U.S. Department of Energy • Office of Fossil Energy • National Energy Technology Laboratory

Fire in the Ice

Spring/Summer 2006 Methane Hydrate Newsletter

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CONTACT

Ray Boswell

Gas Technology Management Division

304-285-4541

ray.boswell@netl.doe.gov

DOE Announces New Fellowship Program Dedicated to Methane Hydrate Research

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) has initiated a new academic research fellowship program designed to support the development of methane hydrate science and enable highly qualified postgraduate students to pursue advanced degrees in an area of increasing importance to the Nation. "I am happy to announce a new graduate fellowship in methane hydrates research that expands the Department of Energy's multi-faceted support for advanced education to include the study of this potentially enormous source of natural gas," said Secretary Samuel W. Bodman on announcing the program. "Students are the foundation of our energy future, bringing new ideas and fresh perspectives to the energy industry. What better way to assure technology innovation than to encourage students working on the development of a resource that has the potential to tip our energy balance toward clean-burning, domestic fuels. This is just one of many outgrowths of the Energy Policy Act of 2005 that will move our country toward a more secure energy future."

The 2-year fellowships will be made available to support work towards M.S. and Ph.D degrees, or in a Post-doctoral appointment. The National Academy of Sciences (NAS) will be responsible for creating and administering the

Secretary of Energy Samuel Bodman (at left) and NETL Director Carl Bauer during a recent tour of NETL's research laboratories.

National Energy Technology Laboratory

1450 Queen Avenue SW
Albany, OR 97321
541-967-5892

2175 University Avenue South
Suite 201
Fairbanks, AK 99709
907-452-2559

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880
304-285-4764

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
412-386-4687

One West Third Street, Suite 1400
Tulsa, OK 74103-3519
918-699-2000

Visit the NETL website at:
www.netl.doe.gov

Customer Service:
1-800-553-7681

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

This newsletter now reaches nearly 500 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)

program in association with NETL and the ongoing interagency R&D effort in methane hydrates.

The NRC currently administers similar programs designed to provide advanced training for highly qualified scientists. For example, over the past two decades, the NRC has made more than 11,000 awards for postdoctoral and senior scientists and engineers to work at National Laboratories.

NETL's new Methane Hydrates Fellowship program will be designed to maintain three to five fellows under tenure at any point in time, supporting work that prepares the individuals to apply hydrate science either in practical applications in industry or in further academic research. Selection of fellows will be based on the technical/scientific merit of proposed projects, their potential to advance the stated goals of the interagency R&D program and the nature of the proposed research environment (including mentors and hosting institutions).

"NETL looks forward to including some of the nation's best young engineers and scientists in the important work being done through the DOE-led interagency program in methane hydrates," commented Carl Bauer, Director of DOE's National Energy Technology Laboratory. "But just as important to us is the chance to provide exciting research opportunities that will attract the nation's brightest students into the energy sciences field. This, in addition to the technological development going on everyday at NETL, is critical to securing our nation's energy future."

The program will feature competitive stipend structures, including a $6k annual travel allowance. Support for research costs will have limits related to the nature of the work (e.g., laboratory versus field), and there will be no support for tuition, considered to be an appropriate institutional contribution. Candidates will be able to name the institution where the work would be done without prior institutional "certification" (however, the quality of the institution will be a consideration in the merit ranking of proposals). All interested students should look for the fellowship to be formally launched through the NAS' established vehicles in the very near future.

Strengthening Science Through Hydrate Research

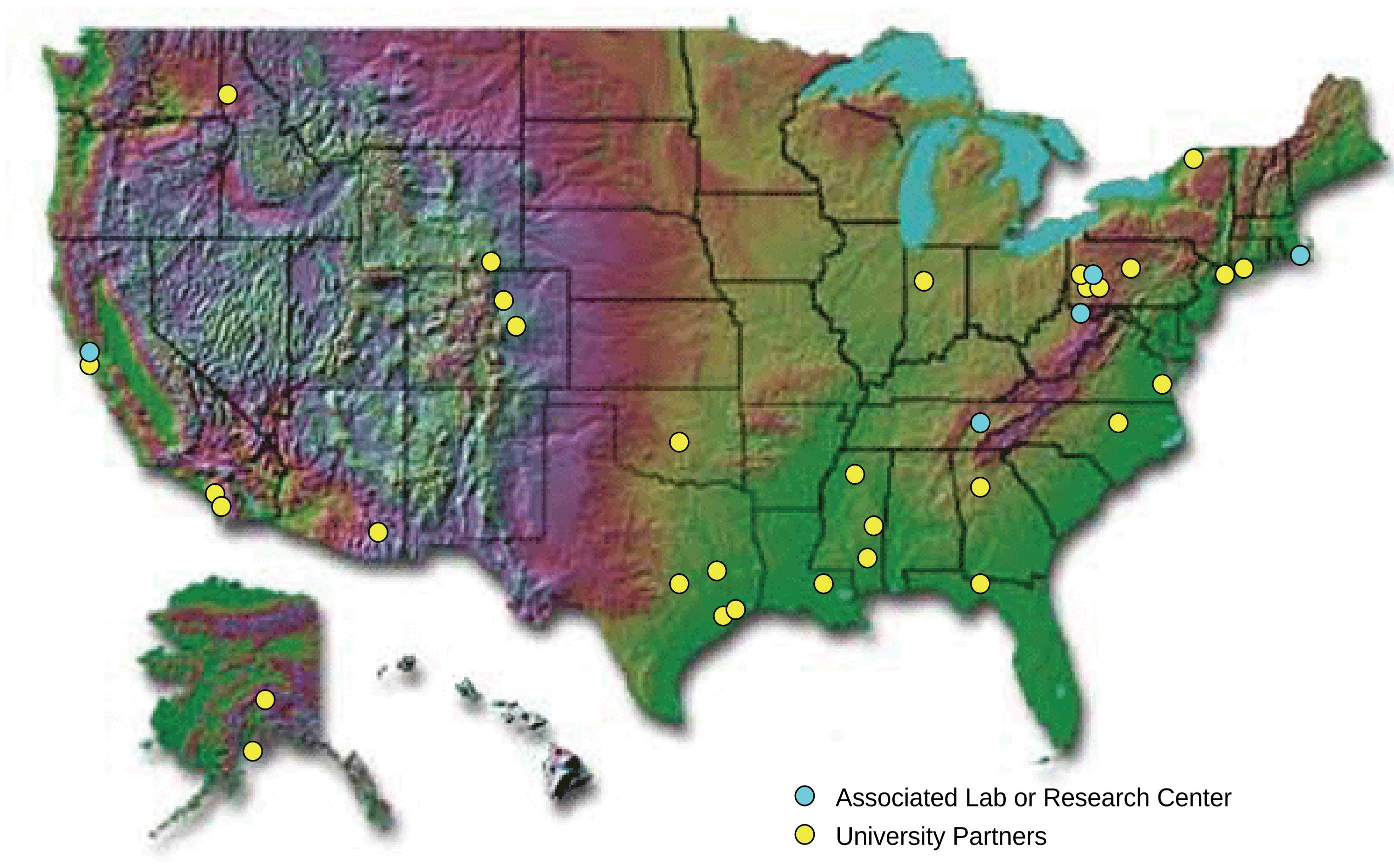
The success of the Department of Energy's methane hydrate research program is not measured solely by the specific results of its individual laboratory and field projects. It is also measured by the degree to which hydrate science, and U.S. science in general, is strengthened through research activity supported by the program.

Funding for the hydrate research mandated by the Methane Hydrate Research and Development Act of 2000 was extended through 2010 when President Bush signed the Energy Policy Act of 2005 last August. This legislation instructs the Secretary of Energy to work with institutions of higher education and industrial enterprises to conduct basic and applied research to identify, explore, assess, and develop methane hydrates as a source of energy. The Act also specifically calls for the Secretary to "promote education and training in methane hydrate resource research and resource development."

A very effective way to both ensure good science and also promote education and training is through the funding of competitive awards to universities and colleges to perform hydrate research. Such funds help make it possible for these institutions to acquire and maintain high quality faculty, particularly in areas such as engineering, geosciences, oceanography, chemistry and biological sciences. Even more importantly, they provide an opportunity for dozens of young scientists and engineers to participate in meaningful research, preparing them for careers in both scientific research and industry.

It is important to recognize that while DOE research contracts made directly with universities fund the work of professors and graduate students, many students are also funded through subcontracts to universities made by DOE's major industrial partners. For example, in the planning and analysis phases of the "Alaska North Slope Gas Hydrate Reservoir Characterization" project, the primary contractor (BP) utilized nearly two-thirds of DOE's funding for tapping into student and faculty talent at the Universities of Arizona and Alaska-Fairbanks for much of the foundational geological and engineering support needed by the project. The Gulf of Mexico Joint Industry Project led by Chevron has similarly utilized university support, through contracts with Rice University, Georgia Tech and Scripps Institute of Oceanography.

Location of Universities Involved With the Interagency Program in Methane Hydrate Research



Since the original funding legislation was enacted in 2000, more than 100 undergraduate, graduate and post-doctoral level students have contributed to advancing the goals of the DOE program through participation in gas hydrate research funded entirely or in part by the Department of Energy. The research performed by these young scientists has been carried out at more than 30 universities, colleges and national laboratories spread across 21 states. Together, these students have earned (or will soon earn) a total of 89 graduate degrees and post-doctoral positions. Of the roughly 500 publications added to the gas hydrate technical literature as a result of DOE-funded research, nearly 150 have been authored or co-authored by these students. Their areas of specialization encompass a wide range of pursuits, including: chemical, civil, mechanical, geological and petroleum engineering; materials science; chemistry, geochemistry; geology, geophysics; marine geochemistry; chemical oceanography; microbiology; and environmental science.

Although a number of students are still completing advanced degrees or continuing research in post-doctoral positions, many have moved on to industry or assumed teaching posts where they are already beginning to influence the next generation of scientists. In the pages that follow, we have collected just a few of their stories as examples of the success of the program in achieving its goal of strengthening the scientific foundation for our Nation's energy future.

Laura Lapham standing with the Johnson-Sea Link prior to diving at a gas hydrate site in the Gulf of Mexico. At the front of the sub is a pore-fluid sampler that measures in situ dissolved methane concentrations in sediments.

Laura Lapham

Marine Sciences (Ph. D. expected 2006), University of North Carolina at Chapel Hill

Chemistry, (B.S. 1997), Florida State University

Laura Lapham arrived at Florida State University expecting to study math. "I wanted little to do with science," she recounts. An inspirational first year chemistry professor (coupled with the sudden prospect of life as a statistician) diverted her towards the laboratory. For the next 3 years, Laura worked in an Oceanography lab under the direction of Dr. Jeff Chanton. During this time, she conducted research on carbon-dioxide/methane cycling in a Canadian wetland and a local landfill. After graduation and a year working as an organic chemist ("I learned that spending all day under a hood synthesizing novel compounds just wasn't for me") she decided to follow up on her earlier interest in carbon cycling. This brought her to the University of North Carolina, where she has been working with her co-advisors, Dr. Chris Martens and Dr. Chanton, to develop a better understanding of biogeochemical and physical controls on methane and sulfate in cold seep environments.

As part of the Gulf of Mexico hydrate research consortium managed by the Center for Marine Resources and Environmental Technology (CMRET) at the University of Mississippi, Dr. Chanton and Laura have developed a Pore-Fluid Array (PFA) which uses OsmoSampler technology to collect and store pore-fluids at different depths in the sediments over time. The instrument has a detachable OsmoSampler package (developed at Monterey Bay Aquarium Research Institute) that can be collected and replaced by a remotely operated vehicle. The idea behind the PFA is to monitor pore-fluid salt and methane concentrations in order to observe hydrate formation or decomposition events, since hydrates exclude salts during formation. The first PFA was placed at Mississippi Canyon Lease Block 118 in May 2005 and is scheduled to be collected in September 2006, after an extended stay on the seafloor (courtesy of hurricanes Katrina and Rita).

Laura considers herself fortunate to have participated in nine research cruises related to methane hydrate research over the past six years: five different visits to sites in the Gulf of Mexico, three trips to offshore Vancouver Island (Barkley

Canyon, Cascadia Margin), and one to the Blake Ridge diapir offshore South Carolina. "The main goal of the Gulf of Mexico hydrate consortium is to develop and maintain a long-term hydrate monitoring station on the seafloor," says Laura. "My contribution to the project has been to help develop and deploy the PFA and collect gravity cores to determine the spatial variability of microbial processes such as sulfate reduction, anaerobic methane oxidation and methanogenesis; processes that control hydrocarbon distributions in surface sediments."

After receiving her degree, Laura hopes to find a post-doctoral position where she can continue investigating the topic of methane cycling, perhaps as it relates to coastal systems rather than deep water processes. She also has an interest in educational outreach programs that help provide materials and resources to help middle school and high school science teachers strengthen their curricula (such as the Teacher Link Program in Raleigh, NC).

Ann Cook

Ann Cook, on the drill floor during a summer 2006 hydrate cruise in the Indian Ocean.

Geophysics (Ph.D. expected 2009), Columbia University

Geophysics (M.S. 2006), Columbia University

Geology and Geophysics (B.S. 2004), University of Tulsa

As a sophomore geology student at the University of Tulsa, Ann Cook applied for a summer internship with the Schlumberger-Doll Research Center in , Connecticut, to be supervised by Dr. Dave Goldberg, a professor at Columbia's Lamont-Doherty Earth Observatory. During that summer she was introduced to hydrates. "I was fortunate as an undergrad, actually being able to synthesize tetrahydrofuran hydrate (THF) in the lab at LDEO, bring it to the Schlumberger lab and utilize the nuclear magnetic resonance equipment there to make measurements," says Ann. Back at Tulsa she continued to work with THF hydrates as part of her senior thesis. "Researchers were beginning to think that THF was not the best analog for methane hydrate … I wanted to try ethylene oxide but the laboratory in Bartlesville I hoped to use thought it was too risky."

That introduction was enough to send her to LDEO as a full-time graduate student with Dr. Goldberg and the Borehole Research Group, where she capitalized on her past experience working as a log analyst for Oklahoma independent, Kaiser-Francis Oil Company. Her master's degree research utilized Ocean Drilling Program (ODP)data, acquisition of which was co-funded by DOE. Using acoustic log data collected during ODP Legs 204 (at Cascadia margin) and 164 (at Blake Ridge); the DOE-Chevron Joint Industry Project (JIP) gas hydrate drilling project in the Gulf of Mexico; and Mallik permafrost wells, Cook examined the relationship between gas hydrate saturation and the cohesive strength of marine sediments.

When we talked to Ann she had just returned from a 2-month hydrate cruise in the Indian Ocean (the first half of a four-month project mentioned elsewhere in this issue) where she served as a logging scientist during the acquisition of one wireline log and twelve logging-while-drilling (LWD) logs. "It was my first cruise and it was very exciting," Cook recounts. "I now have a whole new perspective on the logs that I have been working with, having learned so much about how they are acquired and how logging conditions can impact the quality of the data."

Ann will be working toward her Ph.D. for another three years, and at the moment is not sure where she will end up after that. She adds that, "While I enjoyed working as a teaching assistant here at Columbia last year, there is a real attraction to working in industry. I'm just enjoying the chance to do research while I can."

Tae Sup Yun (left) with fellow doctoral candidate Guillermo Narsilio (now at the University of Melbourne) and instrumented chamber, during the 2005 Gulf of Mexico cruise.

Tae Sup Yun

Geotechnical Engineering (Ph. D. 2005), Georgia Institute of Technology

Geotechnical Engineering (M.S. 2003), Georgia Institute of Technology

Geology, (B.S. 1997), Yonsei University, South Korea

Tae Sup Yun, currently a post-doctoral fellow at Georgia Institute of Technology, has been investigating methane hydrates since he began work there as a graduate research assistant four years ago under the supervision of Drs. Carlos Santamarina and Carolyn Ruppel. His first assignment was measurement of the mechanical and electrical properties of gas hydrate bearing sediments collected in the Gulf of Mexico by the *R/V Seward Johnson* during an National Science Foundation (NSF)-sponsored cruise in Fall 2002. Then, as an MS and PhD candidate he helped design, construct and field test an instrumented high-pressure chamber for measuring compressional and shear wave velocity, strength and electrical resistance of hydrate-bearing cores recovered under pressures up to 20 Mpa. The equipment was one of the important new tools employed during the 5-week cruise carried out in the Gulf of Mexico by the DOE-funded, ChevronTexaco-led Joint Industry Project (JIP) in 2005.

Dr. Yun received his degree last year and while continuing to teach at Georgia Tech, is now deciding among opportunities to work in industry or continue his academic research. His primary interest is in understanding the mechanical behavior of soils at a fundamental level. “I believe that it will be soil mechanics, more so than geochemistry or geophysics, which will determine in the end how easily we will be able to produce methane from subsurface hydrate deposits. Knowing how hydrate-soil mixtures will behave under dynamic conditions is the key issue”

Yun’s thesis work is perhaps best represented in a paper submitted to the Journal of Geophysical Research: B-Solid Earth, entitled “Mechanical properties of sand, silt, and clay containing synthetic hydrate,” by Yun, Ruppel and Santamarina. A second paper submitted to Marine Geology, titled “Instrumented pressure testing chamber for characterizing sediment cores recovered at in situ hydrostatic pressure,” by Yun, Narsilio, Santamarina and Ruppel, provides a good description of the tool developed for use by the JIP.

Dr. Camille Jones in the lab with student Tim Currier.

Camille Jones

Physical Chemistry (post-doc 2000), ORNL

Physical Chemistry (Ph. D. 1999), University of Toledo

Chemistry, (B.S. 1990), Butler University

In the spring of 2005 Camille Jones left her position as a Research Chemist at the National Institute of Standards and Technology (NIST) to become an Assistant Professor of Chemistry at Hamilton College, a liberal arts college in Clinton, NY. “Hamilton has provided me with the opportunity and resources to continue my research, while also working with undergraduate chemistry students,” says Camille. “Undergraduate research is a priority at Hamilton and I am enjoying that aspect immensely.” Several of these students are currently helping Dr. Jones in a DOE-funded effort to use neutron diffraction to study the storage of hydrogen in clathrate hydrates.

Camille began her post-doctoral research career at Oak Ridge National Laboratory, where she worked in the Metals and Ceramics Division. It was there that she first found out about clathrate hydrates and began using neutron diffraction to study their crystal structures. She expanded her work after moving to NIST, using quasi-elastic neutron scattering to look at a variety of cyclic ether guest molecules in hydrates. "We are learning some interesting things about how these molecules rotate within their cages, depending on their size and the temperature," says Dr. Jones. Currently, Jones and her collaborators are employing computational methods to help interpret the results of the neutron scattering experiments, and she has a new collaboration with a Hamilton undergraduate researcher and his mentor, a colleague in the Chemistry Department, to synthesize custom-designed organic molecules that will simplify interpretation of quasi-elastic data.

Her current work, funded by the DOE's Office of Science and part of a collaboration with Tulane University and Los Alamos National Laboratory, began last fall. Three of her eight undergraduate research students are involved in designing new pressure cells and methodologies for synthesizing hydrates for that project. The other five are working on problems related to the synthesis and fundamental properties of hydrates, like studying the behavior of hydrate-forming liquids in the vicinity of the hydrate formation temperature.

Dr. Jones is not studying methane hydrates at this point. "They're harder to make and other very well established groups are studying them. But by looking very closely at some hydrates that receive less attention, I hope to create a research program integrated with undergraduate education where students can expand their scientific knowledge and skills as well as add something to the overall understanding of hydrate formation and why guest molecules behave the way they do," Dr. Jones adds.

At the same time, she is thoroughly enjoying the classroom. "I introduced two X-ray diffraction experiments and even included some hydrates-related bench experiments in the physical chemistry course I taught for the first time last year. I wanted to expand students' knowledge of materials chemistry and awareness of energy-related issues," explained Jones. "These students are smart, conscientious, and enthusiastic--our best hope for addressing energy-related issues in the future."

Evan on deck inspecting an OsmoSampler recovered during IODP Leg 301T off the coast of Costa Rica in 2004.

Evan Solomon

Earth Sciences (Ph. D. expected 2007), Scripps Institution of Oceanography

Geology, (B.S. 2001), University of Nevada at Reno

We talked to Evan as he was packing to leave on an upcoming methane hydrate research cruise to the Indian Ocean. Most grad students take part in perhaps four such cruises while completing a Masters and Ph.D. in an oceanography-related specialty … this will be Evan's ninth. "I'm interested in understanding the dynamics of fluid flow within sediments, particularly as they relate to ocean chemistry," says Evan. "I had focused a lot on hydrogeology at UNR, and when a visiting speaker gave a talk about methane hydrates, it seemed to be a very interesting topic, so I sought out Dr. Miriam Kastner at Scripps." Evan's seafaring has been the direct result of that decision.

Evan's work with Kastner has involved long-term continuous chemical and fluid flux monitoring of two dynamic subsea systems: the Costa Rica subduction zone and the Bush Hill gas hydrate field in the Gulf of Mexico. Off Costa Rica they used continuous water samplers within a borehole observatory to record the chemical and fluid flux. This was the first high-resolution time series data set of chemistry and fluid flow at a subduction zone.

At Bush Hill, as part of a project funded by DOE, Evan helped to develop and deploy a new design of flux meter called the MOSQUITO (Multiple Orifice

Sampler and Quantitative Injection Tracer Observer). The device contains a network of osmotic samplers and a tracer injection feature. The tracer is injected at a single point beneath the seafloor and fluid chemistry and tracer concentrations are continuously sampled simultaneously at multiple depths in a three dimensional array relative to the tracer injection point. The data collected over 430 days in 2002-03 have been used to help characterize the complex hydrology around hydrate mounds and their related benthic communities. The results show that methane from active gas vents adjacent to the mounds act to keep the methane hydrate deposit stable.

In an associated experiment, Evan is using methane concentration data from bubble plumes above the active seafloor methane seeps to model the methane flux from the ocean surface to the atmosphere at four sites in the Gulf of Mexico. Ultimately he hopes to combine his results with remote sensing imagery of over 400 active seeps, to extrapolate these flux rates to the entire northern Gulf of Mexico basin. The Gulf of Mexico is one of the few places in the ocean where methane is not oxidized in the water column. If its contribution of methane to the atmosphere can be more accurately quantified the impact of oceanic methane on the atmosphere will come into sharper focus.

Evan is clearly excited about continuing his research beyond the award of his degree. "I am hoping to do a post-doc where I can apply some of what I have learned to the study of freshwater lake sediments," said Evan. A post-doc study on methane fluxes and gas hydrate formation and distribution in the Indian Ocean is also on his list.

Eilis Rosenbaum

Eilis Rosenbaum with the high-pressure variable volume cell used to form hydrates at NETL in Pittsburgh.

Chemical Engineering (M.S. 2004), University of Pittsburgh

Chemical and Mechanical Engineering, (B.S. 2001), Geneva College

As a chemical engineering undergrad at Geneva College in Beaver Falls, PA, Eilis Rosenbaum decided to complete the course work for both a chemical and a mechanical engineering degree. As a result she began working with Dr. Dave Shaw, an engineering professor who was helping to design sensors for measuring thermal properties of methane hydrates at DOE's National Energy Technology Laboratory (NETL) in Pittsburgh. This introduction led her to pursue a Masters degree in chemical engineering at the University of Pittsburgh, where she continued working with Dr. Gerald Holder and with Bob Warzinski (at NETL) on the development of a new system for measuring thermal conductivity of methane hydrates during formation and dissociation. Eilis's work at NETL was encouraged through the Oak Ridge Institute for Science and Education (ORISE) program, which provides opportunities for students and faculty to contribute to NETL research efforts.

"Historically, methane hydrate thermal conductivity measurements have not been carried out on well characterized samples," says Eilis. "Our objective is to develop the equipment and procedures that will enable us to obtain physical and thermal property information on samples of hydrate and sediment where the composition is well understood." To do this, the team at NETL has modified an existing pressure cell by introducing a transient plane source (TPS) sensing element to determine the thermal diffusivity and thermal conductivity. "Most of my graduate work was focused on helping to develop the equipment and in writing the programs to automate the data collection and analysis process," adds Rosenbaum.

After successfully defending her thesis in 2003, Eilis was hired by Parsons Corporation, an NETL contractor, to continue working on the project.

Arvind Gupta

Arvind Gupta in the lab at LBNL.

Chemical Engineering (Ph.D. expected 2007), Colorado School of Mines

Chemical Engineering (B.E. 2000), Punjab University, India

While pursuing his Ph.D. in Chemical Engineering at the Colorado School of Mines, Arvind Gupta has also spent considerable time performing experiments at Lawrence Berkeley National Laboratory (LBNL) in California. Arvind is interested in how hydrates form and dissociate, on both a microscopic and macroscopic level. On the macroscopic scale, x-ray computed tomography (CT) is one way to visualize and quantify the physical changes that occur during hydrate formation and dissociation. DOE-funded researchers at LBNL are employing CT scanning as a visualization technique (see the Winter 2005 issue of *Fire in the Ice*).

"We've formed pure samples of methane hydrate and also hydrate-sediment mixtures," says Arvind. "With CT scanning we can quantify spatial heterogeneity in the laboratory prepared hydrate samples, and the locations where hydrate forms and dissociates with time. There is a lot of variation; even pure hydrate without any sediment is not as homogeneous as expected." Arvind has also been involved with history matching of experimental results using the TOUGH-Fx/HYDRATE code developed at LBNL by George Moridis, one of his graduate thesis advisors. "The motivation for much of our research is to provide better physical property values for the model," he adds.

At Colorado School of Mines Arvind has been working with his thesis advisor, Dr. Dendy Sloan, investigating the hydrate dissociation process at a microscopic scale using spectroscopic tools like Raman spectroscopy, nuclear magnetic resonance and neutron diffraction. "My research interests also include measurements of hydrate properties such as thermal conductivity, heat capacity, heat of dissociation and permeability for hydrate bearing sediments," adds Gupta. "I'm currently working on measuring the absolute and relative permeability of hydrate bearing sediments as a function of hydrate saturation."

Although Arvind worked for two years as a process engineer in New Delhi after receiving his undergraduate degree, he now feels his future most likely lies in research rather than industry. He sums it up, "I enjoy the challenge and the people."

Greg Gandler

Greg Gandler, at work for Anadarko Petroleum Corporation.

Petroleum Engineering (M.S. 2006), University of Texas

Geological Engineering (B.S. 2004), University of Arizona

Greg Gandler's academic experience with methane hydrates was not as extensive as many of the students highlighted on these pages, but it certainly made a big difference in determining how he got where he is today, working as a production engineer with Anadarko in Houston, Texas.

"I got introduced to methane hydrates while working as a research assistant with Dr. Bob Casavant at Arizona. We were tasked with identifying hydrates from log signatures and doing stratigraphic correlations in the Milne Point Unit on the Alaskan North Slope," says Greg. His work, a preliminary spatial study of fault locations, morphology and inferred hydrate occurrence across the Milne Point Unit, resulted in a paper presented at the 2004 Hedberg Conference. Gandler's study represented just one example of about 12 student projects that were undertaken at the University of Arizona as a result the industry-government-university collaboration associated with gas hydrate research.

As a result of his exposure to the project, Greg chose to pursue a graduate degree in petroleum engineering at the University of Texas, where he received his M.S. in May 2006, after working with Dr. Steven Bryant on problems related to waterflood sweep efficiency. Just a few months into his current position with Anadarko, Greg is now working on carbon dioxide flooding projects in Wyoming. Anadarko has enhanced oil recovery projects underway at three oil fields in central Wyoming, and is investigating the potential for similar projects in Wyoming's Powder River Basin.

According to Greg, "The geological engineering students at the University of Arizona generally end up working in hard rock mining, construction, or oil and gas. Working on the BP-DOE methane hydrates project definitely sparked my interest in a career in oil and gas production, and is the primary reason I am working where I am."

Matt Hornbach

Matt Hornbach and Carolyn Ruppel of Georgia Tech discussing a Blake Ridge seismic profile during a 2003 NOAA research cruise. Photo courtesy of M. Olsen.

Geophysics (Research Associate), University of Texas

Geophysics (post-doc 2004-2006), University of Texas

Geophysics (Ph.D. 2004), University of Wyoming

Physics (A.B. 1998), Hamilton College

Matt Hornbach's introduction to methane hydrates began in Wyoming, about as far away from marine hydrate deposits as one can get. There, in conjunction with professors Steve Holbrook and Demian Saffer, under a research project funded by the National Science Foundation and the DOE, Matt studied seismic data that had been collected during the Fall of 2000 at Blake Ridge in the Atlantic Ocean, 300 miles off the coast of North Carolina. The seismic survey of the methane hydrate system on Blake Ridge included one of the first 3D seismic datasets acquired in a methane hydrate province. This detailed view of the subsurface led to some important new insights into methane release, the dynamics of the free gas system, and the direct detection of methane hydrate.

Analysis of the data led to a number of conclusions, "One of which was that critically pressurized volumes of methane gas exist below methane hydrate deposits, resulting in a potentially unstable ocean floor that is highly sensitive to changing conditions," says Hornbach. "A change in temperature or pressure can cause hydrate to convert into methane gas, causing faulting that allows the gas to escape." This mechanism for the sustained ocean-wide release of methane was the topic of an article in Nature authored by Matt and his professors in 2004.

The study also revealed that while a number of seismic indicators can be used to identify hydrates, remote quantification of hydrate concentrations is best performed through detailed velocity analysis and comparison to rock physics models. This approach forms the basis of ongoing work funded by DOE at the University of Texas, where Matt is now a research associate.

"One of the surprises that came out of the submersible dives at Blake Ridge was the recognition of just how dynamic the methane flux situation is there, at a spot that was previously thought to be relatively static," adds Matt. "My research focuses on using high-resolution seismic data to link shallow geological structure and fluid dynamics in the marine environment. I hope it will lead me to a better understanding of methane mobilization, its impact on climate and its role in sustaining chemosynthetic biological seafloor communities."

Jennifer Dearman

Jennifer Dearman applies some basic engineering technology (a wrench) while assembling a high pressure test cell in the Mississippi State laboratory.

Chemical Engineering (Ph.D. expected 2006), Mississippi State University

Polymer Science and Engineering (M.S. 2000), University of Southern Mississippi

Chemistry, (B.S. 1997), University of Arkansas

Jennifer Dearman has been working with Dr. Rudy Rogers at Mississippi State University on DOE-funded methane hydrate research. Their focus has been on understanding how hydrate formation rates and induction times vary with depth within subsea sediments. In particular, they are investigating the influence that clay type and the presence of microbially-produced surfactants might have on hydrate formation.

Using sediment samples from a core recovered by the *Marion Dufresne* in 631 m of water in the Gulf of Mexico's Mississippi Canyon, the research team measured the rates at which hydrate formed in these sediments in a 450 psi pressurized test cell. "We observed that hydrate formation is most rapid at about 15-18 m of depth," says Jennifer. "Also, hydrate induction time reaches a minimum at about 12 m."

Corollary experiments have shown that biosurfactants catalyze hydrate formation, even at very low concentrations, increasing hydrate formation rate and decreasing induction time. Analysis of the silt, sand, and clay percentages in the core samples, as well as the percentages of various clay minerals present, are being carried out. "Ultimately, we hope to relate bioagents and bio-agent-mineral interactions with hydrate formation trends," says Dearman.

John Pohlman

John Pohlman collecting a sample from gas hydate collected on the northern Cascadia margin.

Chemical Oceanography (Ph.D. expected 2006), The College of William and Mary

Biological Oceanography (M.S. 1995), Texas A&M University

Zoology, (B.S. 1992), Louisiana Tech

While most of the students highlighted in this issue were in school when they were first introduced to gas hydrate science, John Pohlman was already a hydrate researcher when he decided to integrate his research efforts with work towards an advanced degree.

John has worked as a contractor for the U.S. Naval Research Laboratory since 1996. "I had been working for NRL for three years on various coastal ecological studies when the opportunity to work on gas hydrates came up in 2000," recounts John. "One of my first projects was developing a laboratory to perform radiocarbon analysis on gas, sediments and pore fluids to trace the fate of methane carbon in gas hydrate systems."

Subsequently, John had the opportunity to participate in a number of research cruises, including the DOE-supported *Marion Dufresne* voyage to collect cores in the Gulf of Mexico in 2002, and the IODP leg 311 cruise of the *Joides Resolution* to the Northern Cascadia Margin in 2005, where he was one of two organic chemists responsible for on-board chemical analysis of pore fluids collected from cores.

John saw an opportunity to combine his "day job" with an effort to further his education, and enrolled at the Virginia Institute of Marine Science (VIMS), which is associated with The College of William and Mary. Data collected at biogenic and thermogenic gas hydrate sites off Vancouver Island during the Northern Cascadia Margin cruise formed the basis of John's research for his Ph.D. He is investigating the methane biogeochemistry and sulfate reducing bacteria chemotaxonomy at these sites.

"Performing geochemical analysis on pore fluids and sediments from relatively shallow cores, and trying to understand the dynamics of fluid flux at those depths, can help us understand the deeper hydrate systems," adds Pohlman. "We can also infer some things about sediment deposition and stability, an important issue in the Gulf of Mexico."

We talked to John by phone as he was sitting on the dock in Wellington, New Zealand, preparing to embark on a two-week DOE-supported cruise aboard the *R/V Tangaroa* to the Hikurangi Margin off the coast of New Zealand's North Island. "Previous seismic work by scientists at the New Zealand Institute of Geological and Nuclear Sciences has identified a number of bottom simulating reflectors (BSR's). We're going to sample the sediments at these sites and look for evidence of active methane flux," says Pohlman. "We'll also be looking at carbon isotope ratios to determine thermogenic or biogenic origin."

After defending his thesis this fall, John hopes to continue to apply geochemistry to the study of gas hydrates, either with NRL or elsewhere.

Phil Tsunemori

Phil Tsunemori, now working for ConocoPhillips in Alaska.

Petroleum Engineering (B.S. 2005), University of Alaska, Fairbanks

The path that brought Phil Tsunemori to a University of Alaska laboratory performing experiments to validate published methane hydrate dissociation data was not your typical academic ladder. Phil, an instrument technician at a Nebraska sugar beet processing plant, came to Alaska looking for a good oil refinery job. He enrolled at UAF to take some basic math prerequisites, discovered petroleum engineering, and never looked back. Today, four years later, he is a practicing petroleum engineer with ConocoPhillips in Anchorage, thoroughly enjoying his new career.

"As an undergrad, I was assisting the graduate students doing the lab work. We were performing methane hydrate dissociation experiments based on data from North Slope cores, checking to see if the published dissociation curves were representative. We were able to find out that some of the data were not, and that the actual hydrate stability zone was not where one might expect it to be." Tsunemori's paper based on his summer work won the SPE's Student Paper Contest at the Western Regional Meeting in 2004, competing against both B.S. and M.S. students from West Coast universities.

Although he is not currently working on methane hydrates, Tsunemori believes that his research experience helped him get an internship with his current employer the following summer, a post that led to his new job. "I also have found that I have a better feel for the reservoir engineering aspects of my job—particularly the geology—having worked with cores in the laboratory," adds Phil. He was also able to contribute to the research effort in his own way, drawing on his unique background to automate the data gathering instrumentation at the UAF laboratory.

Phil's path may take him back through that laboratory; he has not discounted the possibility of a part-time effort toward an advanced degree at some point in the future.

Mea Cook

Marine Geology & Geophysics (Ph.D. 2006), MIT/WHOI Joint Program in Oceanography

Geosciences, (A.B. magna cum laude 1999), Princeton University

Mea Cook samples a sediment core from the southeast Bering Sea for carbon isotopes and organic biomarker analysis which can give clues to the role of sedimentary methane hydrates in millennial-scale climate change. Photo credit is Tom Kleindinst (WHOI).

As a post-doctoral researcher at Woods Hole Oceanographic Institution, Mea Cook is studying sediment cores from the Bering Sea, using chemical analysis of foraminifer shells to better understand Pacific Ocean paleoceanography and the history of climate change. In a core from the southeast Bering Sea, she was surprised to find the ratio of carbon-13 to carbon-12 in the fossils to be anomalously low, apparently due to authigenic precipitation of carbonate minerals. This made the cores unsuitable for her original purpose, but the question had been raised: could these minerals be the result of methane hydrate dissociation brought on by some climate-altering event? "We know that hydrate dissociation can lead to the formation of carbonate minerals like high-magnesium calcite, aragonite and dolomite … this is seen around some cold seeps," says Mea, "And the carbon-13 to carbon-12 ratio in methane is very low, so this is one possible explanation," Cook adds.

"We proposed a project to compare the timing of the carbon isotopic anomalies in the cores with known millennial-scale, warm climate events that occurred during the last glacial period, to see if there is a correlation," adds Cook. "Then, we will look for molecular biomarkers of methane oxidation in the sediment where the anomalies occur. If they are present, they show that the isotopic anomalies are indeed associated with the presence of methane." If the correlation and the biomarkers are found, this is strong evidence of methane hydrate outgassing as a positive feedback in climate change. This would support the hypothesis that a change in ocean currents triggers the dissociation of hydrates close to the stability zone, and that the released methane makes its way to the atmosphere, adding to climate changes underway. Mea and her colleagues hope to complete their data gathering for this DOE-funded project, both the isotopic stratigraphy and the biomarker analysis, by the end of the 2006.

When not tracking down the role of methane hydrates in climate change, Mea plays the cello. She has been playing since she was eight years old, and received a Certificate in Violoncello and Viola da Gamba Performance, from Princeton along with her geosciences degree.

Namit Jaiswal

Petroleum Engineering, (PH.D. in progress), Texas A&M University

Petroleum Engineering (M.S. 2004), University of Alaska, Fairbanks

Chemical Engineering, (B.S. 2002), UICT, Mumbai, India

Namit Jaiswal in the laboratory

Namit Jaiswal received his chemical engineering degree in 2002 and decided that the U.S. was a good place to apply that degree toward the study of future sources of oil and gas, his primary interest. When we talked to Namit he was rushing between laboratories, a pretty good characterization of how he has spent the past four years. Currently a Ph.D. student at Texas A&M University working with Dr. Daulat Mamora, Namit is investigating the effect of adding hydrocarbon solvents to steam injected in heavy oil recovery projects. He has also landed an internship with Shell, working on the team that is developing the technology to economically produce oil from oil shale. "I found that my work on methane hydrates gave me a good fundamental understanding of thermal processes … something that I have been able to apply in both heavy oil and shale oil research," remarks Jaiswal.

While working on his M.S. at the University of Alaska (Fairbanks), Namit built a unique, state-of-the-art experimental set up for studying the relative permeability of gas hydrate-water systems as part of the BP/DOE-funded assessment of North Slope methane hydrates. This equipment was the first of its kind, giving Namit an invaluable perspective on the joys (and disappointments) of original research. The set-up is being used for formation damage, production profile and phase behavior studies for gas hydrate saturated porous media.

Namit feels fortunate in having had the opportunity to study three different examples of unconventional hydrocarbon resources, and looks forward to applying what he has learned in the industry.

Prasad Kerkar

Prasad Kerkar using the X2B Beamline, National Synchroton Light Source at Brookhaven National Laboratory.

Material Science and Engineering (Ph.D. in progress), State University of New York at Stony Brook

Petroleum Engineering (M.S. 2005), University of Alaska, Fairbanks

Chemical Engineering, (B.S. 2002), Mumbai University, India

"I was looking for something different, not the same engineering courses with different titles," says Prasad Kerkar. That was what brought him from balmy Bombay, India to the University of Alaska's Fairbanks laboratory. His work, part of DOE's collaborative project with BP Exploration (Alaska) and others, employed an experimental set up to quantify the potential for near-wellbore damage from drilling fluids designed for safe hydrate drilling.

After completing requirements for his degree at UAF, Prasad moved on to begin work on his Ph.D. in Material Science at the State University of New York at Stony Brook. Currently, he is working with Dr. Devinder Mahajan at Brookhaven National Laboratory on understanding how hydrates grow within sediments, using x-ray microtomography. "Most of the models for methane hydrate distribution within sediments treat it as being homogenously disseminated as pore filling material, but we see plenty of core evidence of hydrates as massive layers, nodules and fracture fillings. We are trying to understand the geometry of hydrate formation at the grain-size scale, hoping to gain a better understanding of why and how hydrates behave the ways they do."

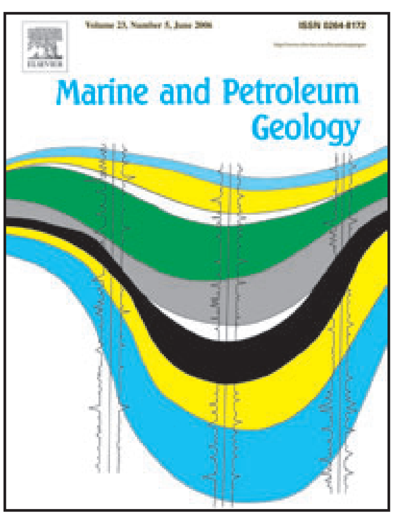
Prasad enjoys the teaching and research aspects of his new position as a Ph.D. Fellow at SUNY Stony Brook, but while he had no second thoughts about pursuing his Ph.D., he plans on working in the energy industry after he catches it.

Industry Conference on Commercial Hydrates Production Scheduled for Later This Year

Hart Energy Publishing, publisher of *Harts E&P* and *Oil & Gas Investor* magazines, has announced that the first "Commercializing Methane Hydrates Conference" will be held in Houston on December 5-6, 2006. The one-and-a-half-day conference will include speakers from Schlumberger and Western Geco on the topic of methane hydrate exploration technology, as well as a broad range of speakers from industry, government and academia on topics such as: Production Technology, Business Aspects and Obstacles, Safety and Regulation, Remaining Challenges, and Case Studies. The cost of attending the conference is $1395 ($1295 if registered by November 14, 2006). Further information, agenda updates and online registration for this conference are available at www.hartenergyconferences.com.

Methane Hydrate Advisory Committee Meeting to be Held in Houston

A meeting of the Methane Hydrate Federal Advisory Committee has been scheduled for November 8-9 in Houston, Texas. The first meeting of the year was held last April in Washington, D.C. The 14-member Advisory Committee provides advice to the Secretary of Energy and assists in developing recommendations and priorities for the Department of Energy's methane hydrate research and development program. The first meeting of next year has also been scheduled, and will take place April 24-25, 2007 in Golden, Colorado. For further information please contact Edith Allison, U.S. Department of Energy, Office of Oil and Natural Gas, Washington, DC 20585. Phone : 202-586-1023.



Call for Manuscripts - Gulf of Mexico JIP

In 2007, the highly-regarded journal *Marine and Petroleum Geology* (Elsevier) will publish a special volume detailing the results of the Chevron-DOE Joint Industry Project (JIP) on drilling for gas hydrate objectives in the Northern Gulf of Mexico. The volume will be edited by Carolyn Ruppel (Georgia Tech), Neal Driscoll (Scripps), Emrys Jones (Chevron) and Tim Collett (USGS). The deadline for submitting manuscripts for consideration is October 15th, 2006. Submissions can be made to any of the editors: Ruppel (cdr@eas.gatech.edu), Jones (ejones@chevron.com), Collett (tcollett@usgs.gov), or Driscoll (ndriscoll@ucsd.edu).

BRANDON DUGAN

Asst. Professor

Earth Science Department, Rice University

dugan@rice.edu

Like many of the scientists "spotlighted" in Fire in the Ice, Brandon's path toward a research career has featured a number of key personalities who made a difference in his choices along the way. In Brandon's case it was a high school biology teacher, John Bohlig, who first got him interested in science. This led to early exposure to research as an undergraduate summer intern at Oak Ridge National Laboratory with Joachim Dorsch and Geri Moline. "That experience drove me to Penn State, where Peter Flemings pushed me to develop critical thinking skills and to become an independent scientist," adds Brandon.

Brandon Dugan enjoys any sort of puzzle

… crosswords, sudoku, arcane trivia contests … you name it. So perhaps it is not so unusual that his professional interests focus on another puzzle that continues to challenge earth scientists: how do methane hydrates influence subsea sediment stability?

"I first became interested in methane hydrate when investigating triggering mechanisms for submarine landslides," says Brandon. "This was during my graduate studies at Penn State where we were starting to link submarine fluid flow and slope failures. I started reading about slope instability related to gas hydrates. As I read more, I became increasingly intrigued by the problem; methane hydrates tend to increase the strength of the sediments but as free gas accumulates beneath the hydrate this drives the system toward failure. I wanted to understand the dynamics of these competing processes."

Brandon received his undergraduate degree in geological engineering from the University of Minnesota before heading to Penn State University, where he received his Ph.D. in Geosciences in 2003. While at Penn State he worked as a visiting scientist for Conoco and ExxonMobil. Subsequently, he was selected as a USGS Mendenhall Post-Doctoral Fellow at Woods Hole, MA, where he worked for one and one-half years before joining the faculty at Rice University as an assistant professor.

At Rice, Dugan is involved in performing geotechnical and geochemical studies on sediments recovered by the ChevronTexaco/DOE JIP from gas hydrate regions of Atwater Valley and Keathley Canyon in the Gulf of Mexico. The goal is to understand the mechanisms that control how, when, and where hydrates form in these different systems.

"Two aspects of hydrate research that interest me the most are the development of models that simulate the evolution of marine hydrate provinces through geologic time and constraining the mechanics of slope instability in hydrate settings," says Brandon. "A few groups are starting to integrate hydrate data and models from a variety of marine settings to develop forward models that simulate hydrate saturation, distribution, and occurrence through space and time. Successful models will push forward our understanding of how dynamic these systems are, how they influence climate and slope instability, and where the largest accumulations are now and were in the past."

Brandon finds modeling to be intellectually stimulating because it provides a glimpse of the dominant factors and controls in hydrate stability. "But these models are limited by the assumptions made," he adds. "So I definitely enjoy testing them against experimental data, and I like to participate in field studies to see first hand which assumptions we should use in our models."

Brandon feels that his primary contribution to methane hydrate research to date has been in the integration of field, laboratory and modeling studies. "As we continue to expand our field, lab, and theoretical studies of strength and stability, we are starting to understand how hydrate systems fail regionally or locally, which in turn influences how fluids and carbon are cycled through the system … for example, methane gas escaping through a fracture versus a catastrophic release of methane."