental Earth System Questions*", including, probing global change - processes that control the variability of Earth's environment, solid Earth cycles - processes that govern the shape of Earth's surface, seismogenic zone, core and mantle dynamics, paleobiology and evolution— the marine biosphere, and catastrophic events; and

- "*Technical requirements for a multi-platform integrated ocean drilling program.*"

Most critically, within each theme, fundamental scientific questions will be posed and the strategies and technology needed to answer them described. Integrated and innovative approaches will be developed that, if necessary, go beyond the simple vision of a drill ship to call upon multiple platforms, new sampling strategies, ties to long-term ocean observatories, and even to continental drilling if appropriate.

The key is to be able to call upon the most appropriate tool or array of tools available to answer the scientific questions posed.

THE NEXT STEP

Given the overwhelming response to the COMPLEX and CONCORD meetings, there is little doubt of the strong support within the community for a new phase of scientific ocean drilling. The challenge will be to design a logistically feasible program that can effectively and efficiently respond to the community's needs. The initial steps have been taken by establishing IODP Planning Sub-Committee (IPSC) under the able leadership of Ted Moore (Jamie Austin, Deiter Eikelberg, Hjimu Kinoshita, Hans-Christian Larsen, and Asahiko Taira, members). IPSC will use all inputs from the community to help define a post-2003 program. The task facing this committee is daunting, but with the continued support and involvement of the community we can all contribute to defining a bright future.

THE AUTHOR

Larry Mayer, currently the NSERC Chair in Ocean Mapping at the Univ. of New Brunswick, will be migrating south in the New Year to the Univ. of New Hampshire, Durham to become the Director of the Center for Coastal and Ocean Mapping and Co-Director of the NOAA/UNH Joint Hydrographic Center.

MICROBIAL FRONTIER, CONTINUED FROM PAGE 9

off to the point where interested microbiologists can more easily perform seagoing research on the *JOIDES Resolution*. Establishing a microbiological laboratory is a major step forward, but certainly not enough. Construction of space for a more permanent microbiology facility including all the equipment that was housed in the van, as well as other instrumentation, occurred this past September during drydock. A radioisotope facility may also be added at some point. The use of radioisotopes such as ^{14}C and ^{3}H will allow microbiologists to determine the rates at which the microbes utilize various substrates. In addition, the use of microautoradiography will allow scientists to determine the activity of microbes seen under the microscope.

We hope that the ODP continues to be a leader in deep biosphere research, to the extent that all appropriate legs are staffed with microbiologists, just as the current program regularly sails with other specialists. Additional specialized technical support will also be required. It's a large ocean out there and every time we probe into its subsurface we find something new. Scientists have just begun to discover Earth's subseafloor inhabitants and their lifestyles. Like the sailing ship stowaways, the microbiological laboratory is aiming to construct a new life at sea and the ODP, which is now operating the only seagoing microbiology laboratory for investigating the seafloor's subsurface biosphere, will continue to define the cutting edge of this exciting research initiative.

THE AUTHORS

Richard Murray, an Associate Professor at Boston University, serves on the JOIDES Scientific Measurements Panel and sailed as an inorganic chemist on Leg 185. The Leg 185 shipboard microbiologists include Martin Fisk (Oregon State Univ.), Shelley Haveman (Göteborg Univ., Sweden), David Smith (Univ. of Rhode Island), and Hubert Staudigel (Scripps Inst.). Other members of the Scientific Party include: J. Ludden and T. Plank (Co-Chief Scientists), C. Escutia (ODP Staff Scientist), L. Abrams, J. Alt, R. Armstrong, S. Barr, A. Bartolini, G. Cairns, G. Guerin, T. Hirono, J. Honnorez, K. Kelley, R. Larson, F. Lozar, T. Pletch, R. Pockalny, O. Rouxel, A. Schmidt, A. Spivack, M. Steiner, and R. Valentine.

LATE PLEISTOCENE PRECESSIONAL FORCING IN THE EASTERN AND WESTERN EQUATORIAL PACIFIC

Helen Perks

Ph.D. Institution:
Scripps Institution
of Oceanography, UCSD

Faculty Advisor:
Ralph Keeling

The JOI/USSAC Ocean Drilling Fellowship funded my work on the development and application of "combustion oxygen demand" (COD) measurements in carbonate-rich sediments of the equatorial Pacific Ocean. The COD technique is a measure of the amount of oxygen consumed by the reduced species in the sediment sample. Measurement of the very low organic carbon content (typically <0.3% (wt)) in samples with a high carbonate background is complicated using traditional methods, and the COD method offers a fast, high-precision measurement which is closely related to the organic carbon content. I interpret the variations I observe in COD to reflect changes in the amount and/or type of organic matter reaching the sediment from the surface waters above. COD thus provides a new tool for studying the fluctuations in paleoproductivity across the large areas of the ocean underlain by carbonate-rich sediments, for which such proxy data are currently still sparse and conflicting.

I had already developed the method and generated data from one core on the Ontong-Java Plateau beneath the Western Equatorial Pacific Warm Pool, RNDB 74P (0°20'N, 159°22'E, 2547 m) (Perks and Keeling, 1998) back to marine oxygen isotope stage 11. I wished to go further back in time at this location (ODP 806 from Leg 130) to examine the Pliocene and also to compare the western with the eastern equatorial Pacific (Leg 138).

For comparison with the western equatorial Pacific core, I chose two sites some 8,000 km east of RNDB 74P, ODP Holes 851 (2°46'N, 110°34'W, 3760 m) and 849 (0°11'N, 110°31'W, 3839 m) from Leg 138. The COD time series from ODP 849 and 851 and RNDB 74P over the last 400 kyr are characterized by values that are generally at least twice as high during glacials as during interglacials, the largest shift occurring from oxygen isotope stage 6 to 5.5. This is consistent with the magnitude of changes inferred from previous measurements of proxies of paleoproductivity in the central and eastern equatorial Pacific in the late Quaternary.

For ODP 849 and RNDB 74P, both on the equator, the COD time series are coherent with the oxygen isotope curves from the same core at the Milankovitch frequencies of 100, 41 and 23 kyr. (Work is ongoing in ODP 849 to produce a higher-resolution oxygen isotope time series). Moreover, both COD time series, from the east and west, are highly coherent with one another over the last 400 kyr, showing pronounced precessionally-forced peaks of higher COD during globally colder periods that are in phase in the two cores (Figure 1). Such an in-phase response in the precessional band between two sites separated by 80° of longitude across the Pacific Ocean suggests that the surface waters of both regions have had a common forcing mechanism over the last 400 kyr. The effects of regional processes are manifested in differences in amplitude between the two data-sets. A probable influence on COD in the western equatorial Pacific that is likely to be weaker in the eastern part of the Ocean is the monsoon cycle.

REFERENCES.

Perks, H.M. and Keeling, R.F., A 400 kyr record of combustion oxygen demand in the western equatorial Pacific: Evidence for a precessionally forced climate response, *Paleoceanography, 13,* 63-69, 1998.

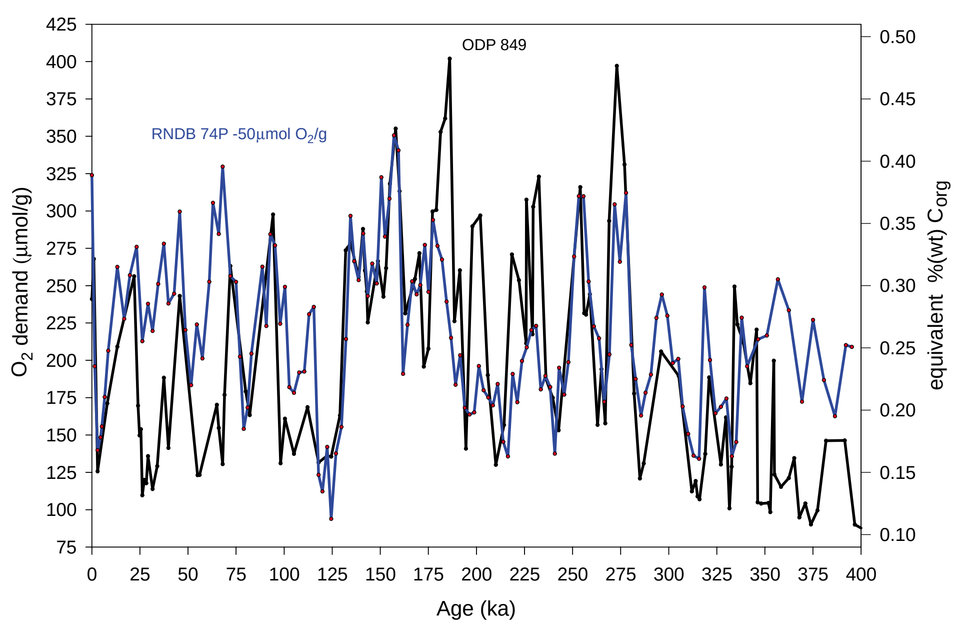
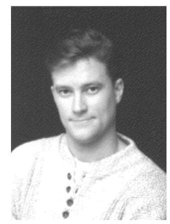


Fig 1: COD in RNDB 74P (blue) from the Ontong-Java Plateau and ODP 849 (black) from the eastern equatorial Pacific. The COD values are reported in µmols of O_2 per g of (dry) sediment sample. Equivalent organic carbon concentrations assume only organic C consumes the O_2 and with an O_2:C ratio of 1 to 1. Sedimentation rates over this interval average 2.0 cm/kyr for RNDB 74P and 3.1 cm/kyr for ODP 849 and only vary within less than a few percent.

Elastic Properties of Gas Hydrate and Hydrate-Sediment Systems



Mike Helgerud

Ph.D. Institution:
Stanford University
Faculty Advisor:
Amos Nur

I am investigating the elastic properties of gas hydrate and sediments containing gas hydrate through laboratory experiments and elastic modeling of well log and vertical seismic profiling (VSP) data. Natural gas hydrates are ice-like solids that trap "guest" molecules in cavities in the water crystal structure (Sloan, 1998). Methane gas hydrate is stable at the pressure and temperature conditions present in the sediments of most of the world's continental margins and deep inland seas.

Current estimates of *in situ* hydrate volumes rely on several assumptions about the presence and distribution of hydrates in the subsurface. A remote sensing technique that could accurately assess the amount and distribution of hydrate in natural deposits would greatly improve these estimates. The best technique for remotely probing sediments beneath deep bodies of water is seismic reflection profiling. Interpreting seismic data for hydrate concentration requires an understanding of the elastic properties of hydrates and sediments containing hydrate. Unfortunately, very little is known about these elastic properties. To address this problem, I have conducted laboratory experiments on propane and methane hydrate and constructed elastic models for hydrate sediment systems.

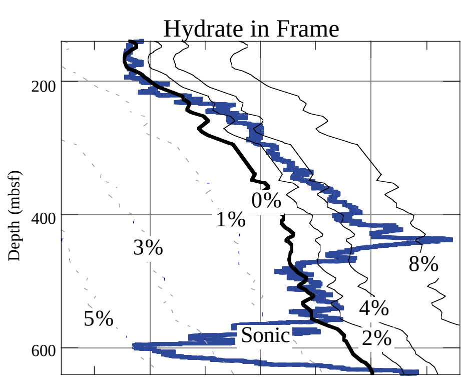


Fig. 1: Elastic properties of methane hydrate. Elastic moduli derived from velocity measurements assuming isotropic, elastic material and a methane hydrate density of 0.90 g/cc.

Initial experiments conducted by bubbling propane gas through water and water saturated sediment columns contained in a clear walled pressure vessel were only partially successful. The speed of sound through a water saturated glass bead pack was observed to increase from 1820 to 2140 m/s upon cycling gas and water through the system and permeability was reduced to almost zero. But interpretation of the results was hampered by an inability to accurately determine the location of hydrate in the pore space. Videotaped experiments on forming hydrate from water and bubbled gas amply demonstrate the shortcomings of this technique for making well characterized hydrate samples. The hydrate produced by this technique has extremely complex arrangements of hydrate crystal morphologies and occluded gas and water. As a result, an entirely new experimental approach was taken, based on the hydrate synthesis technique of Stern, et al. (1996, 1998).

A collaboration with the Stern, Kirby, and Durham produced a system for forming pure methane hydrate and measuring its compressional and shear wave speeds. Methane hydrate is formed in a pressure vessel by warming granulated ice through the melting point of water in a pressurized methane atmosphere. Over approximately 8-12 hours, the entire amount of ice is converted to pure, porous methane hydrate. The porous hydrate is then compacted with a hydraulic ram in the synthesis apparatus. Compressional and shear wave speeds are measured throughout the compaction process. Samples are compacted to <2% residual porosity. An elastic properties summary from a number of experiments is collected in Figure 1.

Elastic properties for methane hydrate are used to model the effect that hydrate formation has on ocean bottom sediments by theoretically placing hydrate in a model for high porosity, clay rich sediments. Hydrate is placed in the pore fluid, modifying only the pore fluid elastic properties; or it is mixed in with the other sediments as a load-bearing component of the frame. Applying this model to sonic (Figure 1) and VSP data from ODP Hole 995, from Leg 164 shows that hydrate concentration estimates obtained from representing the hydrate as a load-bearing frame component produce hydrate concentration estimates consistent with hydrate estimates obtained from resistivity, chlorinity and evolved gas data.

Work is underway to improve the pure methane hydrate property measurements and plans are being made to study hydrates of other gas species and mixtures of methane hydrate and sediment. Efforts are ongoing to improve the hydrate in ocean bottom sediment model and to improve a group of hydrate in sands elastic models.

References

Sloan, E. D., Jr., *Clathrate Hydrates of Natural Gases*, Marcel Dekker, Inc., New York, 705 p., 1998.

Stern, L. A., Kirby, S. H., and Durham, W. B., Peculiarities of methane clathrate hydrate formation and solid-state deformation, including possible superheating of water ice, *Science, 273*, 1843-1848, 1996.

Stern, L. A., Kirby, S. H., and Durham, W. B., Polycrystalline methane hydrate: synthesis from superheated ice, and low-temperature mechanical properties, *Energy and Fuels, 12*, 201-211, 1998.

SWAN SONG

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

This is my last column, but please read on before you fling it into the air with glee. I have some business to conduct here followed by some brief reminiscences and grateful acknowledgements.

First, be aware that progress towards planning a new scientific, integrated ocean drilling program (IODP) is rapid. Several committees (IPSC; CDC) are transforming the plethora of scientific objectives that demand a new program into a coherent plan for post-2003 operations in multi-platform mode. Conceptual designs are being formulated for the Japanese riser vessel and for a U.S. non-riser vessel. Now is the time for you to suggest particular features that you view as essential for the new platforms. Ted Moore (U. Mich.), the IPSC chair, would be pleased to have your input. USSAC has been asked by NSF to prepare a conceptual design for the riserless drilling vessel. Peggy Delaney chairs the USSAC subcommittee (Conceptual Design Committee, CDC) charged with this task. The CDC seeks community input towards this objective; the committee's activities will culminate on March 1, 2000 with submission of the conceptual design to NSF. I urge you to contribute your specifications and to provide both committees with feedback.

One of the much-vaunted features of IODP is the multi-platform capability. USSAC wants the community to know that such a possibility exists in the present program. The SSEPS and SCICOM entertain scientific programs that require deployment of platforms other than the *JOIDES Resolution*. The present system has some flexibility in planning and funding that would allow well-integrated and compelling objectives to be attained using so-called "alternative" platforms. We encourage you to propose such a program if you think that you have a viable concept.

USSAC would also urge you to continue to submit mature proposals to JOIDES for ocean drilling. There has been a recent upsurge of proposal submission, and there are now a number of excellent proposals in the system. Although not every outstanding proposal will come to fruition in this final phase of ODP, a continuing flux of proposals will provide impetus for planning programs for IODP. Yes, preparing such proposals takes a lot of effort, and it is possible that some will be deferred for a time as the new program spins up. Nonetheless, meritorious proposals "in the mill" will have a good chance of becoming top priority objectives in a new program. So please, keep those proposals coming.

During my time on USSAC, I have learned that there are a number of highly dedicated and very effective individuals who deeply value the science and institution of ocean drilling. I thank the members of USSAC for their service and inspiration. In addition, I provide some well-deserved kudos. My experience on USSAC would not have been nearly so good had it not been for the leadership provided by my forward-looking predecessor, former USSAC Chair Roger Larson. The strong behind-the-scenes presence of Ellen Kappel and, more recently, John Farrell as Associate Program Directors of ODP and program managers of USSSP have been essential. Both Ellen and John have been remarkable resources to USSAC and are extremely proactive in their efforts on the drilling community's behalf. Since Ellen's departure, I have had the distinct pleasure of working with John—I cannot say enough good things about him. We certainly should be very thankful to have been able to attract people of his caliber to the position. Likewise, Kate Moran has also been a breath of fresh air as the most recent Director of ODP at JOI. She too has a vision for the future of ODP, near and far, and is dedicated to bringing a new program to the fore. I also acknowledge the many competent JOI staff members who have handled various aspects of the USSAC/USSSP program—thanks to Frank Rack, Jenny Ramarui, Johanna Adams. I especially thank Andrea Johnson for her work with the JOI/USSAC Fellowship Program, her careful editing of the *JOI/USSAC Newsletter* and her gentle but insistent prodding when various items came due, as well as for her excellent recording of the minutes of USSAC meetings. I also acknowledge Paul Dauphin and Bruce Malfait at NSF for their unending support and encouragement of scientific ocean drilling.

Now, I look back wistfully, because my service on USSAC has ended. I know that USSAC will be in excellent hands because Peggy Delaney follows me as its Chair. She and USSAC will help see ODP to a successful completion and will undoubtedly play a major role in promoting IODP. I am confident that IODP will come about because of the dedication of the people who serve on USSAC and many other planning committees. I encourage you all to heed the call and serve the cause. I will remain involved with scientific ocean drilling in some capacity because I believe that this is the greatest earth science undertaking ever.

Sincerely,

Michael A. Arthur
Chair, USSAC

THE CONCEPTUAL DESIGN OF A NON-RISER DRILLING VESSEL

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

Numerous planning documents that have been prepared by the international scientific ocean drilling community have identified a wide range of important scientific objectives for a follow-on program to the present Ocean Drilling Program (ODP), post-2003. The highly successful Conference on Multiple Platform Exploration of the Ocean (COMPLEX), which took place in Vancouver, British Columbia in May 1999, adds an important and convincing element to this argument.

To meet all of these objectives, the scientific community has consistently emphasized that both riser (well-control) and non-riser drilling capabilities will be required. Japan's Science and Technology Agency is building a large (ca. 210 m, 50,000 ton) riser/well-control vessel intended to address some of these requirements. The scientific drilling community has repeatedly argued that any future program would also require a non-riser vessel, similar to the present *JOIDES Resolution*, with enhanced capabilities. The U.S. National Science Foundation (NSF) has indicated that it would seek the necessary resources to bring such a vessel to a future program. This vessel would constitute a major capital asset of the future Integrated (riser and non-riser platforms) Ocean Drilling Program (IODP). To accomplish this, the operational and scientific capabilities of this drilling vessel need to be carefully identified. NSF has requested the U.S. Science Advisory Committee (USSAC) to the U.S. Science Support Program (USSSP) to assist with this effort. In response to this request USSAC has formed the Conceptual Design Committee (CDC) which is chaired by Peggy Delaney of the University of California, Santa Cruz.

The charge to the CDC is as follows:

1) Formulate the conceptual design characteristics of a single, non-riser drilling vessel, optimally configured, to address the widest possible range of non-riser scientific drilling objectives identified by the JOIDES LRP, the COMPLEX report, and other U.S. planning documents. This vessel should be capable of operating globally, to the extent possible in a maximum range of water depths (shallow to deep), and have endurance characteristics similar to the present *JOIDES Resolution*. The drilling limitations relative to defined scientific objectives for such a single vessel should be addressed and alternative drilling capabilities identified.

2) Identify the optimal configuration of onboard scientific measurement capabilities, i.e. geophysical, geotechnical, and scientific laboratory facilities required to achieve the scientific objectives of the program.

3) Provide a feasibility survey of existing and planned drilling vessels having the potential for conversion or modification to meet these operational and scientific requirements.

4) Prepare a detailed report by 1 March 2000, which specifies the operational and scientific characteristics of this non-riser drilling vessel and the science objectives that it will be expected to address.

More information concerning the CDC can be found in the Drill Bits section of this issue of the newsletter. We encourage as much constructive comment as possible from the scientific community concerning this very important activity.

On another note, the following is a list of field programs currently being supported by NSF/ODP:

- The plutonic foundation of a very slow spreading center. Dick (WHOI).
- Structure of Oceanic Crust Formed at 200 mm/yr Spreading Rate. Wilson (UCSB) Harding, Kent (SIO).
- A 3-D Seismic Investigation of the Sediment-to-Rock Transition and its Relationship to Nankai Subduction Thrust Seismicity: U.S.-Japan Collaborative Program. Bangs, Shipley (UTIG); Moore, Morgan (Hawaii); Moore (UCSC).
- Flux of Carbon from a Modern Accretionary Prism (Oregon Margin): *In Situ* Measurements of Hydrocarbon Sequestration as Gas Hydrates and Diagenetic Carbonate. Carson (Lehigh); Kastner (SIO).
- Offset Drilling on the Southeast Greenland Rifted margin: UC Davis Participation on the 1988 DLC Drilling Cruise. Lesher (UC Davis).
- Collaborative Research: What is Subducted along the Southern MAT? U.S.A.-German Project to Characterize the Cocos Plate and Adjacent Forearc. McIntosh (UTIG). Jointly funded with NSF MG&G and Germany.

continued on page 20

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. Timothy J. Bralower
Department of Geology, CB#3315
University of North Carolina
Mitchell Hall
Chapel Hill, NC 27599-3315
tele: (919) 962-0704; fax: (919) 966-4519
bralower@email.unc.edu

Dr. Tim Byrne
Dept. of Geology and Geophysics, U-2045
University of Connecticut
345 Mansfield Road
Storrs, CT 06269-2045
tele: (860) 486-4432; fax: (860) 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, Chair*
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. 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. Jonathon B. Martin
Department of Geology
University of Florida
241 Williamson Hall
Gainesville, FL 32611-2120
tele: (352) 392-6219; fax: (352) 392-9294
jmartin@geology.ufl.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. Tommy J. Phelps
Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box 2008-6036
Oak Ridge, TN 37831-6036
tele: (423) 574-7290; fax: (423) 576-8543
tkp@ornl.gov

Dr. John M. Sinton
Hawaii Institute of Geophysics
University of Hawaii
2525 Correa Road
Honolulu, HI 96822
tele: (808) 956-7751; fax: (808) 956-2538
sinton@soest.hawaii.edu

Dr. Deborah K. Smith
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
tele: (508) 457-2000; fax: (508) 457-2187
dsmith@whoi.edu

Dr. Lisa Tauxe
Scripps Institution of Oceanography
University of California
Geosciences Research Division
La Jolla, CA 92093-0220
tele: (619) 289-2472; 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, ODP
National Science Foundation
4201 Wilson Boulevard, Room 725
Arlington, VA 22230
tele: (703) 306-1581; fax: (703) 306-0390
jdauphin@nsf.gov

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

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) 462-8754
jfarrell@brook.edu

Dr. Jeffrey Schuffert
U.S. Liaison, JOIDES Office
GEOMAR
Wischhofstr. 1-3
D-24148 Kiel, Germany
tele: (49) 431-600-2834; fax: (49) 431-600-2947
jschuffert@geomar.de

JOI/USSAC NEWSLETTER

Editors: John Farrell and Andrea Johnson

The *JOI/USSAC Newsletter* is issued three times a year by Joint Oceanographic Institutions (JOI) and is available free of charge. JOI manages the international Ocean Drilling Program (ODP) and the U.S. Science Support Program (USSSP) which supports U.S. participation in ODP. Funding for JOI/USSSP is provided through a cooperative agreement with the National Science Foundation (NSF).

Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of NSF or JOI. To subscribe, contact: *JOI/USSAC Newsletter*, JOI, 1755 Massachusetts Avenue, NW, Suite 800, Washington, DC 20036-2102; e-mail: joi@brook.edu. For more information about USSSP, visit: www.joi-odp.org.

JOI/USSAC NEWSLETTER

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

PRE-SORTED
FIRST CLASS MAIL
U.S. POSTAGE
PAID
SUBURBAN, MD
PERMIT NO. 3905

NSF REPORT, CONTINUED FROM PAGE 18

▪ 1999: Neogene Evolution of the Costa Rican Arc. Gans (UCSB). Jointly funded with EAR.

▪ Collaborative Research: Long-Term Continuous Sampling of Fluids in Instrumented Boreholes on the Eastern Flank of the Juan de Fuca Ridge. Kastner (SIO); Wheat (Alaska).

▪ Collaborative Research: Structure of the Nicaragua/Costa Rica Subduction Zone: A framework for the Subduction Factory and Seismogenic Zone Initiatives. McIntosh (UTIG); Silver (UCSC).

▪ Global and Local Controls on Depositional Cyclicity: the Canterbury Basin, New Zealand. Fulthorpe, Mann, Frohlich (UTIG).

▪ Collaborative Research: Recharge, Discharge, and Routes of Fluid Flow Within Young Oceanic Crust at the Juan de Fuca Ridge. Fisher (UCSC); Mottl ,Wheat (Hawaii); Becker (Miami). Jointly funded with MG&G.

▪ 3-D Seismic Imaging of an Active Margin Hydrate System- Oregon Continental Margin. Trehu, Nabelek (OSU); Bangs, Sen, Nakamura (UTIG).

▪ Crustal Structure and Evolution of the Newfoundland-Iberia Non-Volcanic Rift: A Seismic Study of the Newfoundland Conjugate Margin. Tucholke (WHOI); Holbrook (Wyoming).

▪ Collaborative Proposal: Long-Term Monitoring Off-Axis Hydrogeology on the Costa Rica Rift Using an Instrumented Wireline Multi-Packer. Becker (RSMAS, Miami); Spiess, de Moustier (SIO).

▪ Collaborative Research: The Effect of Gas Hydrates on Seismic Properties of Sediments and the Relation between the Occurrence of Bottom Simulating Reflectors and Vertical Tectonics: A Proposed Study on the Peruvian Margin. Pecher (UTIG); Clift (WHOI); Ruppel (GA Tech).

▪ Ice-Age and Millenial-Scale Changes of Pacific Intermediate Waters: Ventilation from the Southern Ocean? Pisias, Goldfinger, Mix (OSU); Lyle (Boise St).