Summer 2003

Fire in the Ice

THE NATIONAL ENERGY TECHNOLOGY LABORATORY METHANE HYDRATE NEWSLETTER

CONTENTS

International Science Team Studies Hydrates Off the Coast of Chile

Results may have far-reaching implications

Early this summer, a team of international scientists set forth on a voyage of discovery in the Pacific Ocean offshore from the central Chilean coastline. From March 22 through April 9, scientists from Chile, Japan, the United States, the United Kingdom, Canada, and Germany worked side by side aboard the research vessel Vidal Gomez to chart the unexplored Chilean marine margin and evaluate the presence of gas hydrates.

This interdisciplinary field exploration was carried out in two pilot sectors in the region 33º to 40º South latitude. Methane hydrate investigations centered on different geophysical and geochemical methods to detect and characterize gas hydrates. Geophysical methods applied to this preliminary investigation included reflection marine seismology, transient electromagnetics, heat flow, bathymetry, gravity, magnetism, ocean bottom seismology, high frequency echo sounding for bubbles transported through

Crewmembers aboard the R/V Vidal Gomez.

This is Your Newsletter
Fire in the Ice is the newsletter for the entire hydrate community. It is challenging to bring together such a diverse group of researchers and devise a newsletter that will be interesting to all of you. If you have or know of something you'd like to see published in *Fire in the Ice*, or have ideas for how to improve the newsletter, please contact us.

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Be sure to visit our website at http://www.netl.doe.gov/scng/hydrate

www.netl.doe.gov/scng/hydrate

the water column, and water column geochemistry. A key effort in the program was the application of the Naval Research Laboratory's multi-channel deep towed acoustic/geophysics seismic system (DTAGS). Geochemical analyses included the sediment carbon content, pore water methane concentration, vertical pore water sulfur speciation gradients, and carbon isotope analysis of carbon pools related to hydrate formation, lattice saturation, and content. Chilean scientists contributed to the mutual effort of fieldwork, laboratory experimentation, data interpretation, and modeling. Technical capability and expertise was a collaborative effort among researchers from Chile, Japan, Canada, United Kingdom, United States, and Germany.

This research may have far-reaching implications beyond detecting the presence of hydrates and understanding their nature.

Economic Implications

Many countries around the world with marine coastlines lack traditional energy resources, such as petroleum. However, the potential methane hydrates exploitation in their jurisdictional waters could significantly change the global energy trade picture by the middle of this century. As recently predicted, known petroleum resources will be insufficient in the future; investigations suggest that the use of hydrates represent a great potential for countries throughout world. For example, natural gas generation in Chile from methane hydrates would allow Chile to replace, in the mid-term, the gas that currently arrives from Argentina, and may provide an opportunity for Chile to compete in the distribution market in other Latin American countries. This energy source could also catalyze new energy policies in our own country.

Landslide Hazard

Submarine landslides occur in unstable accumulations of oceanic bottom sediments. In some cases, movement of the seafloor can be caused by gas hydrate decomposition and the resulting gas expansion or liberation. This last observation is particularly important in the context of the Chilean margin, where an association between the locations of methane hydrates and the occurrence of seismic activity centers (caused by the unevenness of the sediment or stress concentration at the interplate contacts) can be useful in identifying risk or areas of uncertainty.

Environmental Considerations

The resource study and characterization of methane hydrates may also prove to be of value in addressing environmental issues. Methane in hydrates is abundant worldwide, and methane, used as a fuel, gives off only half as much carbon dioxide as coal, and 25 percent less than oil. The use of methane over other fossil fuels will help diminish air pollution and acid rain, which in turn will improve environments for forests, waters, farmlands, and communities.

Methane hydrates are located in shallow submarine environments, which are finely balanced ecological systems made up of many components. Interference associated with hydrate exploitation may provoke spontaneous dissociation that could potentially affect climate and the atmosphere on a global scale. Gas hydrates could potentially become associated with global climate change because methane is a very strong greenhouse gas, with nearly 10 times the absorptivity of carbon dioxide.

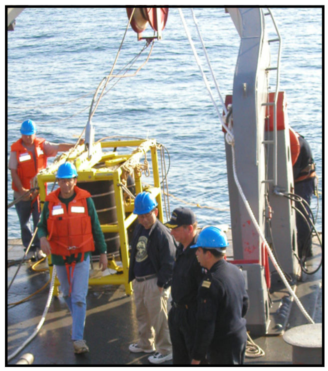
The Chilean research program was built around an awareness of these implications, and the cruise was designed to address many of these important issues. The objective of the program was to integrate field studies with laboratory experiments to understand the variation in methane hydrate content, lattice saturation, and stability. Specific goals were to:

- Refine geophysical, geochemical, and microbiological technologies for prospecting resource content and distribution.
- Define high-priority geographical areas of prospective interest as a function of the methane volume contained in those areas.
- Diagnose the possible environmental effects and geologic risks at the continental margin associated with the natural resource occurrence and resource exploitation.
- Define a conceptual background for the creation of a legal framework for resource management purposes.

The collaboration of researchers and experts from many countries in this effort allowed for an invaluable exchange of technological information and was a rich experience for all involved.

RECENT NRL ACTIVITIES

Recent activities of the Naval Research Laboratory include fieldwork in the Gulf of Mexico, Norwegian-Greenland Sea, Blake Ridge off the coast of Georgia and the Carolinas, Cascadia Margin along the coast of Victoria, British Columbia, and Nankai Trough, near Tokyo Japan.



Scientists launching the DTAGS for assessment surveys.

Corporal Pizarro, machine technician (left), and Sussana Giglio, PUCV master student and SHOA observer, in the lab aboard the Vidal Gomez.

The international research team and crew aboard the R/V Vidal Gomez in the open sea offshore Chile, from left to right: Manabu Tanahashi (AIST), William Monroe (High Tech Inc.), Antonio Urbina (Bosun), Grant Bower (NRL-Stennis), Hitoshi Tomaru (University of Tokyo), Ryo Matsumoto (University of Tokyo), Warren Wood (NRL-Stennis), Denis Lindwall (NRL-Stennis), Mauricio Velázquez (1st Officer), Charles Mégnin (NRL-Stennis), Richard Coffin (NRL-Washington DC), Courtney Ann Schupp, Cristian Davanzo (Captain), Susana Giglio (PUCV master student and SHOA observer), Juan González (PUCV student), Juan Pablo Olivares (Oceanography Officer onboard Vidal Gomez), Rosswell Downer, Juan Díaz-Naveas (Chief Scientist and researcher at PUCV), Roberto Castro (electronic technician SHOA)

New Tools Advance Scientific Studies of Natural Gas Hydrates

by Pete McGrail and Phil Long, Pacific Northwest National Laboratory

It is now known that gas hydrates represent one of the most significant fossil fuel energy resources on earth. Tapping hydrates as a gas resource has only attracted significant attention very recently. The challenges are considerable because gas hydrates are widely and heterogeneously distributed in nature, and commercial production has never been attempted. In addition, advanced methods to produce gas from hydrate reservoirs require information to support modeling of coupled fluid, heat, reactive chemical transport, and mechanical processes that are at the cutting edge of today's gas hydrate science.

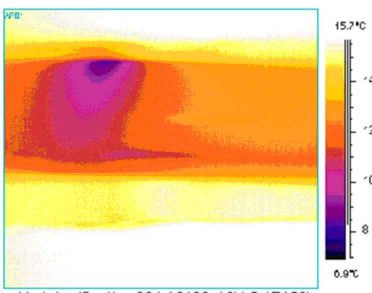
To help fill some of the information gaps in order to evaluate and test new ideas for producing gas hydrates, several new tools are under development at the Department of Energy's Pacific Northwest National Laboratory located in the state of Washington. In this article, we will highlight three of these tools: infrared imaging analysis (IR), resonant ultrasound spectroscopy (RUS), and environmental scanning electron microscopy (ESEM).

Infrared Imaging Analysis. Dissociation of gas hydrates is an endothermic reaction that consumes heat from its surroundings. Thus, when core samples are brought to the surface from deep underground or the deep ocean, the pressure and temperature changes cause hydrate to dissociate into methane gas and water. The resulting thermal anomalies can be imaged with the aid of an infrared camera.

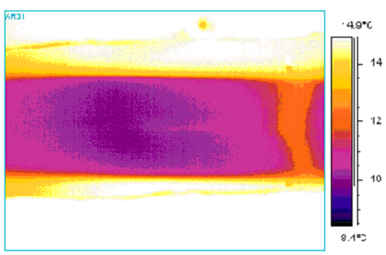
During Leg 204 of the Ocean Drilling Program, extensive IR images were obtained on cores from Hydrate Ridge, offshore Oregon by the Leg 204 Shipboard Scientific Party[1]. Specifically, each 9.5 m core was imaged every 20 cm, providing a very high resolution data set of the temperature of the core liner. Areas of the core where hydrate was present showed up clearly as cold layers, zones, or spots. The image data provided an independent method of estimating gas hydrate abundance and texture as an essentially continuous function of depth. The challenge now is to extract more quantitative information on hydrate abundance from the IR data and to analyze that information by correlating it with stratigraphy, geochemistry, physical property data, and other proxies for hydrate occurrence.

IR imaging of gas hydrate-bearing cores is also planned for the Anadarko sub-permafrost well on the North Slope of Alaska to be completed late in 2003.

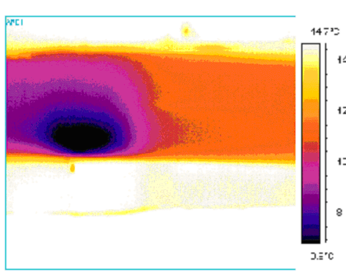
Vein, shallow dip (Section 204-1248C-7H-1; IR128)



Nodular (Section 204-1248C-10H-5; IR152)



Disseminated (Section 204-1248C-11H-2; IR155)



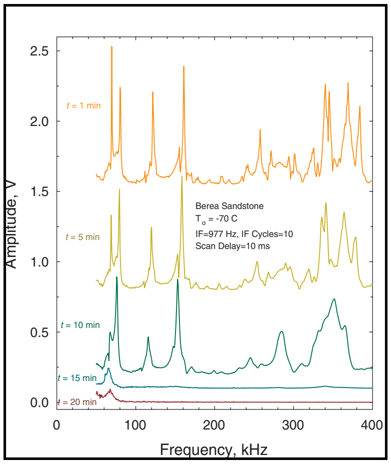
Nodular or blade-shaped (Section 204-1248-11H-6; IR157)

Examples of IR images of core from Site 1248, Hydrate Ridge, Offshore Oregon

[1]Members of the Leg 204 Shipboard Scientific Party are as follows: A.M. Trehu, G. Bohrmann, F.R. Rack, T.S. Collett, D.S. Goldberg, P. E. Long, A.V. Milkov, M. Riedel, P. Schultheiss, M.E. Torres, N.L. Bangs, S.R. Barr, W.S. Borowski, G.E. Claypool, M.E. Delwiche, G.R. Dickens, E. Gracia, G. Guerin, M. Holland, J.E. Johnson, Y-J. Lee, C-S. Liu, X. Su, B. Teichert, H. Tomaru, M. Vanneste, M. Watanabe, J.L. Weinberger. See http://www-odp.tamu.edu/publications/prelim/204_prel/204toc.html for complete contact information for science party members. Funding for IR imaging on Leg 204 was provided jointly by the U.S. Department of Energy, National Gas Hydrate Research Program at the National Energy Technology Laboratory and by the National Science Foundation, Ocean Drilling Program.

Resonant Ultrasound Spectroscopy. Production of gas hydrate reservoirs requires altering the pressure or temperature conditions to cause hydrate dissociation and release of the methane gas. However, the loss of solid hydrate may significantly alter the fundamental mechanical properties of the rock. To address safety issues associated with heavy drilling equipment on the surface, changes in the mechanical properties of sediments before, during, and after hydrate production need to be understood.

Resonant ultrasound spectroscopy is a new method for analyzing the mechanical properties of hydrate-bearing sediments. As an acoustical method, the technique is non-destructive. Also, no bond is used between the transducers and the sample, so the measurement is unaffected by thermal expansion/contraction and freezing/thawing cycles. It is possible to determine (with some restrictions) all the elastic constants of a sample from a single RUS measurement.



Resonant ultrasound spectra of Berea sandstone containing gas hydrate as the specimen warms

Resonance spectra collected on a Berea sandstone containing gas hydrate show what happens as the specimen warms up to room temperature. Resonance peaks abruptly disappear as the gas hydrate dissociates, which shows how sensitive the technique is to the presence of hydrate. The resonance spectra are rich with additional information. For example, the resonance peaks shift to lower frequency as the sample warms, which is caused by a decrease in its elastic moduli, i.e., strength. The lowest frequencies are observed to shift in both frequency and amplitude as the sample warms, which is caused by changes in the shear modulus (the resistance to twisting or torsion).

The key challenges are to develop a pressurized housing for the RUS system so that controlled pressure-temperature measurements can be conducted and to miniaturize the system into a modular unit that can be taken into the field. A new mathematical model is also needed to interpret the RUS spectra, which are impacted by acoustical coupling between the gas and sample surface at high pressure.

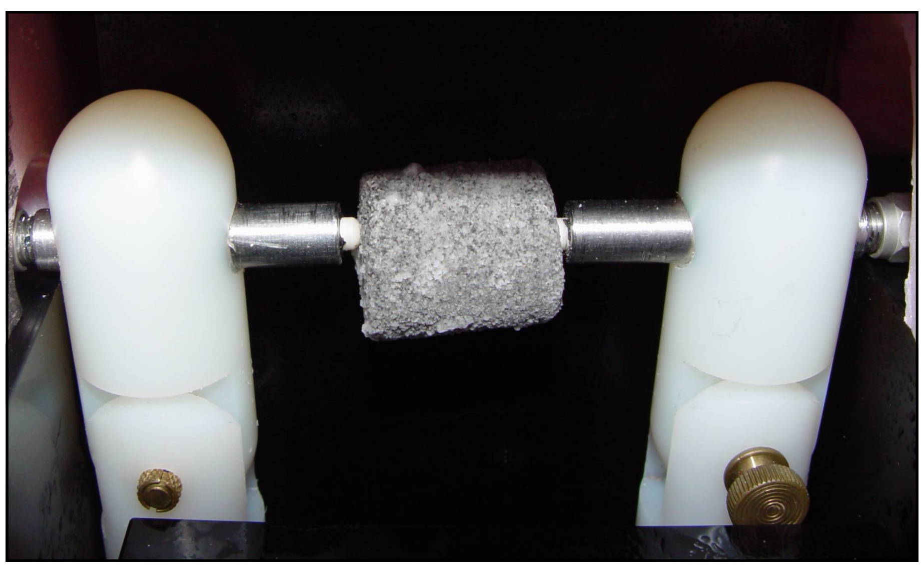
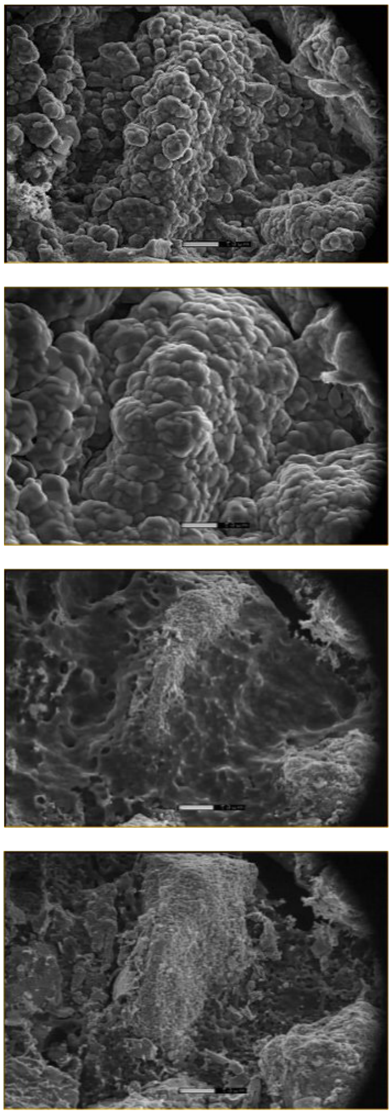


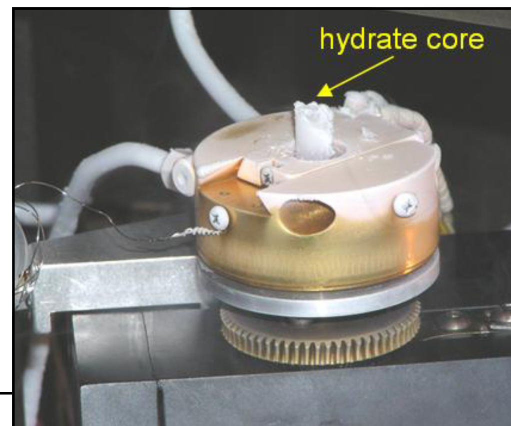
Photo of core sample from the Mallik 5L-38 gas hydrate research well undergoing a resonant ultrasound spectroscopy measurement.

Environmental Scanning Electron Microscopy. The environmental scanning electron microscope (ESEM) provides unique advantages for studying gas hydrates as compared with conventional electron microscopes that operate under high vacuum. In the ESEM, gas hydrates can be studied while exposed to gases (including methane) and water vapor albeit still at relatively low pressure (~0.2 psi). However, by using a cryostage on the instrument, temperature can be adjusted to maintain hydrate stability. Thus, a complete survey of a sample can be obtained without losing the hydrate in the process.

The ESEM at PNNL is equipped with a liquid nitrogen-cooled cryostage, fracture unit, and mass spectrometer. A video recording unit with voice annotation is used to record the hydrate dissociation process in situ. The fracture unit is a simple blade that is used to break a sample and expose fresh surface for analysis. The integrated mass spectrometer is used to measure gas phase composition during hydrate dissociation experiments. The progression of images captured at the left shows initial growth of hydrate/water ice on a sediment grain followed by hydrate dissociation as the sample is allowed to warm up past the hydrate stability region. ESEM studies like these provide a new way to study the microscopic details of gas hydrate formation/dissociation in natural sediment samples.



Video frames captured during ESEM analysis of Mallik 5L-38 core sample under a methane gas atmosphere



Cryostage for ESEM with hydrate core sample mounted for analysis

ElectroScan Model E3ESEM located in the Environmental and Molecular Sciences Laboratory at PNNL

National Research Council Reviews the Methane Hydrate Research and Development Program

The Methane Hydrate Research and Development Act of 2000 revitalized our nation's methane hydrate research program. The bill set forth guidelines for the research and potential development of gas hydrates as an energy resource within an environmentally sensitive framework. Six government agencies (Department of Energy, Minerals Management Service, National Oceanographic and Atmospheric Administration, National Science Foundation, Naval Research Laboratory, and U.S. Geological Survey), in collaboration with universities and private industry, are currently involved in over 30 research projects.

The bill assigned the National Research Council (NRC) to study the progress of the research program to ensure that the research progresses efficiently and addresses pertinent issues. The Secretary of Energy is required to report the Council's findings and recommendations to Congress no later than September 30, 2004.

To comply with this section of the bill, the NRC is currently selecting a committee of experts on gas hydrates. The committee members will soon be posted on the NRC website, and the first of four meetings is planned for late August or early September 2003.

The committee reviewing the 2003 National Methane Hydrate Research and Development Program is charged with:

- providing advice on program emphasis to ensure that significant contributions are made towards understanding methane hydrates as a source of energy and as a potential contributor to climate change by advancing basic and applied research.
- making recommendations for future methane hydrate research and development needs.
- assessing whether the program is meeting the goals of developing technologies for the efficient and environmentally sound development of methane hydrate resources, reducing the risks of drilling through methane hydrates, and mitigating the environmental impacts of hydrate degassing.

NRC comments and recommendations will provide Congress with an understanding of the scientific research and results funded through the National Methane Hydrate R&D Program. Congressional representatives will use the information to determine whether to reauthorize the program, which officially expires on September 31, 2005. A successful National Methane Hydrate R&D Program will have enormous long-term public benefits, including enhanced environmental protection, increased energy security, and a sound foundation of knowledge about a natural phenomenon.

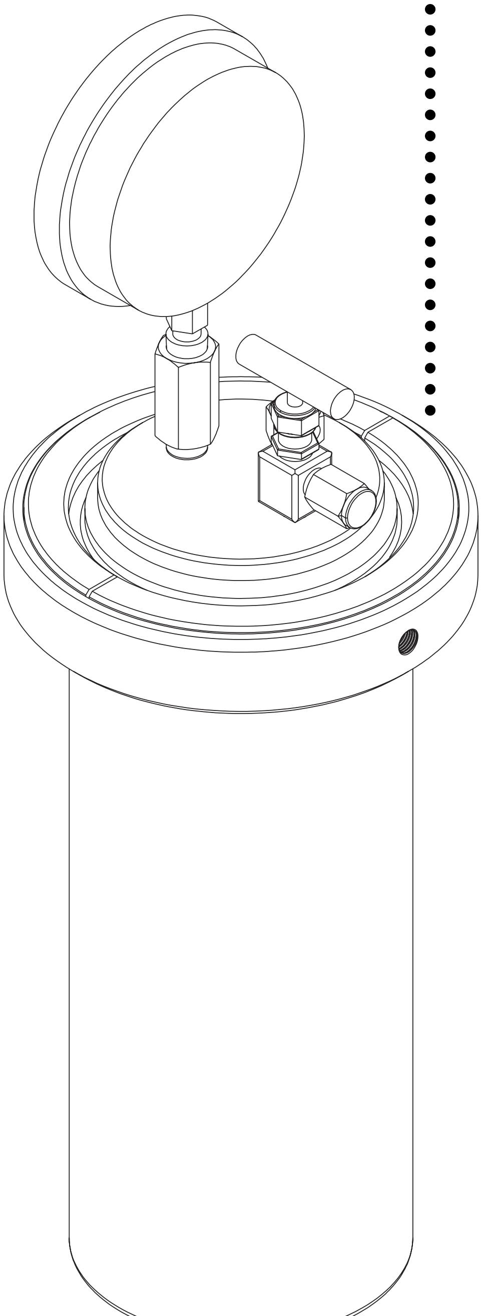
The National Research Council

National Research Council

The National Research Council (NRC) is part of the National Academies, which also includes the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. They are private, nonprofit institutions that provide science, technology and health policy advice under a congressional charter. The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and advising the federal government.

For more information, log onto the NRC website at http://www.nas.edu/nrc/

US DOT Approves Pressure Vessels for Transportation of Pressurized Hydrate Core



The U. S. Department of Transportation (DOT) has given the Ocean Drilling Program (ODP) approval to use certified pressure vessels for transporting pressurized hydrate core collected during Leg 204 of the Ocean Drilling Program (ODP). Larry Obee, John Firth, and others at ODP, Texas A&M University, submitted a design for a wide-mouth vessel capable of holding intact gas hydrate core sections. ODP is in the process of contacting carriers to handle transportation of the pressurized containers.

Pressurized gas hydrate samples are now available to researchers for laboratory studies. It is important that researchers use the samples promptly because hydrate core deteriorates over time. ODP will issue guidelines for the use/tranport of their vessels in the near future.

Details on the pressure vessels are:

- Manufacturer: Parr
- Inside diameter: 3.75 inches/9.53 cm
- Sample length: 10.4 inches/26.4 cm (approx)
- Working pressure: 2000 psia (approx)
- Material: 316 stainless steel
- Sealing mechanism: O ring (keep them heated until actual assembly, if working in Arctic winter conditions)
- Assembly: simple, split ring and hoop mechanism (this is a very quick and easy method of assembly)
- Weight: 30 lbs/13.6 kg (approx)
- Cost: $2500 (includes vessel, burst disk, and pressure gauge)

For more information about the pressure vessels, please contact Larry Obee, obee@odpemail.tamu.edu, 979-862-8717.

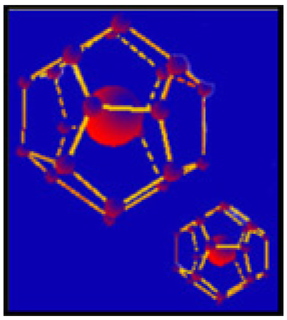
There is a quantity discount of 10% for 5 vessels, 15% for 10 vessels, and 25% for more than 15 vessels placed in one order. Separate orders may be combined to reduce costs. ODP has already placed an order for two vessels. Anyone interested in combining orders please contact Larry Obee or John Firth (firth@odpemail.tamu.edu) at ODP. Anyone who purchases a certified vessel must apply for their own DOT approval for shipping. Contact Larry Obee or John Firth for additional information about this.

If you have questions on how to acquire core samples, please contact William J. Gwilliam (william.gwilliam@netl.doe.gov) or go to the ODP web site directly at http://www-odp.tamu.edu [science & curation/ sample requests & policy/ fill-out forms].

Announcement

DOE/NETL Methane Hydrate Conference and the 4th ChevronTexaco JIP Workshop

September 29–October 1, 2003 Westminster (Denver), Colorado



On September 29 and 30, 2003, the U.S. Department of Energy, Office of Fossil Energy/National Energy Technology Laboratory (NETL) will host a Methane Hydrate Conference. This conference will provide updates and highlights of ongoing research supported by the National Methane Hydrate R&D Program. Multiple government agencies and researchers will participate. In addition to sessions on arctic and marine methane hydrate projects, the conference will include a poster session and reception.

Immediately following the conference, on September 30 and October 1, 2003, the ChevronTexaco Joint Industry Project (JIP) on "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico" will hold its fourth workshop. This workshop will present the results of Phase I of the JIP project, and will offer plans for Phase II for discussion and critique.

For more information, please view the JIP Naturally Occurring Gas Hydrates event website at **http://www.TheEnergyForum.com/Hydrates2003.asp** and the NETL Project Review event website at **http://www.TheEnergyForum.com/NETL2003.asp**. Please note that the Website URLs are case sensitive.

Registration: Registration must be done online by going to the registration page on either event website* shown above. Deadline for registration is September 25, 2003. To partially offset the cost of the workshops, a registration fee of $50.00 (US) for the DOE/NETL Conference and $125.00 (US) for the JIP Hydrates workshop will be charged to all attendees.

Venue: The workshop will be held at the Westin Westminster Hotel in Westminster, a suburb northwest of Denver, Colorado. Reservations can be made by calling 303-410-5000 or 1-800-WESTIN-1. Ask for the Gas Hydrates rate or give the code GASHYDRT.

Reception and Poster Session: There will be a reception and poster session on the evening of September 30th. Those interested in displaying a poster should contact Wendy DiBenedetto for details (see below).

For more information or if you have questions concerning the JIP workshop or registration, please feel free to contact Wendy DiBenedetto at The Energy Forum at 281-477-3636 or **Wendy@TheEnergyForum.com**. Questions concerning the DOE Conference should be addressed to Kathy Bruner at 304-285-1338 or **kathy.bruner@eg.netl.doe.gov**.

* NOTE: If your computer security settings are high, you may not be able to use the online form. Should you have any difficulty please contact Wendy DiBenedetto at 281-477-3636 or email Wendy@TheEnergyForum.com.

NOAA's Office of Ocean Exploration Announces the 2004 Proposal Solicitation

Craig McLean, Director of the National Oceanic and Atmospheric Association (NOAA) Ocean Exploration Program (OE), has announced the Fiscal Year 2004 proposal solicitation. OE is currently seeking pre-proposals to implement its mission to expand our knowledge about the ocean's physical, chemical, biological and archaeological characteristics through expeditions to unknown or poorly-known oceanic and Great Lakes regions.

The OE Fiscal Year 2004 solicitation was published on Friday July 25, 2003 in the Federal Register. The Announcement of Opportunity and additional guidance can be found at: http://explore.noaa.gov/. Please email any additional questions to oar.oe.faq@noaa.gov.

The deadline for pre-proposal submissions is September 3, 2003. Please note that e-mail and/or FAX submissions will NOT be accepted.

Cruisin' for Hydrates

2003 Methane Hydrate Research Cruises

2003 Dates	Institution/s	Chief Scientist/s	Cruise Name	Research Vessel/s	Research Area
Early October	GHRC/CMRET-UM	R. Woolsey T. McGhee	R/V Pelican	R/V Pelican	GOM
10/1-24	GEOMAR, TAMU, UNAM	G. Bohrmann	SO-174-1 OTEGA-II (Leg 1)	R/V Sonne	Texas-Louisiana Slope
10/25-11/12	GEOMAR, TAMU, UNAM	G. Bohrmann	SO-174-2 OTEGA-II (Leg 2)	R/V Sonne	Campeche Slope, Mexico

CMRET	Center for Marine Resources and Environmental Technology
DTAGS	Deep-towed Acoustics/Geophysics System
FSU	Florida State University
GEOMAR	GEOMAR Research Center, Kiel, Germany
GHOSTS	Gas Hydrate Observation, Sampling, and Tracer Study
GHRC	Global Hydrology Resource Center
GOM	Gulf of Mexico
LSU	Louisiana State University
MMS	Minerals Management Service
NOAA	National Oceanic and Atmospheric Administration
NRL	National Research Laboratory
NURP	National Underwater Research Program
OMEGA	Oberflächennahe MarinE Gashydrate
ROPOS	Remotely Operated Platform for Ocean Science
TAMU	Texas A&M University
UM	University of Mississippi
UNAM	Universidad Autonoma de Mexico
UNC	University of North Carolina
VIMS	Virginia Institute of Marine Sciences

Announcements

Mallik 2002 Gas Hydrate Production Research Well Program

International Symposium on Methane Hydrates

"From Mallik to the Future"

December 8 to 10, 2003,
Hotel New Otani, Chiba, Japan

The partners of the Mallik 2002 Gas Hydrate Production Research Well Program* are pleased to announce an International Symposium on Methane Hydrates. This meeting will serve as the first public release of the scientific and engineering results from the Mallik program that was undertaken to study the production potential and environmental conditions of gas hydrates. Three research wells were completed during the winter of 2002 in Mackenzie Delta, N.W.T., Canada. The diverse science program included a broad suite of core studies, surface and downhole geophysical surveys, and reservoir simulation modelling. Production testing experiments for the first time monitored formation response and gas flow induced by pressure drawdown and thermal stimulation.

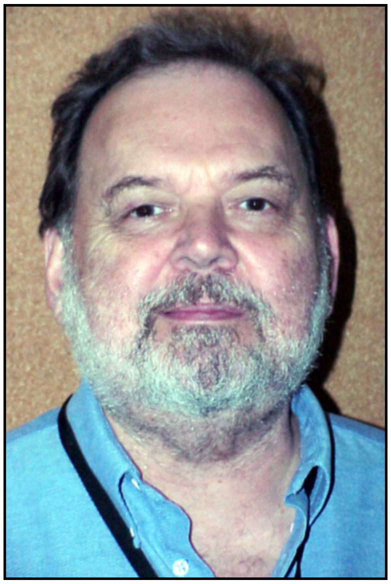
An open session in the symposium will also explore future international gas hydrate science and production research priorities and venues to further collaboration.

Conference Chair:	Mr. Noboru Tezuka (JNOC)
Co-Chair:	Dr. Rolf Emmerman (GFZ)
Program Chair:	Mr. Scott R. Dallimore (GSC)
Co-Chairs:	Dr. Timothy S. Collett (USGS)
	Dr. Michael Weber (GFZ)
	Dr. Takashi Uchida (JNOC)
	Mr. Takahisa Inoue (JNOC)
	Mr. Tetsuo Yonezawa (JNOC)

For more information, see the Mallik Project web sites (gashydrate.com; icdp.gfz-potsdam.de) and follow the links to the "From Mallik to the Future" symposium.

* Partners of the Mallik 2002 Gas Hydrate Production Research Well Program: Geological Survey of Canada (GSC), Japan National Oil Corporation (JNOC), GeoForschungsZentrum Potsdam (GFZ), United States Geological Survey (USGS), United States Department of Energy, India Ministry of Petroleum and Natural Gas (Gas Authority of India/Oil and Natural Gas Corporation), BP-Chevron-Burlington Joint Venture Group. The program was also accepted as a project within the auspices of the International Continental Scientific Drilling Program.

Spotlight on Research



JOE GETTRUST

Joe is married to Dr. Bronya Keats. Bronya is a geneticist, and chairman of the Genetics Department at the LSU Medical School. Their son Patrick is a college student majoring in Political Science at the University of Alabama when he is not in Japan visiting friends.

Reference: *Wood, W. T., J. Gettrust, N. R. Chapman, G. D. Spence, and R. D. Hyndman, Decreased stability of methane hydrates in marine sediments due to phase boundary roughness, Vol 420, Nature, Dec 12, 2002.*

JOE GETTRUST–NAVAL RESEARCH LABORATORY

Joe Gettrust is the Geology-Geophysics Section Head and Supervisory Geophysicist for the Seafloor Sciences Branch at the Naval Research Laboratory (NRL). The Seafloor Sciences Branch provides the Navy with information on marine geology and environments that may affect Navy operations.

As head of the Geology and Geophysics Section, Joe directs fundamental research in seafloor and sub seafloor processes using geophysical (primarily seismic and acoustic) techniques. Much of his associated methane hydrate research is based on field measurements, many of which are made by the section's unique deep-towed multichannel seismic system, DTAGS (Deep Towed Acoustics/Geophysics System), with support from wave propagation and fluid flux modeling.

Joe became fascinated with methane hydrates after several years of conducting research into the properties of deep-ocean sediments using DTAGS. In 1989, while he and his team were investigating the Blake Ridge area, they discovered that the DTAGS data had imaged the entire hydrate stability zone. The high resolution of these data showed faults that extended from the Bottom Simulating Reflector (BSR) to within meters of the seafloor. The existence of faults cutting through the hydrate stability zone is an important factor that must be considered in models for the generation and dissociation of gas hydrates.

"The success of this first study in a gas hydrate region allowed us to successfully propose ongoing research in gas hydrates that continues to this day," says Joe.

In addition to the discovery of the faults through the hydrate stability zone on Blake Ridge, Joe's research has made two other significant contributions to our knowledge and understanding of hydrates. The first is the discovery that the BSR "reflector" is frequency-dependent, which has been documented in work conducted with colleagues from Victoria University and the Geological Survey of Canada on the Cascadia Margin. The second is the development of a model that predicts the impact of a "rough" base of gas hydrate stability on the dissociation of gas hydrates. This work (Wood et al., 2002) was predicated on DTAGS data taken on the Cascadia Margin. The seismic data were used to constrain numerical simulations that estimate the geologic timing and extent of perturbations to the hydrate stability zone.

And there is much work still to be done. Joe says we need significant improvement in our capability to characterize the distribution and concentration of gas hydrates. One improvement would be to develop technology that generates shear waves by placing a seismic source on the seafloor. This would allow scientists to take advantage of the fact that the shear velocities in hydrated and un-hydrated sediments vary much more than compressional velocities. Furthermore, as shear velocities are insensitive to gas in sediments, a comparison of compressional and shear seismic-sections would allow researchers to differentiate between a true BSR (where the solid clathrate structure reverts to free gas and fluid) and a carbonate layer, for instance.

However, Joe also believes that while seismic investigations will continue to be productive, biogeochemical investigations may lead to the greatest advances in our understanding of gas hydrates.

Early in Joe's career, he was fortunate to work with two splendid mentors to whom he is deeply indebted and attributes his own successful research career. Dr. Robert P. Meyer, University of Wisconsin – Madison, Joe's major professor, shaped his life in many ways, and Dr. Anton Hales, Australian National University, provided excellent scientific guidance and encouraged Joe to expand his scientific interests.