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Fire in the Ice

Vol. 6, Iss. 3 Methane Hydrate Newsletter

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International Team Completes Landmark Gas Hydrate Expedition in the Offshore of India

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In mid-August, a team of scientists from India, North America, and Europe completed a four-month expedition aboard the drillship *Joides Resolution* (JR) exploring for gas hydrates in the offshore of India. Led by the Indian Directorate General of Hydrocarbons (DGH) and the U.S. Geological Survey (USGS), the expedition was part of the Indian Government's National Gas Hydrate Program (NGHP). NGHP Expedition 01 was among the most complex and comprehensive gas hydrates field ventures yet conducted. The successful recovery of a wealth of log and core data over a range of geologic environments has provided information that will inform gas hydrates science for years to come.

Pushpendra Kumar (ONGC) and Jim Brewton (USGS) process core samples during Leg 3 of NGHP Expedition. (Courtesy NGHP Expedition 01)

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Interested in contributing an article to *Fire in the Ice*?

This newsletter now reaches more than 700 scientists and other individuals interested in hydrates in sixteen countries. If you would like to submit an article about the progress of your methane hydrates research project, please contact Karl Lang at 301-670-6390 ext. 129 (klang@tms-hq.com)

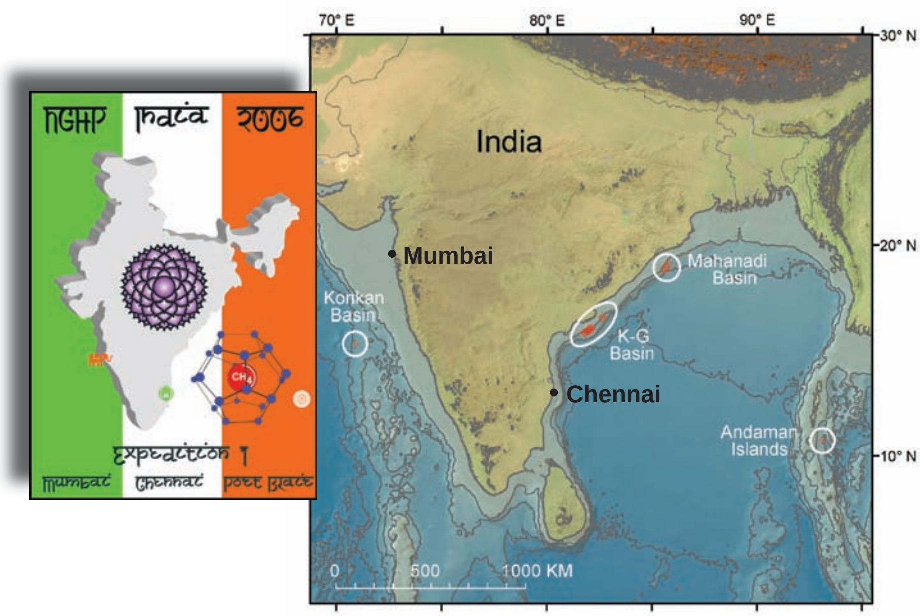
International Collaboration a Key to Success

The NGHP Expedition 01 research voyage was an excellent example of the international spirit of collaboration that continues to infuse gas hydrates research. This Expedition was planned and managed by DGH and the USGS, and was enabled by a long list of contributors, including the Consortium for Scientific Methane Hydrate Investigations (CSMHI - led by Overseas Drilling Limited (ODL) and FUGRO McClelland Marine Geosciences), the Integrated Ocean Drilling Program, the Joint Oceanographic Institutes, Texas A&M University, the Lamont-Doherty Earth Observatory of Columbia University, and the U.S. Department of Energy's National Energy Technology Lab. The science team was led by Dr. Timothy Collett (USGS) and consisted of more than 100 leading scientists and professionals.

Project Objectives and Structure

The operational phase of NGHP Expedition 01 began with the arrival of the scientific crew in Mumbai, India on April 28, 2006 and ended 113 days later with the departure of the ship from its final berth in Chennai on August 19, 2006. The expedition consisted of four separate research drilling, logging, and coring "legs."

- Leg 1 (April 28-May 16): the JR sailed southwest from Mumbai to a location in the Kerala-Konkan basin of the Arabian Sea where it conducted drilling, logging, and coring operations. It then sailed around the southern tip of India to the port of Chennai.
- Leg 2 (May 17-June 6): after personnel and equipment transfers in Chennai, the ship sailed to ten sites in the Krishna-Godhavari (K-G) and Mahandi basins where it conducted logging-while-drilling (LWD) operations before returning again to Chennai.
- Leg 3 consisted of two parts. Leg 3A (June 7-June 25) began when the crew, informed with the LWD results from the previous leg, visited two selected sites within the Krishna-Godhavari basin for drilling, coring, and logging operations. After returning to Chennai for personnel and equipment transfers, Leg 3B (June 26-July 17) continued with additional drilling, coring, and logging operations at five sites within the Krishna-Godhavari region.



Map of drilling locations

- Leg 4 (July 18-August 19): the JR sailed across the Bay of Bengal to core and log a site in the Anadaman Sea off Little Andaman Island. The ship then traveled northwest to explore two sites within the Mahanadi basin. Finally, the JR moved southwest to further explore two additional sites within the Krishna-Godhavari basin before returning to port in Chennai. Drilling, coring, and logging operations were conducted at each of these sites during Leg 4.

Operational Highlights

NGHP Expedition 01 logged a significant number of important accomplishments. The crew completed 113.5 days of operations without significant injury or incident, while at the same time achieving a remarkable degree of efficiency; only 1 percent of total operation time could be categorized as "down time" due to equipment malfunction or weather.

The drilling completed during the expedition enabled the examination of 9,250 meters of total sedimentary section from 39 drilling locations across 21 sites located in four geologically-distinct settings. This included the collection of LWD log data in 12 holes spread over 10 sites, wireline log data at 13 sites, and vertical seismic profile data at 6 sites.

The coring operation was particularly successful, boasting the collection of 494 conventional cores, encompassing 2,850 meters of sediment, from 21 holes (with a 78 percent overall recovery factor). In addition, scientists collected detailed shallow geochemical profiles at 13 locations and established temperature gradients at 11 locations. The expedition also carried out 97 deployments of advanced pressure coring devices, resulting in the collection of 49 cores (up to 1-meter-long) that contain virtually undisturbed gas hydrate in host sediments at near *in situ* pressures.

The large volume of core material provided an opportunity for extensive sample collection to support a wide range of post-cruise analyses by researchers around the globe. Samples included roughly 6,800 whole round core samples for examination of interstitial water geochemistry, microbiology, and other information; 12,500 smaller (5 to 20 cc) sub-samples for paleomagnetic, mineralogical, and paleontological analyses; 140 gas-hydrate-bearing sediment samples maintained in liquid nitrogen; five 1-m

Science team leader Dr. Timothy Collett guiding core sampling on the catwalk of the JR (Courtesy NGHP Expedition 01) gas-hydrate-bearing pressure cores for analyzing the physical and mechanical properties of gas-hydrate-bearing sediment; and 21 re-pressurized cores (nine of which represent sub-samples from gas-hydrate-bearing pressure cores).

Scientific Findings and Impact

The number and level of expertise of the scientists on board allowed the NGHP Expedition 01 science team to efficiently utilize extensive on-board lab facilities to examine and prepare preliminary reports on the physical properties, geochemistry, and sedimentology of all the samples collected prior to the end of the expedition. Because much of the “science” was begun while the samples were being obtained and logged, findings and insights should be available relatively early, despite the huge volume of data collected. Preliminary results indicate that this expedition:

- Conducted comprehensive analyses of gas-hydrate-bearing marine sediments in both passive continental margin and marine accretionary wedge settings;
- Discovered gas hydrate in numerous complex geologic settings and collected an unprecedented number of gas hydrate cores;
- Delineated and sampled one of the richest marine gas hydrate accumulations yet discovered (Krishna-Godovari basin);
- Discovered one of the thickest and deepest gas hydrate occurrences yet known (Andaman Islands) which revealed gas-hydrate-bearing volcanic ash layers as deep as 600 meters below the seafloor;
- Established the existence of a fully developed gas hydrate system in the Mahanadi basin of the Bay of Bengal;
- Demonstrated the utility of employing advanced logging-while-drilling operations to high-grade potential sites for later coring operations; and
- Demonstrated a series of significant advances in infra-red imaging and pressure coring data acquisition and analysis techniques.

Going Forward

The program has now turned its full attention to assuring that the samples and data are efficiently transferred to shore-based labs for further study and full integration with data and insights gathered from previous gas hydrate research activities. Initial preliminary technical reports on the scientific findings of NGHP Expedition 01 are expected to be released as early as March, 2007. A final synthesis of the project’s findings is expected to be available in 2008. Collaboration between the U.S. and India on gas hydrate research is expected to continue through established and developing agreements among DGH, the USGS, and DOE.

Core sample of massive gas hydrate (courtesy NGHP Expedition 01)

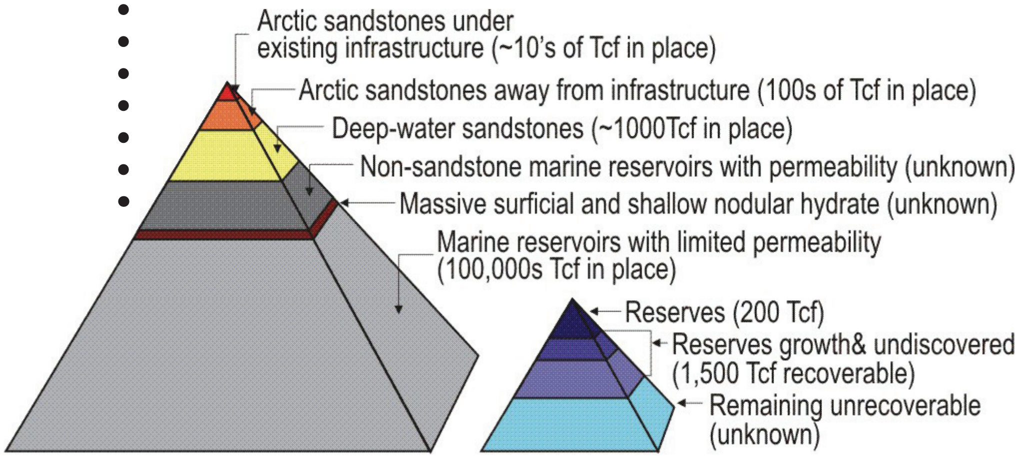
The Gas Hydrates Resource Pyramid

Ray Boswell (US DOE/NETL) and Tim Collett (USGS)

Over the past six years, the U.S. National Methane Hydrate R&D Program has worked to clarify the resource potential of gas hydrates by developing a fuller understanding of the occurrence of and natural controls on gas hydrate in nature. As a result of these efforts, we now recognize that the 1980s model (necessarily simplistic due to lack of field data) that portrayed subsurface gas hydrates as ubiquitous components of relatively uniform temperature and pressure-controlled stability zones is no longer viable. Instead, the Gas Hydrate Stability Zone (GHSZ) has been found to have a very complex geometry, with significant variability due to lateral and vertical changes in pore water salinity and heat flow. Furthermore, within the stability zone, the occurrence of gas hydrate is now recognized to be neither continuous nor random, but instead controlled by the complex interaction of factors unique to gas hydrate systems (necessary temperatures, pressures, and geochemical regimes) as well as many of the same parameters that industry has been using for decades to explore for more conventional resources (gas source, timing and pathways for water and gas migration, and suitable host reservoir).

The recently-published Interagency R&D roadmap (see Announcements in this issue of *Fire in the Ice*) recognizes that the wide range of geological settings for gas hydrate will produce a variety of gas hydrate occurrences. With respect to their relative prospects for future production, we present several of these key varieties ("gas hydrate prospect types") within the context of a gas hydrates "resource pyramid." Resource pyramids are commonly used to display the relative size and producibility of different elements within a category of resources, with the most promising resources at the top and the most technically challenging at the base. The pyramid shape results from the natural tendency for the most abundant elements of a resource group to also typically be the most difficult to profitably extract. A schematic resource pyramid for non-gas-hydrate natural gas resources is shown, at the appropriate scale with respect to the gas hydrates resource pyramid, in the figure below.

The peak of the Gas Hydrates Resource Pyramid (those resources that are closest to potential commercialization) is represented by gas hydrates that exist at high saturations within quality reservoirs rocks under existing Arctic infrastructure. This resource is currently estimated to be in the range of 33 trillion cubic feet (Tcf) of gas-in-place (in the "Eileen" trend of Alaska's North Slope). Of that total, reservoir modeling conducted within the structure of the BP-DOE cooperative agreement on the North Slope suggests that as

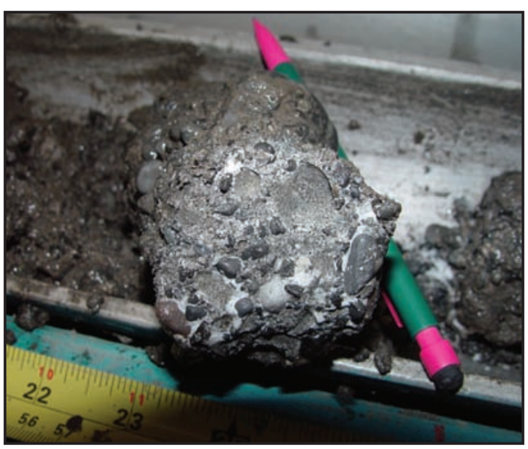


Gas Hydrates Resource Pyramid (left). To the right is an example gas resources pyramid for all non-gas-hydrate resources.

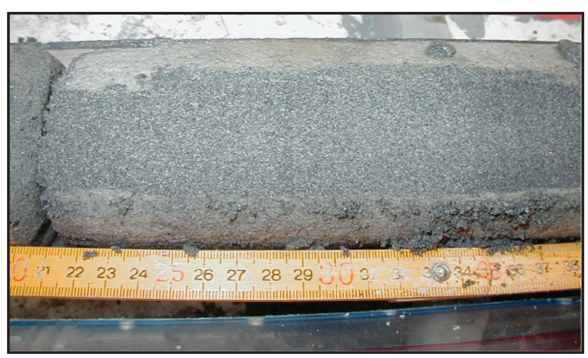
much as 12 Tcf of that volume may be technically recoverable. The next largest class of hydrate resources (shown in orange) are those less well-defined accumulations that exist in similar geologic settings (discretely trapped, high-saturation occurrences within high-quality sandstone reservoirs) on the North Slope, but away from existing infrastructure. The current USGS estimate for total North Slope resources is approximately 590 Tcf gas-in-place.

The next most challenging group of resources includes gas hydrates of moderate-to-high concentrations that occur within quality sandstone reservoirs in the marine environment. Because these resources will be challenged by the likely high costs of extraction from very deep water, the most favorable accumulations are those found in the Gulf of Mexico that lie in the vicinity of oil and gas production infrastructure. The scale of this resource is not well known, but is the subject of an ongoing assessment by the U.S. Minerals Management Service (MMS). Recent work by the MMS has revealed the occurrence of significant volumes of sandy sediments within the shallow section. In addition, the existence of high-quality reservoir sandstones with high gas hydrate saturation are known from the Gulf (see article on Alaminos Canyon 818 on page 12 of this issue of *Fire in the Ice*). Similar occurrences have also been reported by expeditions to the Nankai Trough offshore Japan and by the recent IODP Expedition 311 offshore Vancouver Island.

On the pyramid, below the resources associated with sand and sandstone-reservoirs, come massive deposits of gas hydrate, generally found encased in fine-grained muds and shales. Most promising among this group of gas hydrate occurrences are those with elevated gas hydrate saturations due primarily to extensive structural disturbance of the sediment. Such fractured reservoir accumulations may be common in certain areas, with thick sections exhibiting massive vein fills, or high concentrations of small hydrate nodules, smaller vein fills, and massive layers parallel to bedding planes. However, unlike the sand/sandstone systems where grain-supported reservoirs result in high matrix permeability and for which well-based production concepts are more plausible, extraction of methane from these shale-encased fractured accumulations will be very problematic. Major technological advancements beyond current production systems will be needed.



Example of disseminated gas hydrate (white) within porous and permeable Arctic sandstone from the Mallik site, Northwest Canada (courtesy Mallik 2002 Gas Hydrate Project)



Example of disseminated gas hydrate (white specks) within porous and permeable marine sandstone from the Nankai Trough, offshore Japan (from Fujii, et al, 2005 ICGH Proceedings)

A special class of gas hydrate occurrences are massive gas hydrate mounds that lie exposed on the seafloor (or beneath a very thin layer of sediment) and extend to unknown depths. These features are possibly very dynamic and may be very common; however, the amount of gas resource represented is unknown. Recovery of methane from such features may be very difficult due to both their potentially limited size and the likelihood for significant disturbance of sensitive sea-floor ecosystems.

At the very base of the gas hydrate resource pyramid are those finely-disseminated accumulations, typified by the Blake Ridge accumulation offshore the Carolinas, in which large volumes of gas hydrate are relatively evenly distributed through vast volumes of fine-grained and relatively undeformed sediment at low (~10% or less) saturations. Perhaps the bulk of the world's global gas hydrate in-place resource (in the hundreds of thousands of Tcf gas-in-place) resides within this resource class. Unfortunately, the prospects for economic recovery of natural gas from this highly disseminated resource are very poor with current technologies. A major paradigm shift will be necessary to enable commercial extraction from such deposits.

In accord with this view of the gas hydrate resource base, the Interagency Program's effort to assess the future energy supply potential of gas hydrates recognizes the investigation of sand and sandstone reservoirs as it's highest priority. This work will focus on utilizing the natural laboratory of the Alaska North Slope to address questions of production technologies, with the near-term goal being the establishment of an extended production test facility. In the marine environment, the program will target exploratory drilling, the development of remote sensing systems, and the advancement of geologic models to better constrain the scale and nature of the marine gas hydrate resource, both in sandstones (highest initial priority) and in dense accumulations of massive forms associated with fracturing. The program will continue to support the development of the science and technology that will enable the reliable appraisal of gas hydrate prospects of all types by providing an improved understanding of the variety of natural geological systems that produce such deposits.

Example of nodular gas hydrate from zone of intensely deformed fine-grained sediments (courtesy NGHP Expedition 01, India)

Example of massive sea-floor mound from Offshore Vancouver Island (courtesy Ross Chapman, U.Victoria)

Gas Hydrate Potential of the Mid Atlantic Outer Continental Shelf

William W. Shedd (MMS, New Orleans, LA) and Deborah R. Hutchinson, (USGS, Woods Hole, MA)

For the last two years, the Minerals Management Service (MMS) has been studying the resource potential of gas hydrates in federal offshore lands of the Outer Continental Shelf (OCS) off the Atlantic, Gulf of Mexico, Pacific, and Alaska in collaboration with the U.S. Geological Survey (USGS), the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the Naval Research Lab (NRL) and academia. Utilizing its extensive seismic, well, and geochemical databases, the MMS will be reporting the in-place resource numbers within the next few months. Though the methodology of the study was not prospect oriented, discrete prospects have been recognized.

Gas hydrates off much of the Atlantic OCS have been identified by the presence of a coherent and continuous bottom-simulating reflection (BSR). BSRs are interpreted as a seismic reflection event that marks the base of the hydrate stability zone (HSZ) where free gas beneath the HSZ forms a large acoustic contrast with the presumably hydrate-saturated zone above. Though not considered a tool to quantify hydrate saturations, most researchers feel the existence of BSRs in seismic data indicate the presence of free gas and at least some hydrate. The classic BSR recognized since the 1970's at the Blake Ridge hydrate accumulation appears in USGS seismic data as a discrete strong, negative reflection (very similar to gas prone "bright spots") within the anticlinal sea-floor morphology (Figure 1). When the Blake Ridge region was drilled in 1995 by the Ocean Drilling Program (ODP), gas hydrates at low saturations were recovered in fine-grained mud deposits.

Although gas hydrates have been known in the vicinity of the Hudson Canyon for many years, the MMS study is the first to attempt to quantify the hydrate as a prospect. The BSR noted in the mid-Atlantic OCS occurs in a sedimentary drift deposit similar to the Blake Ridge and is identified by several discrete, bedding-parallel, high-amplitude negative reflections (suggestive of gas filled sands) that can be traced updip into low-amplitude, positive, bedding-parallel reflections that terminate at an unconformity (Figure 2). Connecting these phase reversals allows the BSR to be recognized. What is significant about this prospect, called the Whale prospect, is its size – approximately 12,000 km^2 (3 million acres) in a region that is approximately 90 by 280 km (55 by 175 miles) long. Only one of the

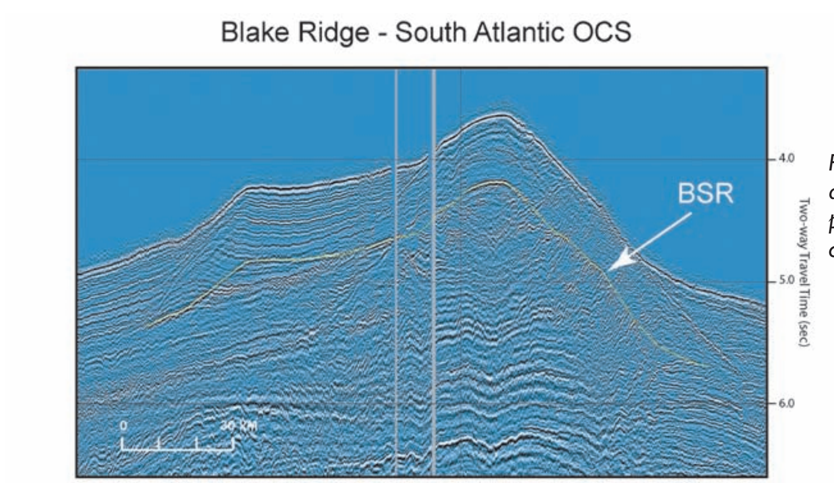


Figure 1: Example of a seismic profile across the Blake Ridge region showing the prominent Bottom Simulating Reflection (BSR) crosscutting bedding horizons.

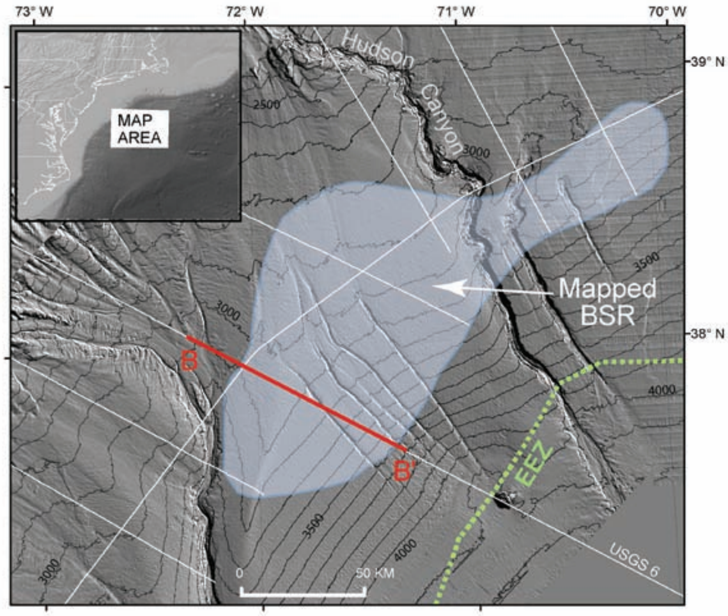


Figure 2: Map of the mid-Atlantic OCS region showing the regional extent of the Whale hydrate prospect. The area outlined by the mapped BSR covers much of the crest of the Hudson sediment drift deposit. BB' shows the location of the seismic profile shown in Figure 3. Bathymetry for this map comes from recent high-resolution multibeam bathymetric surveys conducted by the University of New Hampshire and NOAA. Contour interval is in meters.

five dip lines defining the prospect (Figure 3) extends past the downdip edge of the prospect, so its true size may be larger. More seismic data are needed for better definition of the composition and edges of the prospect. Additionally, the MMS assessment study of reservoir sand potential from nearby well control and seismic stratigraphy indicates a high probability for glacially derived Pleistocene sands within the hydrate stability zone in this prospect, as opposed to the mud-dominated system at the Blake Ridge. The presence of sands may significantly increase the chances that the prospect contains high-saturation intervals of hydrate.

The magnitude of this prospect was only recently recognized for two reasons. First, these seismic data were initially collected in the early 1970's when computer processing was time-consuming and available only at specialized and (generally) expensive facilities. Consequently, the seaward end of the seismic line where the BSR is most obvious was not initially processed by the USGS. Second, the original interpretations were done on paper records that were not easily redisplayed or rescaled to enhance certain reflections. For the current analysis, the MMS used all the original USGS lines reprocessed by FugroRobertson and loaded digitally on workstations. This approach enables all the lines to be viewed simultaneously and manipulated on one screen.

Though much more work needs to be done to quantify this resource, the size of this prospect alone suggests a significant potential resource. The free gas potential below the BSR is significant, also, in that the strong negative events interpreted to be gas sands are 15-30 km wide by 65-95 km long (10 to 20 miles by 40 to 60 miles). The engineering hurdles associated with the production process, the lack of pipeline infrastructure, the water depth (greater than 3,000 m [10,000 feet] of water), and the political hurdles associated with the OCS drilling moratorium in this area all need to be resolved before this resource can be exploited.

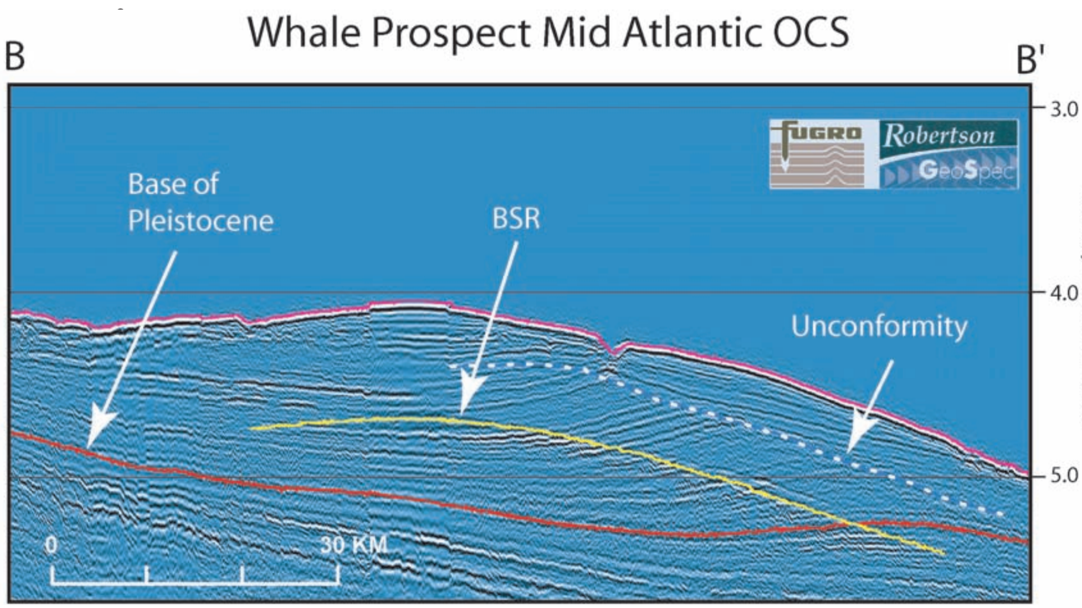


Figure 3: Seismic profile across the Whale hydrate prospect showing the mapped BSR together with a prominent unconformity and the base of the Pleistocene deposits. The hydrate stability zone above the BSR lies within Pleistocene and modern sediments and is likely to contain sand-rich intervals where gas hydrate could be highly saturated.

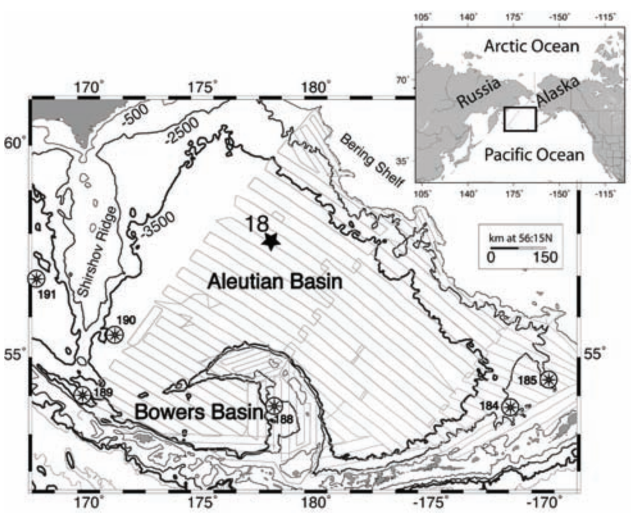
Possible Deep-Water Gas Hydrate Accumulations in the Bering Sea

Ginger A. Barth, David W. Scholl and Jonathan R. Childs (USGS, Menlo Park, CA)

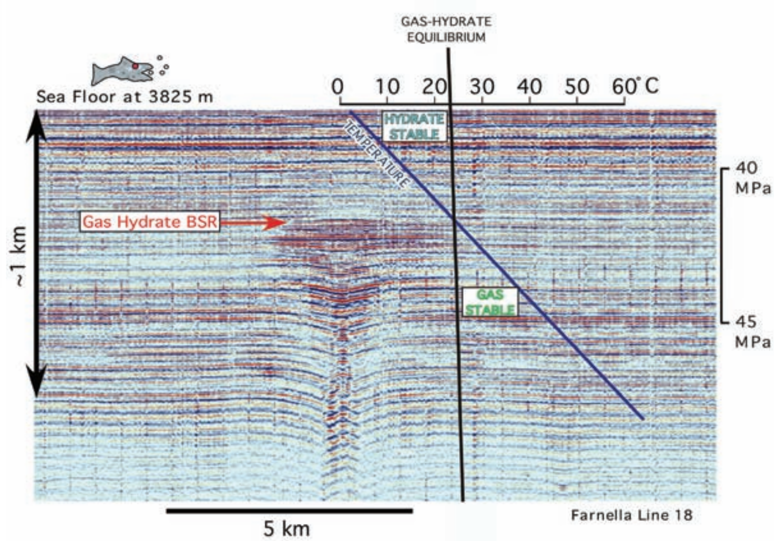
Seismic reflection images from the deep-water Aleutian and Bowers Basins of the Bering Sea contain many hundreds of acoustic Velocity-AMPlitude (VAMP) anomalies, each of which may represent a large accumulation of natural gas hydrate. Against a backdrop of essentially horizontal sedimentary reflections, the VAMP anomalies stand out as both high-amplitude bright spots and zones of vertically aligned horizon distortions. The VAMPs are interpreted as natural gas chimneys overlain by concentrated hydrate caps.

The key to our interpretation of the VAMPs is the change in seismic characteristics that occurs at the predicted depth of the base of methane hydrate stability (~360 m below the sea floor). Basin wide, a high amplitude reversed-polarity hydrate bottom simulating seismic reflection (BSR) is typically present at this level. Within the VAMPs, above the hydrate BSR, horizons appear arched upward, consistent with a velocity pull-up caused by the higher acoustic velocity of interstitial hydrate. Below the BSR, horizons often brighten and appear down-warped, consistent with lowered acoustic velocities and enhanced impedance contrasts due to the presence of some free gas in the pore spaces.

VAMP anomalies are observed in both single- and multi-channel reflection images of every vintage. They were first noted in the 1960's, and a gas hydrate interpretation was forwarded in the 1970's. Now thirty years later, with the advantages of today's seismic analysis capabilities and a geo-referenced Bering Sea seismic database, we are able to extract quantitative



Bering Sea location map. Note that the Aleutian and Bowers Basins lie at 3600-3900 m water depth. Star marks the location of the VAMP example shown at right. Circled stars represent nearest drilled wells, from DSDP leg 19. Track lines represent ~24,000 km of digitally recorded USGS single channel seismic coverage.



A prominent VAMP anomaly in a single-channel seismic reflection image from the central Aleutian Basin. Pressure-temperature overlay predicts the base of methane hydrate stability, for comparison.

details that were not previously accessible. Our database contains over 30,000 km of single channel and short-streamer multi-channel seismic reflection data, most of which was collected by the USGS between 1975 and 1982. The database was developed to address sediment thickness and basement topography questions relevant to Law of the Sea (LOS), Article 76. With data and tools in place, our LOS analysis effort is also shedding new light on the distribution and origin of gas hydrate in the Bering Sea.

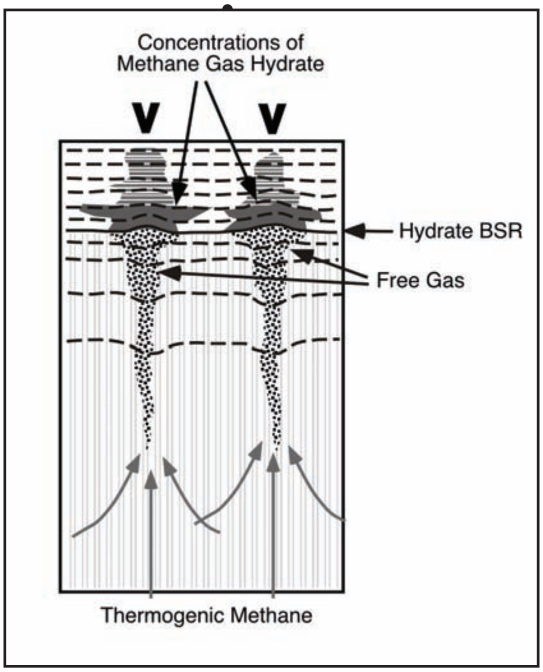
We are learning that the Bering Sea VAMPs are large features, typically 2 to 8 km across within the hydrate stability zone, with approximate cylindrical symmetry. They are wider than they look, with total widths roughly twice that of their eye-catching central bright spots. Analyses of interval travel time variations suggest that lithology controls the anomaly distribution within each VAMP. Hydrate concentration estimated over 50 to 100 m intervals reaches 40% of pore space in some intervals, assuming that all travel time variation is due to hydrate presence.

VAMP spatial distribution is strongly linked to basement topography within the basins. The larger VAMPs with the most well-formed hydrate-zone travel time anomalies are associated with underlying basement highs. Sediment thickness is 2 to >4 km throughout these basins, and folded or faulted structure is generally absent. We hypothesize that basement topography affects differential compaction of the sediment and therefore controls the long-lived locations of vertical egress for deep basin fluids. These pipe-like fluid seepage zones appear to provide ongoing focused delivery of thermogenic methane to the hydrate stability zone, creating the VAMPs.

A typical large VAMP structure appears to store roughly 1 Tcf of hydrate-bound natural gas, comparable to a larger conventional gas field. The concentration of hydrate in these apparent subsurface bodies is an unusual manifestation of hydrate accumulation, yet the structures are so numerous in the Aleutian and Bowers Basins that they may represent a combined volume significant in the global context. The Bering Sea VAMPs occur in a small oceanic basin setting, at water depths >3600 m. This is also atypical, but is evidence that volumetrically significant gas hydrate can be present beyond the continental margin.

The Bering Sea VAMPs present intriguing possibilities in the areas of resource potential, global methane budget, and habitats for deep sea life. Yet the interpretations remain untested. A conclusive field study, or drilling program, has yet to be carried out.

The authors welcome your comments, questions or preprint requests: gbarth@usgs.gov.



VAMP anomaly interpretation. Sedimentary horizons are sketched as they appear in seismic images. We attribute the horizon distortions largely to velocity variation, particularly within the hydrate stability zone. Gray shading represents the most concentrated hydrate accumulations; gray striped shade suggests lower volume fractions of hydrate.

Alaminos Canyon Block 818: A Documented Example of Gas Hydrate Saturated Sand in the Gulf of Mexico

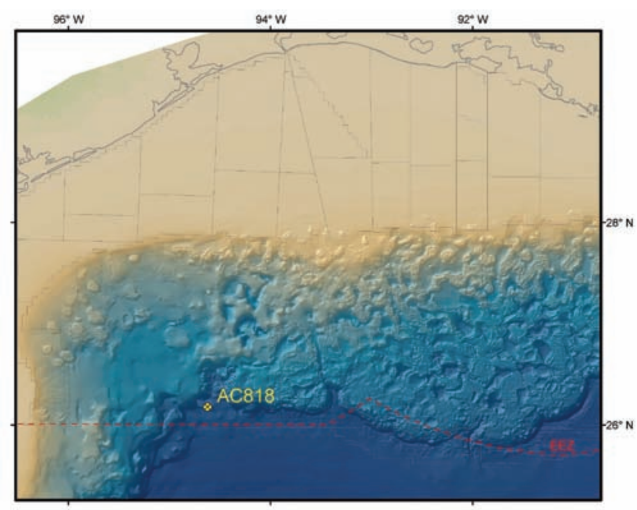
Stacey Smith (Chevron), Ray Boswell (U.S. DOE/NETL), Tim Collett (USGS), Myung Lee (USGS) and Emrys Jones (Chevron)

Chevron USA has made available to the research community data that provide the first confirmation of the presence of a thick zone of gas-hydrate-saturated sandstone in the Gulf of Mexico. The data also represents the first known full suite of geophysical well logs taken by the oil and gas industry across the gas hydrate stability zone in the Gulf.

The data was collected in 2004 in an exploration well located in roughly 9,000 feet of water in Alaminos Canyon Block 818 (known as the "Tiger Shark" area). Chevron's conventional hydrocarbon targets were Paleocene Wilcox sandstones, however, analysis of seismic data over the structurally-based prospect showed anomalous responses at the predicted depth of the regional oil and gas reservoir sandstones within the shallower Oligocene Frio Formation. Chevron determined that the Frio, which at this location is only slightly more than 1,500 feet beneath the seafloor due to a major erosional unconformity, was most likely within the zone of gas hydrate stability based on expected formation temperature and pressure, and water chemistry.

To determine if gas hydrates were present, Chevron designed the well to maximize the opportunity for obtaining a full suite of quality well logs across the interval. Instead of the standard practice of rapidly drilling and casing large boreholes through the hydrate stability zone, Chevron set the surface casing at an unusually shallow depth to ensure that hole size in the Frio zone was conducive to acquisition of quality well logs. In addition, Chevron controlled drilling parameters to prevent turbulent flow and potential wash-out of the formation. Both efforts were successful and a full log suite, including gamma ray, resistivity, density, and acoustic velocity, was obtained.

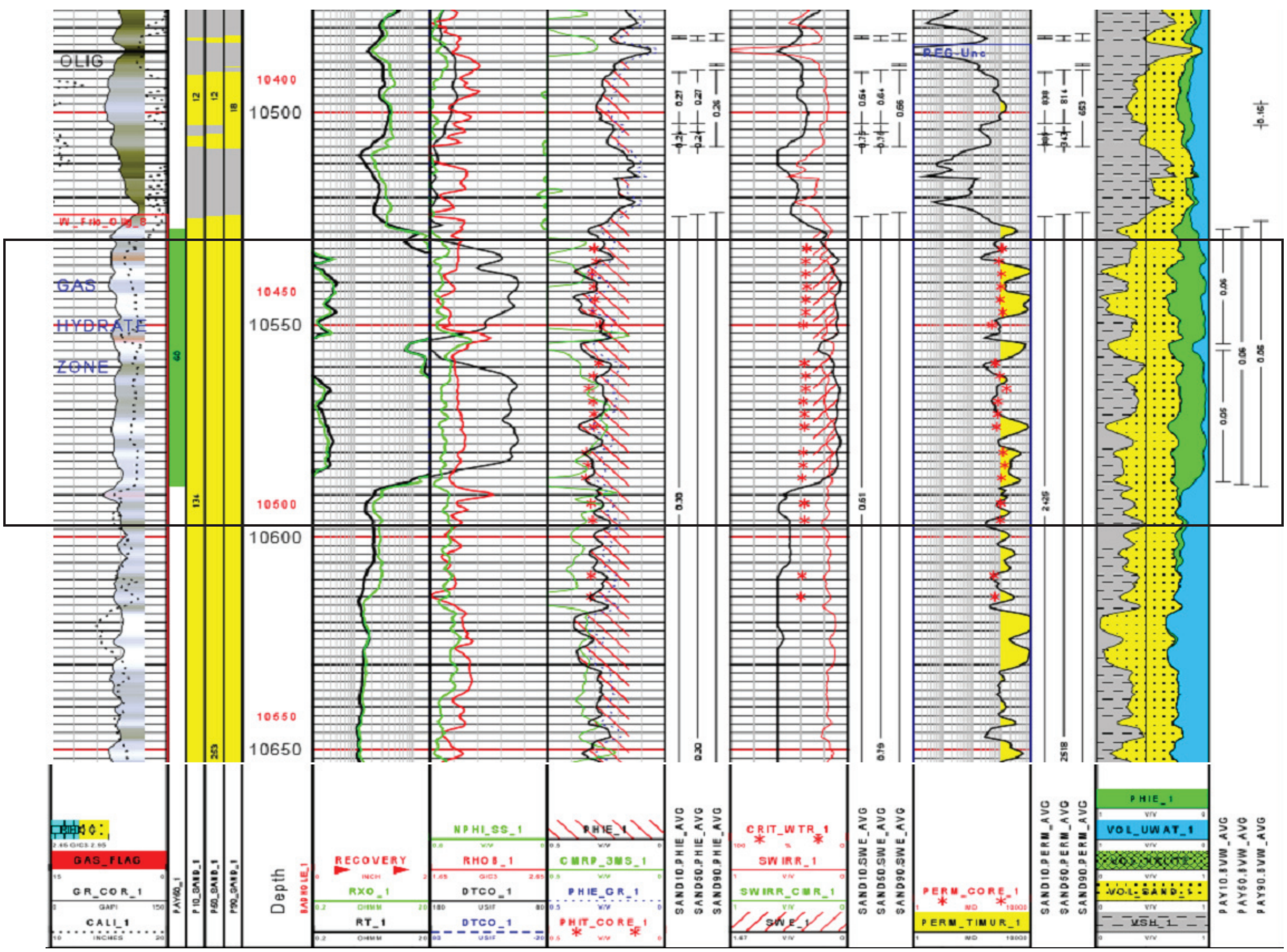
During drilling below 22-inch surface casing (set at 10,320 feet drilling depth), which was accomplished with a riser, gas began to flow out of the formation at a depth of ~10,537 feet. The drilling fluid was "weighted-up" to control the gas flow, a 17 7/8 casing was set (10,434 feet) and drilling proceeded. The hole, which was drilled with a 14 3/4-inch bit, remained well in-gauge and 16-inch casing was set below the target sandstone interval at 11,652 feet. Gas shows



Approximate Location of subject well in Alaminos Canyon block 818 were commonly observed throughout the Frio interval. Chevron has estimated that the drilling fluid within the well was approximately 70° F. Shut-in bottom hole pressure measured at 10,537 feet was 4,478 psi.

Most notable in the log data is the juxtaposition of high resisitivities and high acoustic velocities, a feature generally indicative of gas hydrate occurrence. Also notable is the muted gamma-ray response, which would normally indicate a silt or shale with only minor sand content. However, side wall cores taken in the interval indicated an immature lithic sandstone with elevated radioactivity due to high concentrations of volcanic glass and potassium-feldspar-bearing rock fragments.

Initial examination of the well log data indicates approximately 60 feet of hydrate-bearing sand (10,530 to 10,590 drilling depth) with porosity of roughly 30% and resistivity in the range 30 to 40 ohm-m. Side-wall cores revealed formation intrinsic permeability in the Darcy range. Initial estimates of gas hydrate saturation derived from analyses of the resistivity and p-wave velocity data indicate a range of from 60% to over 80% of available pore volume. Preliminary calculations indicate that the base of the gas hydrate stability zone at this location is below the base of the hydrate-bearing zone observed in the well. Further analyses of this accumulation are currently underway by the USGS and others in support of the DOE/Chevron Gulf of Mexico JIP and will be reported in more detail in future publications.



Well log montage showing data collected over the suspected gas hydrate-bearing interval (boxed area) at Alaminos Canyon Block 818 (courtesy Chevron). Log data for this well can be obtained through the public information section at www.mms.gov/.

Methane Hydrate Advisory Committee Identifies Near-Term Goals

A meeting of the Methane Hydrate Advisory Committee in Houston on November 8-9 was attended by 33 committee members and invited presenters. One important task of this meeting was to provide feedback to DOE on a draft five-year plan for methane hydrate research derived from the 20-year, long range "Interagency Roadmap for Methane Hydrate Research and Development" approved at the April 2006 meeting of the Committee. The committee also heard reports on the status of several field activities: the BP Milne Point hydrate project, the Chevron JIP Gulf of Mexico project, and two summer 2006 expeditions -- the Barkley Canyon Expedition conducted by Monterey Bay Aquarium Research Institute, and the Indian Government's Expedition. The next full meeting of the committee will take place on April 24-25, 2007 in Golden, Colorado.

Update on DOE/BP Alaska North Slope Characterization Project

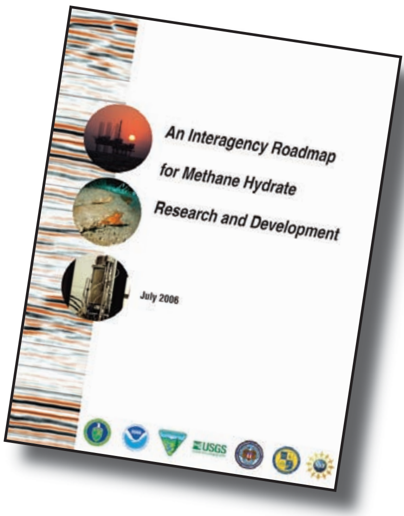
An effort by BP Exploration (Alaska), the U.S. Department of Energy, and the U.S. Geological Survey to assess gas hydrate resources on the Alaskan North Slope will proceed into the field phase with the spudding of a vertical test well within the Milne Point Unit in late January or early February, 2007. The well will drill, core and wireline log the full extent of the gas hydrate stability zone within the previously described "Mt. Elbert" prospect. A series of short-duration wireline reservoir performance tests with the Modular Dynamic Tester (MDT) will also be obtained. The findings of this test will be used to guide the further progression of the project into long-term production testing.

Reservoir Simulator Code Comparison Study Website Now Available

The National Energy Technology Laboratory (NETL) and the U.S. Geological Survey (USGS) are guiding a collaborative, international effort to compare methane hydrate reservoir simulators. As part of this effort, a website is now publicly available at www.netl.doe.gov/methanehydrates (the full web address is http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/MH_codecompare/MH_CodeCompare.html). The website provides background information about the study, a list of participants involved, an overview of the simulators included in the study, as well as detailed information about each case study being compared. Results are available for each problem the group has completed to date and new information and results files will be added to the site as they become available.

"Lab Call" for Research on Gas Hydrates

DOE/NETL is soliciting proposals for National Lab Field Work Proposals (FWP) on the issue of gas hydrates in the natural environment. NETL is particularly interested in studies that: 1) clarify gas hydrate's role in global carbon cycling, global climate, and/or large scale instabilities on the continental margins; and 2) address the potential environmental implications of gas hydrate dissociation due to either natural causes or human/industrial activity. Collaborative projects between Labs or among Labs and respected private researchers/institutions are encouraged. Interested parties should contact Tim Grant at tim.grant@netl.doe.gov for more information.



Interagency R&D Roadmap Published

Representatives of the seven federal agencies participating in the national methane hydrates R&D program have prepared a long-range roadmap outlining the goals and strategies for the program over the period through 2025. This plan will form the basis of a detailed five-year R&D plan to be presented to the Federal Advisory committee in April of 2007. To access the document, go to http://www.netl.doe.gov/methanehydrates.

Recent Methane Hydrate Project Reports Posted on the DOE/NETL Website

DOE/NETL maintains a website describing its program in Methane Hydrates at netl.doe.gov/methanehydrates. Among the publications available are downloadable copies of Topical and Technical reports by each of our private research partners. Recent reports added to these pages include the following

- Chevron/DOE Joint Industry Project (JIP) Cruise Report: a 196-page report describing the scientific activities and findings of the shipboard science team from the March 2005 expedition of the *Uncle John*.
- JIP Semi-annual Report: a 143-page report outlining the findings of the JIP through March, 2006.
- BP/DOE Alaska North Slope Resource Characterization Project Semi-Annual Report: a 222-page report describing the scientific activities and findings of the project through June, 2006.
- U. Mississippi Sea Floor Monitoring Station: a 508-page report detailing program activities through March, 2006.
- Final technical report "Controls on Gas Hydrate Formation and Dissociation, Gulf of Mexico: *In Situ* Field Study with Laboratory Characterizations of Exposed and Buried Gas Hydrates" by Scripps Institution of Oceanography and Texas A&M University.

To access these and other project information go to www.netl.doe.gov/methanehydrates and click the link Methane Hydrate Projects under the section Key Links.

Spotlight on Research

MARTIN ROTHFUSS

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When not manufacturing coring tools on drillship decks, Martin enjoys hiking and biking in the Harz Mountains of Northern Germany, where his house is situated between a small river and a forest. He particularly enjoys "hunting" mushrooms and inviting friends to join in fresh mushroom dinners.

Marine Hydrates No Match for Engineering Persistence

German engineers have a motto, "Geht nicht – gibt's nicht; und wenn doch, müssen wir uns etwas einfallen lassen," which can be roughly translated as, "It can't be done, it's impossible … but nothing is impossible so we'll just have to come up with a solution." Martin Rothfuss put this bit of wisdom into practice when working with pressure coring tools during last summer's cruise of the JOIDES Resolution in search of methane hydrates in the Indian Ocean.

"There are two existing pressure corers capable of connecting to the core transfer system in use on the drillship; the Fugro Pressure Corer, designed for softer formations, and the HYACE Rotary Corer, or HRC, designed for drilling in more consolidated formations," explains Martin. Although most of the formations encountered during the cruise consisted of soft, sticky clays, the type not typically drilled with the HRC, it was necessary to deploy both tools in order to minimize drilling down time. So the challenge was to design and implement tool modifications—on the spot—that would allow coring of soft formations using the HRC. "Working both day- and night-shifts I designed and built, together with the rig mechanic and the ship's welder, a modified drill section and a new cutting head adapted for the clayey formations where hydrates were expected," recounts Rothfuss. "With this new design we were able to successfully obtain more than a dozen full length cores under pressure." Each of the cores was investigated in a GEOTEK x-ray, gamma ray and p-wave measurement chamber and afterwards either degassed or stored under full pressure in specially designed storage chambers for further investigations on shore.

Martin studied at the Institute of Petroleum Engineering (IPE) of the Technical University Clausthal in Clausthal-Zellerfeld, Germany, graduating with a German "Diplom-Ingenieur," equivalent to a M.E. "I first got involved with gas hydrates in 2002 when I took over responsibility for further development of the existing HRC pressure coring tool which had been developed at IPE," says Martin. "At the time the tool was in a prototype stage. It had been tested successfully on one research cruise, however, it proved to be unreliable during a subsequent cruise. At the begining of 2006 the HRC was handed over to Fugro and I worked 6 months as a freelance engineer for them on drillships investigating gas hydrates offshore Borneo and in the Indian Ocean."

Fugro is an international company that collects and interprets geotechnical data. Martin begins work this month with Fugro Engineers B.V., where he will be mainly involved in the design, development, testing and application of pressure coring tools and systems for the investigation of deep sea soils.

Rothfuss finds the most challenging aspect of his work to be the hands-on application of equipment under the "real life" conditions of a drill ship. "Conditions in a real bore hole in the real seabed are much different from conditions in a laboratory or a test stand," says Martin. In addition, he explains that the data obtained from a tool's operation during the coring process are limited. "It can be very difficult after an unsuccessful run to figure out what went wrong and what can be done to improve the function and reliability of the tool. Especially if you are not in a workshop but ending a 30-hour shift at night on a drillship during a tropical storm and have just been informed by the chief scientist that the bit will reach a hydrate bearing formation in 3 hours and that it would be very nice if he could be certain of obtaining a core."

Martin gives the credit for instilling in him that "try and try again" stubbornness to his engineering Professor Dr. Claus Marx. The practice of transforming ideas into mechanical parts he learned from the designer of the HRC and former head of the workshop at the Institute of Petroleum Engineering, Karl-Eduard "Edy" Winter.

Martin also describes his belief that the ability to collect pressurized cores under in-situ conditions will remain an indispensable element of research on gas hydrates, and that, "Improving the systems that allow the acquisition of these cores will remain an important contribution to the science of methane hydrate and eventually, to its commercial production."