

Fire in the Ice

Vol. 10, Iss. 1

Methane Hydrate Newsletter



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First Trans-Shelf-Slope Climate Study in the U.S. Beaufort Sea Completed

By Richard Coffin (NRL), Kelly Rose (NETL-DOE), Jens Greinert (NIOZ), Warren Wood (NRL-Stennis), and the Shipboard Science Party

In recent years the volume of methane released through the Arctic Ocean to the atmosphere and its potential role in the global carbon cycle has become the focus of an increasing number of studies. One such study occurred in September 2009 when the Methane in the Arctic Shelf/Slope (MITAS) expedition departed the chilly waters off the coast of Barrow, Alaska on board the U.S. Coast Guard icebreaker *Polar Sea* (Figure 1).

In comparison to other areas of the Arctic Ocean, like the Canadian-Beaufort and Svalbard regions, the sources and controls of methane flux across the U.S. Beaufort Shelf and Slope is largely unconstrained. To help address this issue, the MITAS expedition evaluated methane contributions from a variety of potential sediment and marine sources by examining how much methane is making its way from the subsurface, through the marine filter to

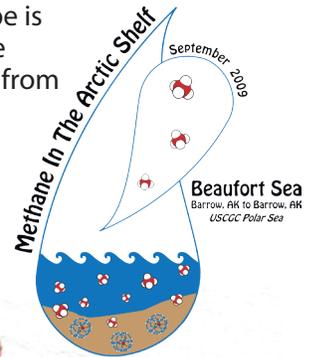


Figure 1: Seen here is the MITAS 2009 expedition science party. The expedition, led by researchers with the U.S. Naval Research Laboratory (NRL), the Royal Netherlands Institute for Sea Research (NIOZ), and the U.S. Department of Energy's National Energy Technology Laboratory (NETL), was organized with an international shipboard science team consisting of 33 scientists with the breadth of expertise necessary to meet the expedition goals.



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This newsletter now reaches more than 1000 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 Jennifer Presley at 281-494-2560. jennifer.presley@tm.netl.doe.gov

the atmosphere. To help address these questions, the MITAS expedition collected samples and analyses from acoustical data, sediment cores, the water column and atmosphere along three transects of the northern and northeastern coasts of Alaska in the Beaufort Sea.

Unlike other areas across the Arctic Shelf, there is a significant lack of data, particularly modern seismic, bathymetry and other remote sensing surveys across the U.S. Beaufort Shelf. During the planning stage of this expedition a thorough examination of existing and available datasets with support from key research groups in the region (e.g. USGS and MMS) was conducted in order to grade and select areas of final interest. These regions were ranked using a set of favorable factors, including: ship accessibility to the area, evidence of shallow gas flux along faults or fractures, seafloor mounds or pockmarks, and sub-surface free gas and gas hydrate accumulations.

The MITAS expedition targeted two near-shore locations identified as having likely subsurface free gas and gas hydrate occurrences: 1) the Hammerhead region to the east near Camden Bay and Canning River System, and 2) the Thetis Island region of the central Beaufort Shelf near Harrison Bay and the Colville River System (Figure 2). Both were evaluated to water depths as shallow as 30 meters for potential targets. The expedition also ventured into deeper waters, up to 2077 meters water depth, to evaluate the methane flux along the transition from the U.S. Beaufort shelf to slope regions.

This expedition accomplished field sampling from the sediment sub-surface to the atmosphere, led to the successful acquisition of more than 1000 kilometers of 3.5 kHz acoustical profiles, and took 34 Conductivity-

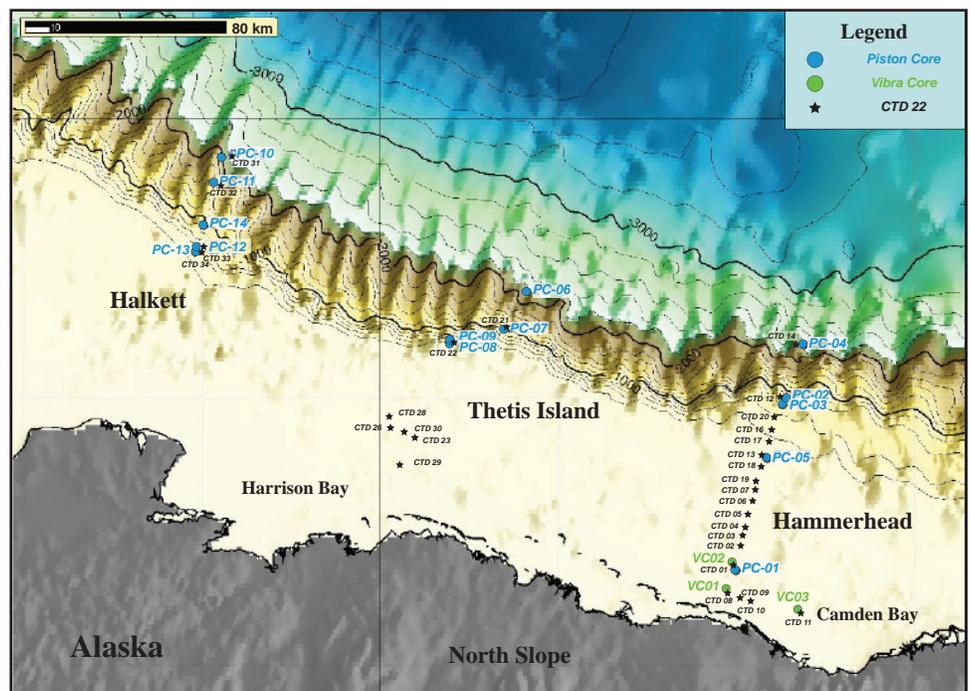


Figure 2: Bathymetric map (CI 100 meters) of the Alaska North Slope documenting the core and CTD sample locations. One long sampling section was placed along the Hammerhead transect. Two other sampling areas are offshore Thetis Island, and along the Halkett transect. The final selection of the transects, in particular coring locations, was refined while at sea based on preceding coring results and the continuous evaluation of acoustical and 2-D seismic datasets.

- Temperature-Depth (CTD) casts including water sampling for geochemical analyses, three vibrocores, 12 piston cores, and 20 multi-cores. Numerous sub-samples were collected and shipboard analyses were completed on the recovered cores.

- **Shipboard activities**

- During MITAS 2009, sediment coring was conducted with vibro-, piston and multi-coring devices. The vibrocorer and piston corer were capable of collecting cores up to 5 and 9 meters in length respectively. Upon recovery, each core was immediately sampled for sediment gas and, when appropriate, void gas measurements. Temperature measurements at ~10 cm increments were taken along the length of the core which was then sectioned and scanned using a multi-sensor core logging system (MSCL) for measurement of key physical properties.

- Upon completion of the MSCL scan, each core section was split in half longitudinally into two equal halves. Lithostratigraphic visual core descriptions and geochemical pore water sub-sampling via rhizon samplers were performed simultaneously on the half designated as the archive. Sub-sampling for post-cruise microbiologic, geochemical, and sediment analyses occurred on the designated working half. All sediment cores were preserved for future analyses following shipboard processing.

- The multi-core rosette was equipped to take four simultaneous, half-meter long cores per cast and was deployed throughout the surveyed region (Figure 2). Similar sub-sampling of the multi-cores was conducted for post-expedition geochemical and geomicrobiological analyses.

- Water column sampling was conducted with a rosette equipped with conductivity, temperature, and density (CTD) sensors and 10-liter Niskin bottles. As a result, profiles from the seafloor to the sea surface illustrating changes in the temperature, salinity, and methane gas saturation versus depth were produced. Additional water samples from each CTD cast were taken for post-expedition analyses.

- The 3.5 khz acoustical data collected using the Polar Sea's shipboard system was interpreted and utilized along with existing 2-D seismic profiles during the expedition to refine and select final coring and CTD locations (Figure 3). Finally, atmospheric measurements were taken continuously along the entire expedition track using a PICARRO G1301 gas analyzer measuring CH₄, CO₂ and water vapor at a 5 sec frequency. CTD data were processed after acquisition using Seabird software and loaded into the database oriented software package ODV (Ocean Data View) for visualization purposes. PICARRO data were linked to GPS and weather data onshore for plotting the methane concentration distribution in the atmosphere.

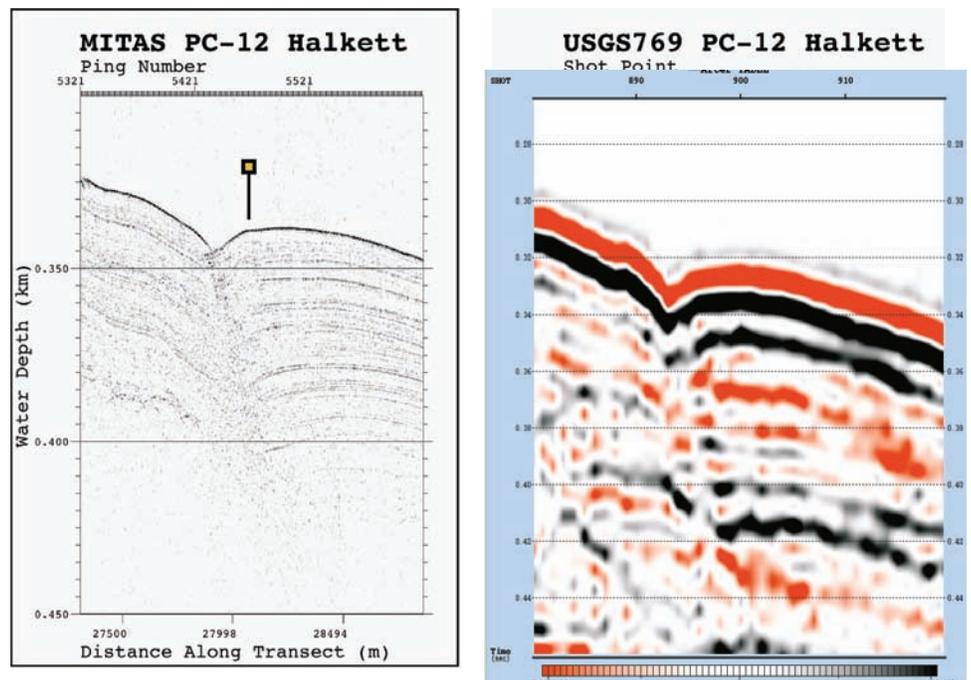
- **Preliminary findings**

- Vibrocoring was selected for coring of shallow water sites during the MITAS expedition because of the potential to obtain longer cores in consolidated sediments where multi-coring and piston coring were inappropriate or inadequate. The highly consolidated nature of sediments on the shelf limited maximum vibrocoring recoveries to 2.84 meters. Despite the limited depth of penetration, the sediments recovered in these cores were relatively undisturbed by the coring process and provided key insights into the nature of sediments in the shallow Beaufort shelf proximal to the Camden Bay and Canning River System. Physical properties measurements taken from the MSCL-S, as well as subsamples for radiocarbon C-14 age dating and xrd/xrf analysis are currently being processed.

- Piston core recoveries averaged 5 meters in length, with poorer recoveries generally in the shallower, shelf regions again due to the more consolidated nature of the sediments there. Throughout the region sediments were dominantly clayey-silts and silty-clays mainly composed of terrigenous material, with occasional drop stones, and silt or sand lamina. The presence of organic material was highly variable, but when present was almost entirely terrigenous as well, including intact marsh grasses and other woody debris. Methane gas was observed in three of the cores based on visual observations and shipboard geochemical analyses.

- Pore water geochemical analyses were conducted on subsamples taken from shallow sediment cores along all three transects. These analyses helped constrain changes in methane concentration vertically within each core and spatially across the shelf and slope. The majority of the sediment samples analyzed from the shallow shelf and deeper slope regions contained very low concentrations of methane, indicating very low methane flux from the subsurface in these areas. However, in three cores there were significantly elevated methane concentrations throughout the cored interval. These cores were located near the shelf-slope break along the Halkett and Thetis Island transects.

- The range of downward sulfate diffusion for this study was approximately 1 to 150 mM $\text{SO}_4^{2-} \text{m}^{-2} \text{a}^{-1}$. Based on comparison of the methane and sulfate profiles, methane flux from the subsurface was highest at two sites along the Halkett transect. At these two sites there were indications of subsurface gas accumulations, the presence of a BSR, and steeply dipping faults based on the interpretation of the 3.5 khz acoustic and pre-existing 2-D seismic datasets (Figure 3). Finally, pore water gas composition and stable carbon isotope analysis showed that the methane is biogenic at all three locations.



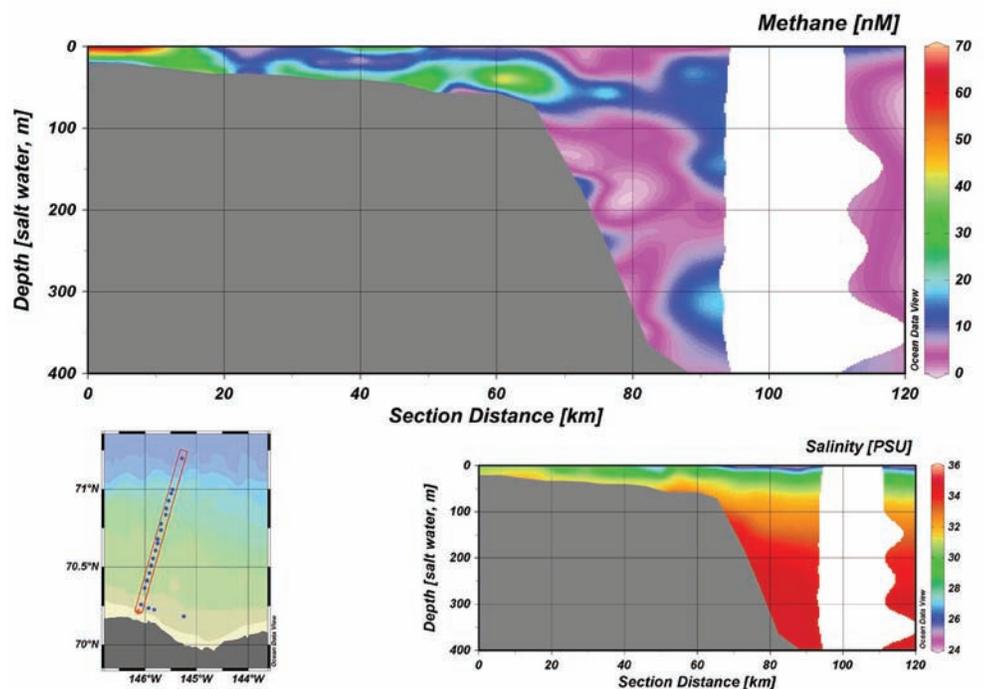
- Figure 3: 3.5 Khz and 2-D seismic data from near Piston Core 12 along the Halkett transect. Note the fault extending to the seafloor documented on both datasets.

- Analysis of CTD water column samples taken along these transects confirmed strongly elevated levels of methane throughout the water column across the shelf region. Methane concentrations drop to “normal” open ocean concentrations in the deeper water, slope region (Figure 4). Increased methane concentrations near the seafloor were only identified at three locations which were roughly correlative with the three stations where elevated methane concentrations in the sediment cores were also measured. This relationship is indicative of gas flux from the subsurface into the water column and appears to be largely controlled by faults or fractures and subsurface indicators of gas based on the 3.5 khz acoustic and 2-D geophysical data at these sites (Figure 3).

Ongoing and Future Activities

- Ongoing work and analyses include further constraining the sources of methane detected in the sediment cores and water column and evaluating the role ocean currents and temporal changes in the water column may play in the lateral and vertical distribution of methane through this part of the Arctic. Further evaluation of the subsurface structural and sedimentary controls on the concentration and migration of methane also continues. Utilizing the results of this study will provide the foundation for models seeking to constrain and characterize the nature of methane flux from the U.S. Beaufort Shelf.

- Studies of this type work to constrain and balance methane contributions from the subsurface, to the water column and subsequently the atmosphere from a variety of potential sources. The science party from this expedition continues to process and analyze the data recovered from the expedition with plans to publish results and interpretations from those datasets over the upcoming year. The results of this expedition will be compared with data obtained from similar studies such as the recently published work off Eastern Siberia and Spitsbergen Norway.



- Figure 4: Oceanographic sections along the Hammerhead transect showing methane concentrations and salinity.

Gas Hydrate Features in the Qilian Mountain Permafrost, Qinghai Province, China

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Permafrost Associated Gas Hydrate Projects in China

In 1999, a marine gas hydrate investigation was officially carried out offshore China under the sponsorship of China Geological Survey. Gas hydrate was discovered in the spring of 2007 in the northern slope of South China Sea (Zhang *et al.*, 2007). In 2002 and 2003 a precursory geological and geochemical investigation along the Qinghai-Tibet railway permafrost zone on gas hydrate potentials (Lu *et al.*, 2007) was financed by our organization, the Institute of Mineral Resources, Chinese Academy of Geological Sciences. Since the preliminary results were possibly indicative of gas hydrate potentials in the Qinghai-Tibet railway permafrost (Lu *et al.*, 2009), China Geological Survey formally initiated a project for "investigation on gas hydrate prospects within permafrost areas around China from 2004 to 2006". As a continuum, another project for "investigation and evaluation on gas hydrate potentials in the Qinghai-Tibet permafrost from 2008 to 2010" was subsequently launched by China Geological Survey.

Geological Settings in the Qilian Mountain Permafrost

The study area is situated in the Qilian Mountain permafrost and geographically located in the Muli town of Tianjun county, Qinghai province in the northeast of the Qinghai-Tibet plateau (Figure 1). Tectonics there are composed of the North Qilian structural zone, the middle Qilian block and the South Qilian structural zone. The alpine Qilian Mountain permafrost is about 10×104 km² in area and about 60~95 m in thickness (Zhou *et al.*, 2000). In the Qilian Mountain area there are many well-developed, small-scale coalfields, of which the Middle Jurassic Muli coalfield (with the Jiangcang) and the Muli formations) is biggest in

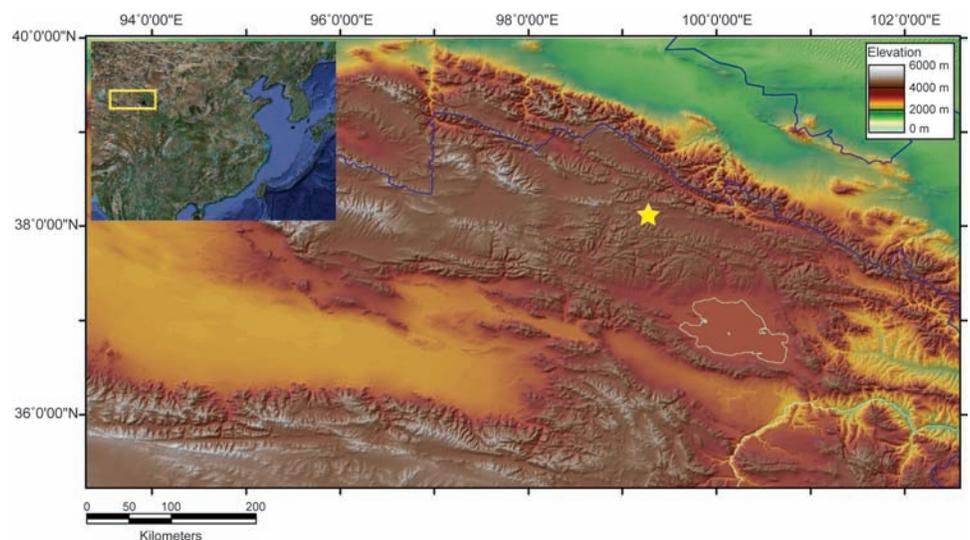


Figure 1: Topographic map of Qilian Mountain area, China. Yellow star indicates area of interest.

Qinghai province. The drilling sites lie in the southern flank of a complex syncline of the Juhugeng mining district of the Muli coalfield. Due to thrust faulting, the complex syncline is actually composed of two monoclines with all levels of fault.

Scientific Results from the Drilling

In the winter of 2008 and the summer of 2009, four scientific experimental wells were drilled in the Qilian Mountain permafrost in Qinghai province, China. White to grayish white ice-like gas hydrate (Figure 2) was encountered in three holes and its related anomalous phenomena were observed in all the four holes in the field, including flammable phenomenon (Figure 3), strongly bubbling and water seeping on the fresh surface of cores, a chain of bubbles coming from under water when cores were submerged, extraordinary gases coming from the hole when gas hydrate bearing layers were drilled through, a large amount of gases when gas hydrate bearing cores were extracted under airtight conditions, heavy hydrocarbon traces and residual cellular textures over the surface of gas hydrate bearing cores, concomitant rhombic autogenetic calcite crystals, relatively low temperature signals indicated by infrared camera, etc. Furthermore, peaks of large and small cages of gas hydrate were explicitly detected by Raman spectrometry. Additionally high electric resistivities and sonic velocities were recorded in the well log, corresponding to gas hydrate bearing layers.

In the Qilian Mountain permafrost, gas hydrate and its associated anomalies are vertically and horizontally discontinuous and occur mainly in fissures of mudstone, oily shale, siltstone, fine sandstone, secondly in the pore space of fine to middle grained sandstone at an interval of 133 to 396 mbs, which are not necessarily related to lithography but strongly controlled by fissures. Gas geochemical characteristics reveal that gas hydrate is mainly composed of CH_4 , secondly of C_2H_6 , C_3H_8 and CO_2 . Their Raman spectra are indicative of a kind of Structure II gas hydrate. Gas composition and carbon and hydrogen isotope geochemistry of gas hydrate show that gases from gas hydrate mainly originate from thermogenic gases partially mixed with microbial gases.



Figure 2: Grayish white patches of gas hydrate in the fissure of core.



Figure 3: Flammable phenomenon of gas hydrate.

Global Climate and the Response of Oceanic Hydrate Accumulations

By Matthew T. Reagan and George J. Moridis, Earth Sciences Division, Lawrence Berkeley National Laboratory and Scott M. Elliott, Mathew Maltrud, Philip W. Jones, COSIM (Climate Ocean Sea Ice Modeling), Los Alamos National Laboratory

Vast quantities of methane are trapped in oceanic hydrate deposits, with estimates of 3,000, 10,000, or even 74,000 gigatons of methane carbon (Buffett and Archer, 2004; Gornitz and Fung, 1994; Klauda and Sandler, 2005) trapped as hydrate in ocean sediments. An increase in temperatures at the seafloor, driven by climate change, could change the extent of the gas hydrate stability zone (GHSZ) and dissociate hydrates, leading to methane release into the ocean, and perhaps eventually the atmosphere.

Because methane is a powerful greenhouse gas, there is concern that such a release could have adverse consequences. This positive feedback has been proposed as a driver of past rapid climate change (Kennett *et al.*, 2000). While this hypothesis is controversial, the role of methane in climate cycles is currently an active area of research and hydrates are considered a potential source. Interest has increased since a team lead by the University of Birmingham discovered plumes of methane gas bubbles erupting from the seabed off the island of West Spitsbergen in a region where ocean warming has been documented (Westbrook *et al.*, 2009). Are these releases driven or regulated by dissociating gas hydrates, and what could be the climate and ecosystem consequences? A team of researchers from Lawrence Berkeley National Laboratory and Los Alamos National Laboratory is working to answer these questions.

The first step was to quantify local methane release under warming conditions. Using a 1-D representation of heat and fluid flow, hydrate phase behavior, and methane transport in the sub-seafloor, the team established that the majority of deep-ocean hydrates would be stable under expected

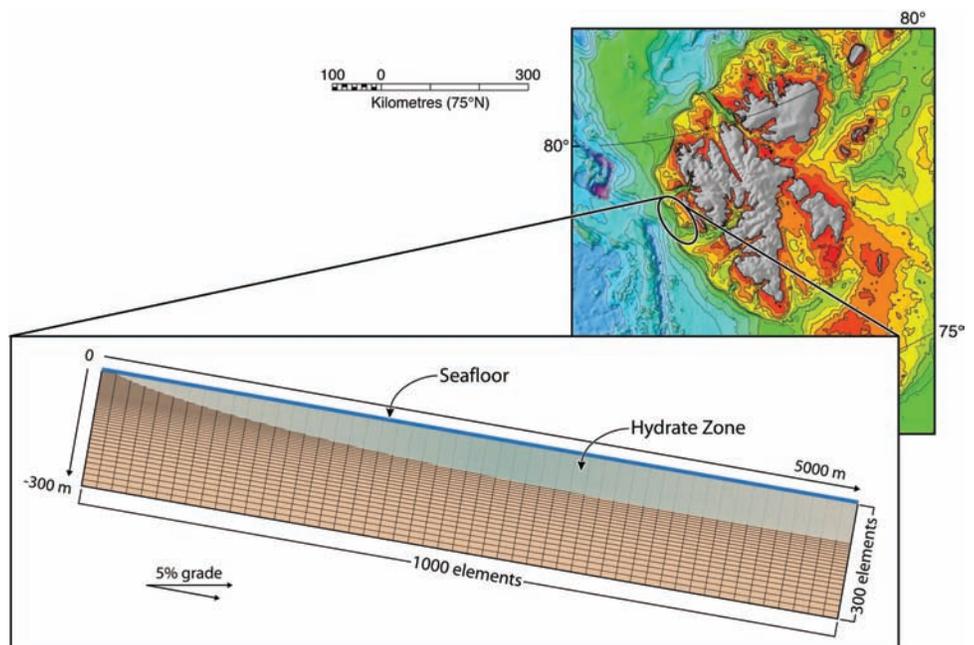
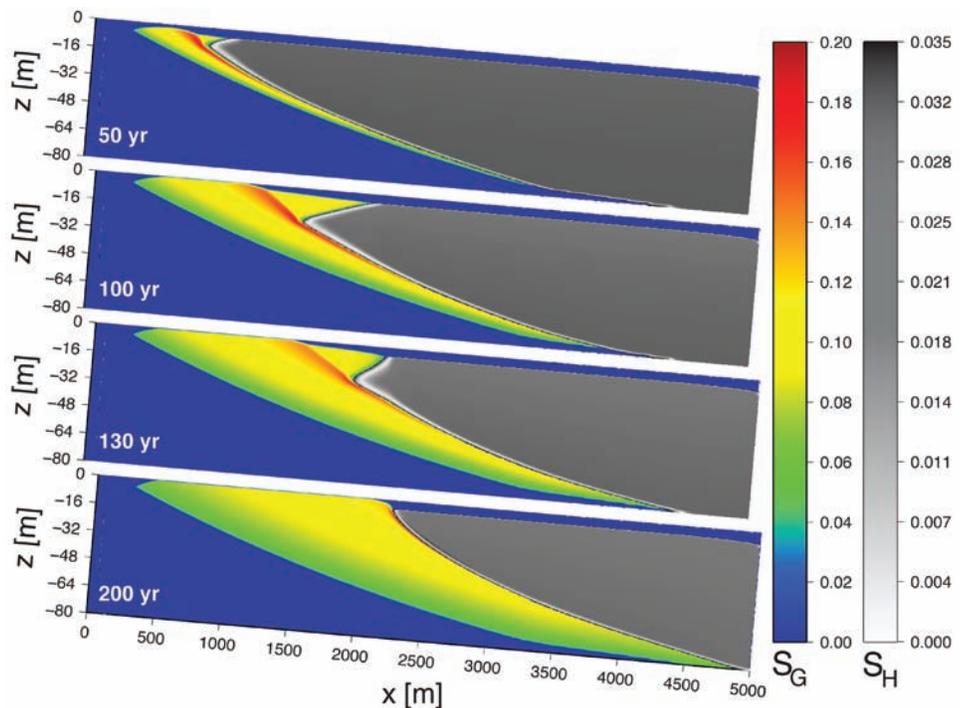


Figure 1: Illustration of the system location, simulated domain, extent of gas hydrate stability zone, and boundaries for the 2-D sloping system. Gridlines are a schematic representation only (not to scale).

- warming conditions. However, sea-floor and shallow sub-seafloor hydrates at low latitudes, such as those observed in the Gulf of Mexico, and especially gas hydrates at higher latitudes, particularly where they occur in shallow waters, such as in parts of the Arctic Ocean, may be susceptible to a mere 1 °C – 3 °C of warming (Reagan and Moridis, 2008). Regions like the Barents Sea, the shallow Bering Sea, or the Sea of Okhotsk are where the first effects of warming should be apparent, and hydrates at 300 m to 400 m depth may already have been affected. The simulations show that such releases occur primarily in the gas phase, and the methane fluxes exceed that found at typical “cold” methane seeps.

- The second step was to consider the possibility that such methane releases may already be occurring, and to test the hypothesis that the Spitsbergen system is hydrate-driven. We conducted large-scale, 2-D simulations in conditions representative of the Arctic continental shelf along the western Svalbard margin, using the massively parallel version of the TOUGH+HYDRATE code (Reagan and Moridis, 2009). The model uses a 2-D slice of a representative sloping system, 5000 m in length, between 300 m and 550 m depth. Figure 1 shows a schematic of the mesh and the initial extent of the GHSZ. The simulation used 300,000 gridblocks with discretization as fine as $dz=0.25$ m and a uniform initial hydrate saturation of 3% within the GHSZ. Historical temperature data suggest that bottom-water temperature has been rising at an average rate of 0.03 °C /yr, and we model this change with a linear 3 °C temperature increase at the seafloor over a 100 yr period from an initial temperature of 0 °C. After 100 years of simulation, the ocean temperature is held constant for an additional 100 yr.

- Figure 2 illustrates the evolution of hydrate and gas saturation with time. The effects of the lowering of the top of the GHSZ are evident as the hydrate recedes downslope. Hydrate-derived CH_4 ascends along the base of the hydrate, and this “plume” contacts the seafloor and moves downslope with time. Figure 3 presents the evolution of gas flux as a



- Figure 2: Gas saturation, S_G , and hydrate saturation, S_H , within the 2-D system at $t = 50, 100, 130,$ and 200 yr.

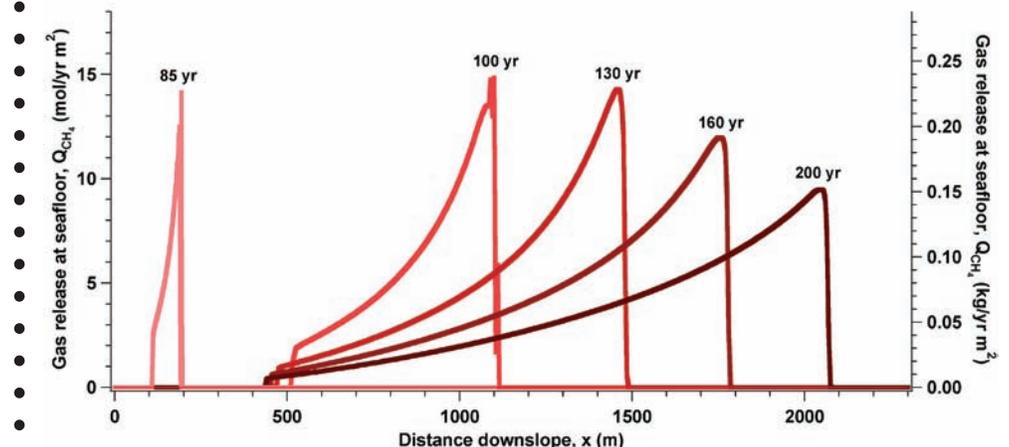
- function of time and position. The peaks in Figure 3 correspond closely to the intersection between the seafloor and the gas-phase plume pictured in Figure 2, and the peaks fall within the range of depths for plume origination reported by Westbrook team. The 2-D results also match, point-to-point, the results generated by the 1-D column model.

- Methane release into the ocean reaches a peak of 8800 mol/yr with a total of 920,000 mol of CH_4 released after 200 years of simulation. Integrated over the 30-km length of the plume-zone at the Spitsbergen margin, this would contribute 0.004 Tg/yr of CH_4 to the ocean for this system alone, small in comparison to the global flux of methane but potentially significant to the local ocean chemistry and biology. Roughly 700,000 km^2 of the Arctic Ocean falls within 300 m – 500 m depth, and this system represents a mere 0.02% of that area. If hydrate-driven plume systems exist in other areas with similar depth and temperature conditions, the cumulative effect could be huge in absolute terms.

- The third step begins to address the consequences of such a release, and to determine the fate of the methane. Working with the methane fluxes from Step 1, the team is conducting simulations of methane release into the oceans using an ocean general circulation model known as POP, the Parallel Ocean Program.

- The team began by constructing a natural global marine methane cycle, driven by contemporary upward seabed fluid flow and also by methanogenesis within the sinking particle rain created worldwide by photosynthesis. Uptake by bacterial methanotrophs or “methane eaters” was included, subjecting unperturbed gas releases to local oxidation and limiting background methane penetration to the atmosphere. The hydrate-derived methane fluxes were then added to the model at key locations along the continental margin, focusing mainly in the Arctic, where the global warming signal will be felt first and foremost. Links were forged within the ocean model to geochemical cycles for the major metabolites and nutrient elements required for methane consumption.

- The POP simulations predicted depletion of several key reactants by the methanotrophs as they attempted to deal with massive hydrate-derived methane plumes—oxygen, nitrogen and trace metals may all be removed from the water column at different locations. This means they may be unavailable to support existing organisms and ecosystems, and implies



- Figure 3: Flux of gaseous methane at the seafloor at different times, presented as mol CH_4 per m^2 at downslope position x along a 1 m-wide, 2-D slice of the continental slope.

• that these releases would be strong perturbations to the geochemistry of Arctic seawater. Potentially stressed locations include the enclosed and poorly ventilated Okhotsk Sea and Bering Sea as well as central basin waters directly beneath the pole. The methanotrophs must also become inactive when resources run low, permitting the methane plumes to spread.

• The POP simulations also suggest that a further layer of security exists which could prevent hydrate-derived methane from reaching the atmosphere. The growing plumes encounter a brackish (freshened) cap of Arctic Ocean surface water that guides them around the Arctic shelf break at a depth of several hundred meters and on into the deep Atlantic, where long residence times guarantee oxidation. However, in these early calculations, the LBNL-LANL team has assumed that the methane emanating from hydrates dissolves rapidly in seawater. In the Spitsbergen system, scientists are documenting bubble plumes rising many tens of meters above the sea floor. The next generation model will thus include bubble plume dynamics, and also investigate the future stability of the fresh Arctic surface layer.

• Once integrated these models will form the basis for a new source term to global climate models, and allow the first quantitative assessment of relationship between dissociating hydrates and global climate.

• **Acknowledgments**

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Tests of a new marine EM survey method at Mississippi Canyon 118, Gulf of Mexico

By Karen Weitemeyer and Steven Constable, Scripps Institution of Oceanography

Although gas hydrate is an important alternative energy resource and represents a hazard to offshore drilling and development, estimates of global hydrate volume vary greatly. It is difficult to estimate bulk concentrations of hydrate using seismic methods, and drilling methods only provide samples for discrete points, offering little information about regional extent since hydrate is not always stratigraphically controlled.

Gas hydrate is, however, electrically resistive compared to the surrounding sediments, making it a prime target for electrical and electromagnetic (EM) survey methods. One such method utilizes the controlled source electromagnetic (CSEM) technique to image the bulk resistivity structure of the subsurface, providing an indication of the concentration and geometric distribution of hydrate. Although EM methods have lower resolution than seismic methods, the use of combined CSEM and seismic data can constrain the areal extent of hydrate.

In the fall of 2008, extensive data sets were collected over four prospects in the Gulf of Mexico using a standard CSEM technique with deployed seafloor receivers, and a new technique using a fixed-offset towed receiver. Presented here are the preliminary results from Mississippi Canyon 118 (MC 118; Figure 1A).

Survey methods

MC 118, a designated Minerals Management Services observatory, has large outcrops of hydrate on the seafloor but no direct evidence of hydrate at

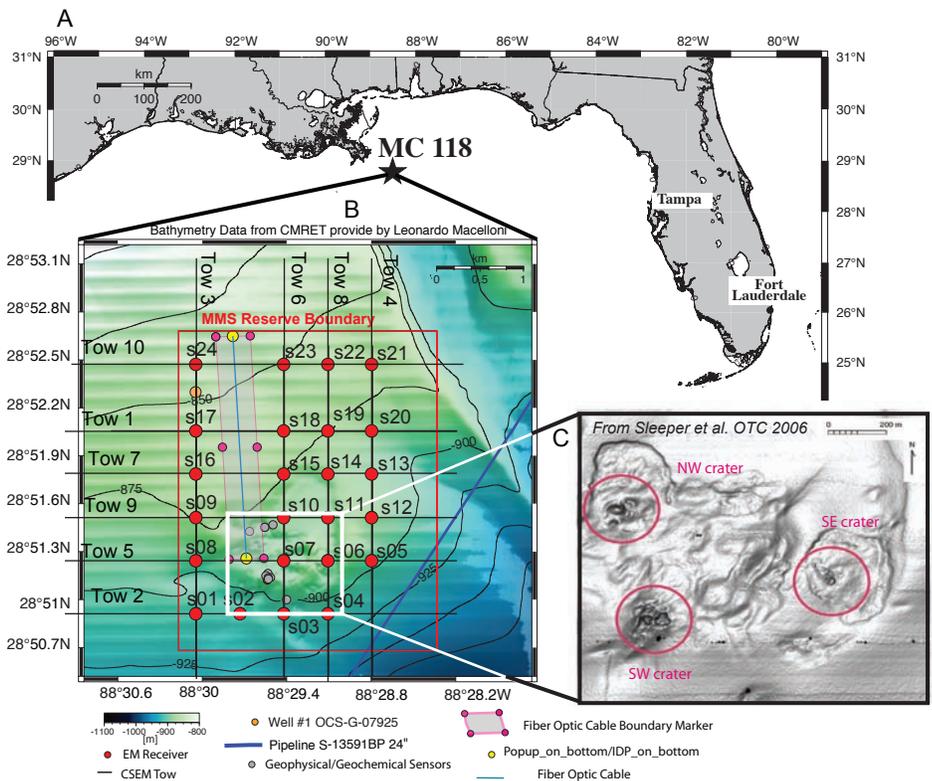
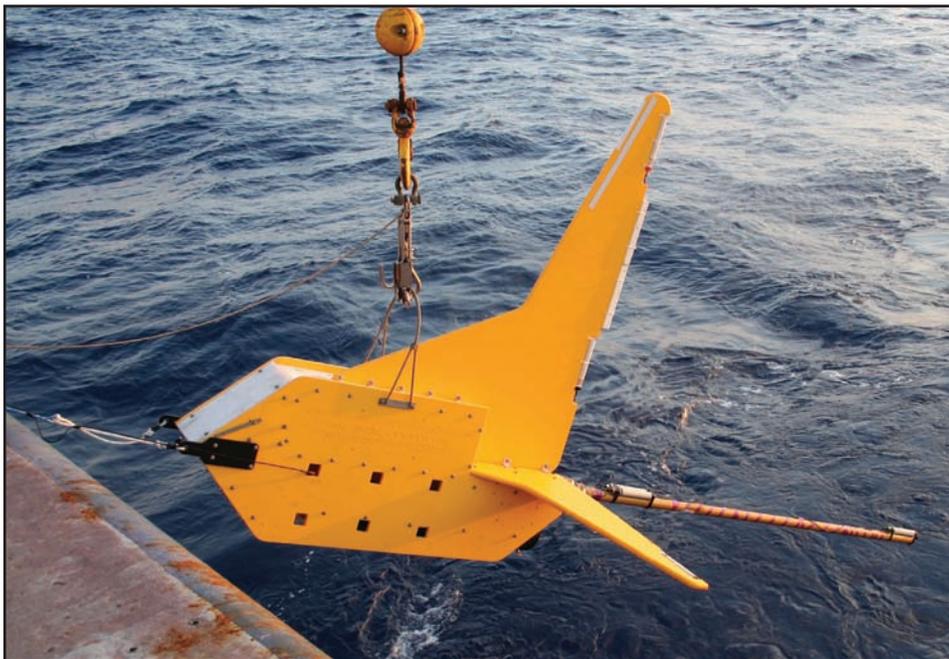


Figure 1: Location and survey map of Mississippi Canyon 118 with detail of the three craters (bathymetry provided by Leonardo Macelloni and the close up of the three craters locations is from Sleeper et al., 2006). Water depths are 800-900 m.

- depth. The main area of interest is a hydrate/carbonate mound consisting
- of three main craters venting methane gas into the ocean at various flux
- rates (McGee *et al.*, 2008) (Figure 1C).
- Twenty-four ocean bottom electromagnetic (OBEM) receivers were
- deployed in a 6 x 4 array and SUESI, Scripp's deep-towed electric
- field transmitter, was towed over the 10 lines forming the survey grid.
- SUESI "flew" at an altitude of 60 m above the seafloor to avoid already
- installed equipment and pipelines (Figure 1B), while transmitting
- a compact, broad spectrum waveform with a frequency content of
- 0.5 to 60 Hz. A 50 m long antenna and 200 amp transmission were
- used. In addition to the seafloor receivers, the "Vulcan," a new, multi-
- component, fixed-offset receiver (Figure 2) was towed in tandem with
- and 300 m behind SUESI (Figure 3).
- Vulcan's development was motivated by model studies of dipping hydrate
- dikes, which produce signatures in the vertical electric field at short offsets,
- suggesting the need for more than the traditional horizontal receivers.
- In contrast to the seafloor instruments, for which navigation errors in the
- transmitter-receiver geometry become large at short ranges, the source-
- receiver offset for Vulcan is fixed and known. While towing at several knots
- the noise floor of Vulcan is comparable to the seafloor instruments when
- its shorted antennae are considered. Vulcan collected high quality CSEM
- data during our experiment.
- **Vulcan and OBEM apparent resistivities**
- We can generate apparent resistivity pseudosections for both the fixed-
- offset receiver (Vulcan, Figure 3, right) and the seafloor receivers (OBEM,
- Figure 3, left) in order to observe lateral variations in resistivity across the
- CSEM tow line. Although there are no analytical expressions for CSEM
- apparent resistivity, we can generate equivalent half-space resistivities



using the Dipole1D forward modeling code of Key (2009), which allows us to model actual transmitter and receiver geometry. Different half-space responses are computed and compared to the measured electric field amplitudes to find the best half-space resistivity represented by each data point. Apparent resistivities computed this way are then projected into depth.

Vulcan apparent resistivity pseudosections were generated using the total electric field derived from the three

Figure 2: Photograph of the fixed-offset towed receiver (Vulcan) being deployed off the back deck of a ship. The vertical antenna is 1 m, the wingspan antenna 2 m, and the electrode spacing on the tail 'stinger' is also 2 m. It contains a 4-channel amplifier and data logger system similar to the OBEM instruments and three 10" glass floatation balls to provide neutral buoyancy. Vulcan also records output from a Paroscientific depth gauge and a heading, pitch, and roll sensor.

- components measured by Vulcan (Ex, Ey, Ez) for all frequencies below 15.5 Hz. Frequencies above this are too sensitive to the geometry of the transmitter and receiver. The frequencies were projected into a depth using skin depth attenuation and then a smoothing algorithm was used to generate the image seen in Figure 4.

- The OBEM pseudosections are computed at the single frequency of 6.5 Hz (Figure 5). The major axis of the polarization ellipse was used in selecting the half-space forward models that matched the recorded data, and the depth projection was derived from the source-receiver spacing.

Preliminary results

- The Vulcan data (Figure 4) show MC 118 to be rather conductive with a background resistivity of 0.5-1 ohm-m and is generally featureless except at the SE crater. No constraints were placed on the intercepting tow lines and so the fact that three lines independently give a resistive body at the SE crater provides confidence that this is a geological feature (rather than an experimental artifact or navigation error). The E-W line that crosses through the SE crater is overlaid on chirp acoustic line 119 from Sleeper *et al.* (2006) for comparison with electrical resistivity. The acoustic blanking or wipeout zones at MC 118 are attributed to authigenic carbonate as well as free gas and gas hydrate (Lapham *et al.*, 2008).

- Carbonate rocks are present on the floor of the SE crater, as well as a pavement of dead methanotrophic clams. There is no evidence for recent venting, suggesting that the conduit once supplying methane to these clams became blocked, perhaps due to hydrate formation (McGee *et al.*, 2009; 2008). The SE crater resistor appears to have some depth extent and the acoustic blanking there is correlated with resistive seafloor. However, acoustic blanking zones towards the SW crater is associated with the background resistivity of 1 ohm-m. The acoustic signature here is attributed to shallow carbonates (Macelloni, pers. comm.), suggesting that hydrate and carbonates, which we initially thought would be confounding electrical resistors, are in fact differentiable. Only drilling at the SE crater will confirm that the resistor there is hydrate, but it seems like a reasonable interpretation at this time.

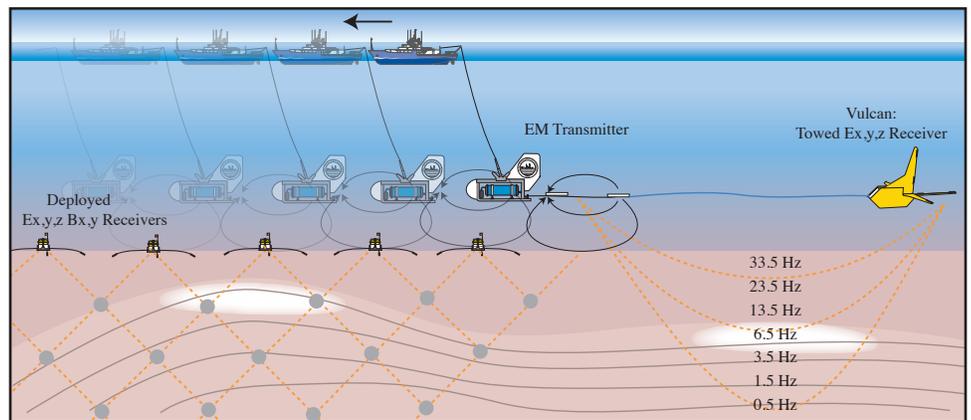


Figure 3: Building apparent resistivity pseudosections. For the OBEM receivers the midpoint between the transmitter and receiver is projected at 45 degrees below the seafloor on the assumption that larger ranges between transmitter and receiver are sensitive to deeper resistivity structure (left). For Vulcan, apparent resistivities are projected into a depth by using the skin-depth attenuation of the different frequencies measured; low frequencies have a larger skin depth and therefore map to a deeper depth than the high frequencies (right).

Figure 5 shows OBEM pseudosections, which are consistent with those from Vulcan. Three CSEM tow lines show a resistor at the SE crater, again with a background resistivity of about 1 ohm-m. Pseudosections do not provide a quantitative estimate of depth (only an inversion will resolve this), but we estimate that the OBEM data are sensitive to the top few kilometers of sediment and the Vulcan data to the top few hundred meters. Thus the slightly elevated background resistivities from the OBEM data are probably a result of sampling deeper, more compacted, sediments. Inconsistencies between the Vulcan and OBEM pseudosections in the E-W tow line crossing site 9 are likely caused by navigational errors, although they could be due to a resistor too deep to be visible by Vulcan.

In summary, CSEM data from the towed instrument Vulcan and ocean-bottom recorders have been used to discover a resistive feature under the inactive vent at the SE crater of MC 118. This resistive area is thought to be associated with the formation of hydrate within an internal plumbing system when this vent was once active. The EM data appear to have been able to distinguish between the presence of carbonate and hydrate, counter to our expectations. These early results provide a compelling argument that CSEM surveys can be used to map hydrate in the Gulf of Mexico and eventually help quantify the total volume. This survey also serves as a proof of concept for the use of Vulcan-type towed receivers in future CSEM surveys, providing a considerable reduction in survey time and cost over the use of deployed receivers.

Mississippi Canyon 118 Vulcan apparent resistivity depth section (frequencies <15.5Hz; Total Electric Field)

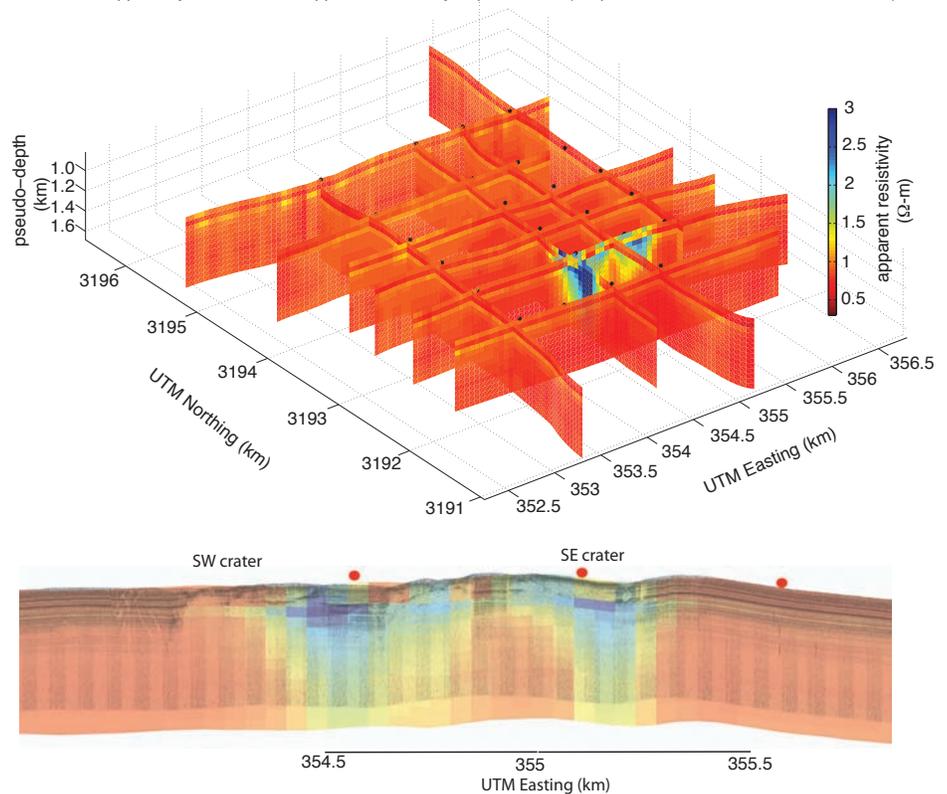


Figure 4: Apparent resistivity frequency-depth sections for Vulcan at MC 118 (top) and an EW transect from Line 5 (which crosses the SE crater) overlain on chirp acoustic data from Sleeper et al. (2006), showing the correlation of resistivity with acoustic blanking (bottom).

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ACKNOWLEDGMENTS

This work was funded by NETL under contract DE-NT0005668 with additional support from CGG-Veritas, Chevron, emgs, ExxonMobil, Fugro, Shell, Statoil, WesternGeco Electromagnetics, MMS, and shiptime support from University of California.

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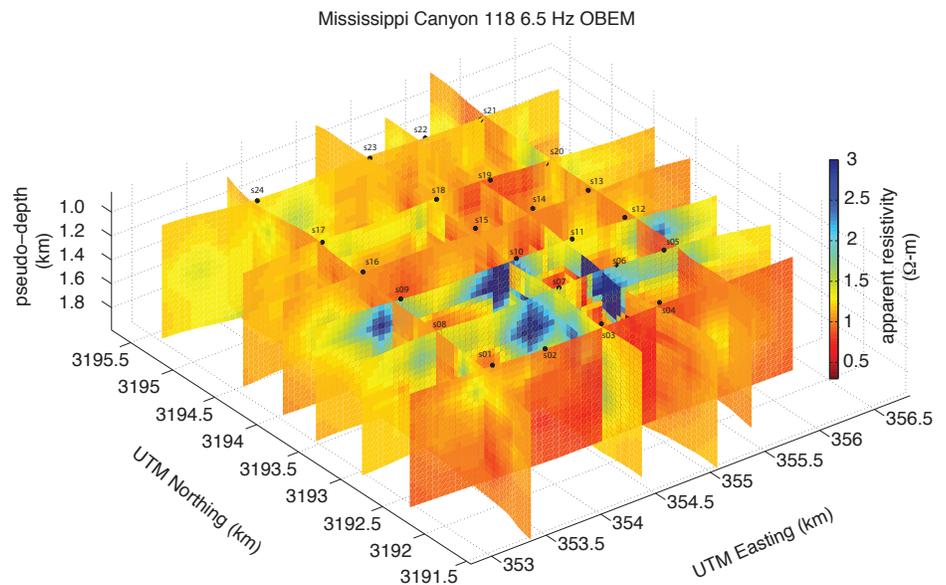


Figure 5: Mississippi Canyon 118 ocean bottom electromagnetic receiver apparent resistivity pseudosections at 6.5Hz.

2nd Ulleung Basin Gas Hydrate Expedition (UBGH2)

By Gas Hydrate R&D Organization, Korea

In 2007, Korea successfully completed Logging-While Drilling (LWD), coring, and Wireline Logging (WL) for the 1st Ulleung Basin Gas Hydrate Expedition (named as UBGH1) in the Ulleung Basin, East Sea of Korea. Subsequently, a 2nd gas hydrate expedition (UBGH2) is tentatively scheduled from May 2010 to August 2010 to explore gas hydrate in the Ulleung Basin, East Sea onboard the Fugro Synergy (Figure 1).

UBGH2 will be drilled at ten sites (10 sites for LWD and coring, 2 sites for wireline (WL) logging and vertical seismic profiling). The drilling sites were decided through the deep discussion in the international advisory committee meeting (USA, Canada, UK and Korean scientists). Based on geological and geophysical data, the top 10 sites among 25 prospect sites were ranked.

The 10 sites are divided into four groups according to seismic characteristics that indicate gas hydrate presence. The proposed sites mostly cover whole area of the Ulleung Basin, East Sea. The depths to be drilled are approximately 50 m beneath bottom-simulating reflector (BSR). Thus, the expected drilling depths range from 230 m to 360 m below seafloor. The water depths at the proposed sites are range from 910 m to 2160 m.

The Korea National Oil Corporation (KNOC) contracted with Fugro to supply drilling, coring, WL and associated services for UBGH2. LWD tools planned in UBGH2 are Geovision, Sonicvision, Ecoscope, and Telescope from Schlumberger. WL tools of Fugro Alluvial Offshore LTD (FAOL) will be deployed for two sites. Conventional and pressure coring will be conducted for ten sites. The acquired cores will be described on-board and post-cruise analyses will include geological, geochemical, geophysical and geotechnical aspects, using both whole-core and split-core sections. Also,

pressure core analysis will be enhanced by Gas Hydrate Ocean Bottom Simulator (GHOBS), a new pressure core cell from the Korea Institute of Geoscience and Mineral Resources (KIGAM) and modified PCAT system from Fugro GeoTek. Fugro Synergy, which was newly built in 2009, was determined as the drilling vessel. GeoTek for core analysis services and Schlumberger for LWD will join in this program. Technical decision for LWD and core analysis including post-cruise analysis will be made by KIGAM and the Korea Gas Hydrate R&D Organization (GHDO). Based on the geological understanding from UBGH1 and UBGH2, Korea is anticipating finding suitable areas for future field production test site and to reservoir assessment of gas hydrate in the Ulleung Basin, East Sea of Korea.



Figure 1: The Fugro Synergy. Photo courtesy of Bergen Yards.

CO₂-CH₄ Exchange in Natural Gas Hydrate Reservoirs: Potential and Challenges

By Helen Farrell (ConocoPhillips), Ray Boswell (NETL-DOE), James Howard (ConocoPhillips), and Richard Baker (NETL-DOE)

At present, depressurization is thought to be the most feasible method for production of gas from gas hydrate reservoirs. This approach is simple and has most recently been validated by tests conducted by Japan and Canada at the Mallik site in Canada (Yamamoto and Dallimore, 2008). Long term field tests need to be conducted before depressurization can be considered a viable technology for gas hydrate production on a commercial scale. DOE-NETL has recently partnered with ConocoPhillips to investigate an alternative production method employing the injection of CO₂. This process can release CH₄ while sequestering CO₂ in hydrate form.

Pure CH₄ and CO₂, and mixtures of both, form structure I (sI) type hydrates (Sloan, 1998, Lee *et al.*, 2003). CO₂-CH₄ exchange is driven by the greater chemical affinity for CO₂ over CH₄ within the clathrate structure, as evidenced by higher heat of formation:



Theoretical and experimental studies using bulk hydrates have confirmed that the molecular exchange occurs spontaneously, but with low-rate exchange reaction kinetics. These low rates led most to believe that CO₂-CH₄ exchange was impractical for commercial field applications. However, work by a ConocoPhillips-University of Bergen team has shown promising experimental and modeling results for the process in porous media settings at conditions well within both the CO₂-hydrate and CH₄-hydrate stability fields, (Graue *et al.*, 2006; Stevens *et al.*, 2008). These results include: 1) relatively rapid CH₄ release; 2) exchange of CH₄ with CO₂ approaching 70%, and 3) exchange occurring with no observable water liberated during the process.

The Potential

If recent experimental and modeling findings can be validated by initial field trials and subsequent larger-scale multi-well pilot studies, the exchange process could have the potential to resolve some key technical hurdles related to potential gas hydrate production.

Providing an option for sequestration of CO₂: While other options may exist for CO₂ management, the potential to sequester CO₂ (where such needs exist) while producing a useful commodity, such as methane, could be very positive.

Reducing or eliminating water production: Gas hydrate depressurization requires large volumes of water to be removed from the reservoir. During the exchange process the water remains in the reservoir as part of the newly formed CO₂ hydrate.

Enhancing reservoir geomechanical stability: Shallow gas hydrate reservoirs are poorly consolidated and the hydrate provides mechanical integrity to the formation. Under production by depressurization the reservoir transforms into a mixture of sand, gas and water. The water must be lifted and wellbores must be designed to minimize sand production. Production may lead to reservoir compaction and overlying surface subsidence. However, if the exchange process occurs as now predicted

(without full dissociation) it is hoped that geomechanical stability could be maintained during production.

Extending recoverability to a wider range of geologic settings: With depressurization, more energy must be invested to drive dissociation in shallow reservoirs with lower pressures and temperatures. However, the exchange process may be less sensitive to initial conditions, thus permitting it to be applied to reservoirs at a wider range of initial conditions.

Decreasing near-well bore plugging: Modeling indicates that production via depressurization is endothermic and results in cooling. Thus it can result in the formation of pore-filling, secondary CH_4 -hydrate or water-ice, particularly in the well and the near-well-bore region. This reduces permeability and decreases production rate. Initial results indicate that CO_2 - CH_4 exchange, which involve both endothermic and exothermic changes, will not result in significant cooling (Figure 1).

The Challenges

Reservoir Deliverability: CO_2 injected into a natural reservoir will encounter free water as well as gas hydrate. Formation of CO_2 -hydrate directly will further reduce reservoir permeability and the ability to inject CO_2 . Initial experimental results suggest that measureable permeability remains, however this is a key issue under ongoing study.

Extending and quantifying porous media experimental results: The experimental and modeling work needs to be extended to larger scales to evaluate issues of exchange rate as a function of porous media parameters, including grain and pore size, sediment consolidation, mineralogy, and formation water geochemistry. The research will continue to focus on the pressure temperature conditions that are appropriate for gas hydrates on the ANS. Researchers also need to know more about potential rates at which CO_2 can infiltrate a CH_4 -bearing reservoir measured over longer spatial scales.

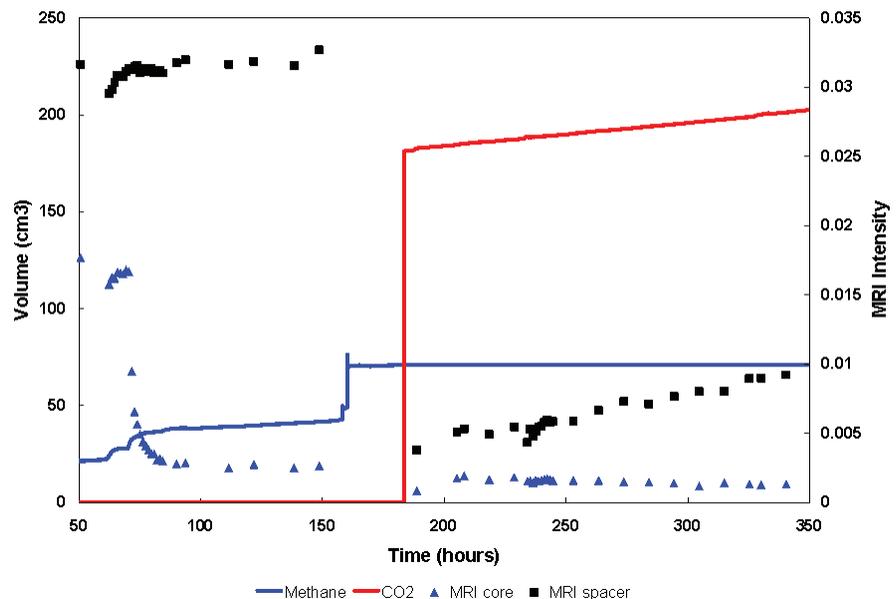


Figure 1: Results from experimental work utilizing MRI imaging conducted by ConocoPhillips and U. Bergen. Methane is consumed within a sandstone core as the core is cooled (CH_4 formation) as noted by initial core MRI intensity drop. After CO_2 flush, methane enters and is produced from a spacing within the sample ("fracture" representing the well bore – note increasing MRI Intensity) as CO_2 is consumed. Note the minimal change in MRI intensity in core as the exchange occurs, indicating no detectable release of free water (from Stevens, et al., 2008).

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Recovery efficiency: Whereas depressurization will theoretically consume 95% or more of the gas hydrate within the area of influence of a production well, CO₂ will only replace CH₄ in the larger cages of the clathrate structure, yielding a theoretical limit for exchange efficiency at 64% (Lee *et al.*, 2003). Initial numerical simulations of a 5-spot CO₂ injection – CH₄ production scenario (White and McGrail, 2008) indicate that this limit can be produced relatively rapidly, although these results require further verification. Other studies have shown that mixed gas injection (i.e., CO₂ + N₂) can boost recovery to 85% (Park *et al.*, 2006).

Feasible field-scale concepts: Reservoir engineering and field-scale trials need to be undertaken to determine field development scenarios including: well type, configuration and spacing, well completion methods and reservoir management parameters (Figure 2). Such information will help determine how CO₂-CH₄ exchange may be able to contribute to gas hydrate reservoir management.

Next Steps

DOE is collaborating with ConocoPhillips to determine the nature and potential of CO₂-CH₄ exchange technologies in porous gas hydrate reservoirs. This science is extremely new and much research remains to be done. Experimental studies and numerical modeling from ab initio to reservoir scale will continue at both ConocoPhillips labs and in the DOE National Labs.

All these efforts will be used to inform the planning, implementation, and analysis of an initial field trial anticipated to be conducted in collaboration with ConocoPhillips in Alaska (current target date for field work is spring 2010).

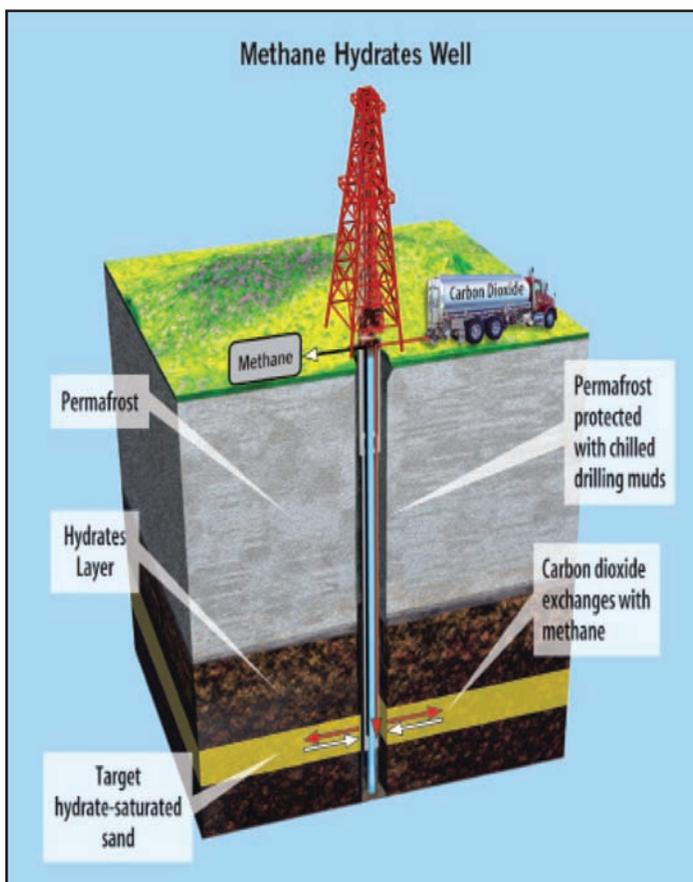


Figure 2: Schematic of CO₂-CH₄ exchange concept (Courtesy ConocoPhillips).

SUGAR: Marine gas hydrate technology development for environmentally sound energy development and CO₂ sequestration

By Klaus Wallmann and Jörg Bialas (IFM-GEOMAR)

In summer 2008, the SUGAR project (SUBmarine GAs hydrate Reservoirs) was launched in Germany. The project aims to produce natural gas from marine methane hydrates and to sequester carbon dioxide (CO₂) from power plants and other industrial sources as CO₂-hydrate in marine sediments. This large-scale national project is funded by two federal ministries and German industries. The project has ~25 institutional partners from academia and industries and is coordinated at the Kiel-based Leibniz Institute for Marine Sciences (IFM-GEOMAR). Since hydrates do not occur in the shallow marginal seas of the German exclusive economic zone, German industries and academia are seeking international partners to develop their hydrate deposits in a joint effort and to test the new SUGAR technologies in the field.

Environmental risks of hydrate exploitation

The role of marine methane hydrate in the natural environment was thoroughly investigated in a number of large scale projects funded by the German Ministry of Research and Education and others over the last decades. These studies show that rich ecosystems flourish around outcropping methane hydrate deposits at the deep-sea floor. In addition, continental slope sediments are often cemented and mechanically stabilized by methane hydrates; future seafloor warming could induce large-scale hydrate dissociation leading to slope failure and potential greenhouse gas emissions.

To mitigate these environmental risks, all work within the SUGAR project targets exclusively those subsurface gas hydrate deposits that are covered by extensive layers of impermeable fine-grained sediments. The impermeable sedimentary apron will also inhibit the release of methane into the environment during gas extraction. Outcropping hydrate deposits will not be exploited. In addition, our goal is to preserve the mechanical stability of the sediments by the injection of CO₂ and the formation of CO₂-hydrate. In contrast to methane hydrates, CO₂-hydrates will not dissociate as readily upon future seafloor warming. Gas swapping in hydrates will thus help to mitigate future greenhouse gas emissions at the seafloor.

Carbon capture and storage (CCS)

Capture of CO₂ at power plants and storage of CO₂ in geological formations is an important measure to mitigate anthropogenic CO₂ emissions and global climate change. Current concepts for large-scale CO₂ sequestration involves injection of CO₂ as supercritical phase in depleted oil and gas reservoirs and deep saline aquifers located on land or below shallow seas. However, supercritical CO₂ is a mobile, buoyant, and highly reactive chemical. Only those reservoir rocks that are covered by thick and impermeable cap rocks can be developed for CO₂ storage. Supercritical CO₂ may nevertheless ascend through bore holes, faults and fractures and may escape into the environment. Also, the pore space of deep aquifers is occupied by saline formation water and natural gas. The displacement of these fluids and gases by injected CO₂ may cause strong over-pressures in the reservoir and/or the leakage of brine and gas into the environment. Furthermore, there may simply not be enough storage capacity in saline aquifers and depleted oil and gas reservoirs to accommodate a significant fraction of the global anthropogenic CO₂ production. We believe

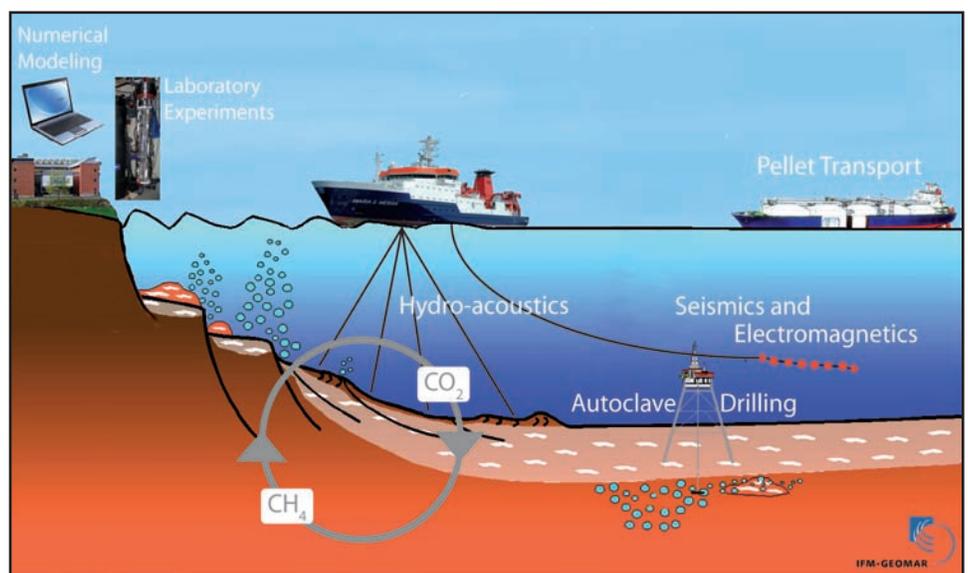
that CO₂-hydrate storage approach, which sequesters the CO₂ in more highly stable solid form within available pore space provided by the methane extraction, may help to resolve these problems.

The current rise in global CO₂ emissions is largely caused by the increasing use of coal as energy resources. The power supply system of many rapidly growing economies depends largely on coal. Fortunately, many of these emerging states also possess vast methane hydrate accumulations and could utilize this resource not only to produce natural gas but also to safely store CO₂ from coal power plants.

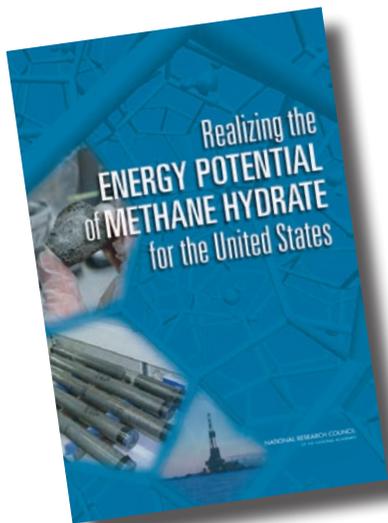
Presently, the SUGAR project is developing improved hydroacoustic, seismic, electromagnetic, and autoclave drilling equipment and testing them in field settings to locate new hydrate deposits, to image the three dimensional distribution of hydrates in the sub-surface, and to quantify the methane inventory of hydrate deposits. We have developed new software for the joint inversion of seismic and electromagnetic data and have expanded existing basin models to simulate the formation of methane hydrates via gas migration. In the lab, we are investigating the production of natural gas from methane hydrates via injection of CO₂ under in-situ conditions. Various approaches to accelerate gas swapping in hydrates and to improve the rate of natural gas production from hydrates are under study. These include pressure reduction, the addition of specially designed polymers, injection of supercritical CO₂, and the generation of heat by in-situ methane burning in the reservoir. The results of the laboratory experiments are up-scaled by reservoir modeling to identify the most efficient set-up for methane production and CO₂ storage in hydrates.

In a second phase of the SUGAR project, starting in July 2011, we intend to test hydrate exploitation technologies in the field with international cooperation partners.

Further information: <http://www.ifm-geomar.de/index.php?id=3563&L=1>



• Announcements



• **NRC report *Realizing the Energy Potential of Methane Hydrate for the United States* now available online**

• At the request of Congress, the National Research Council (NRC) evaluated the Department of Energy's (DOE's) Methane Hydrate Research and Development Program. This evaluation, contained in the report "[*Realizing the Energy Potential of Methane from Methane Hydrate for the United States*](#)", was released to the public on January 28, 2010 and reviews the Program's research portfolio and management processes and outlines recommendations for the Program's future research initiatives. The DOE Program has been tasked by Congress since 2000 to lead and coordinate the national effort to develop knowledge and technology necessary for commercial production of methane from methane hydrate in a safe and environmentally responsible way.

• The NRC report notes that the Program's main research objectives in recent years have been guided by two general aims: (1) to conduct an initial assessment of the potential for commercial development of methane from methane hydrate resources, specifically on the Alaska North Slope, and (2) to demonstrate the recoverability of methane from marine methane hydrate-bearing deposits, primarily through work in the Gulf of Mexico. Field, experimental, and modeling projects supported by the program have all contributed to addressing these aims, with more than 40 different research projects either completed or underway since 2000.

• Management of the Program has been consistent and effective during the past five years, the report found. The Program has worked to increase the success of the research it funds, has supported education and training of young researchers, and has enhanced collaborative efforts with other research entities, including other federal agencies, universities, industry, and national laboratories. It has also strengthened the transparency of its activities, notably through implementation of a peer-review process for ongoing research projects and increased communication with the public and the global research community through the Program Web site and other outlets.

• To better meet its goals of assessing the potential of the long-term production of methane from methane hydrate, the NRC report recommended that the Department of Energy should aim to expand future research in several areas: (1) design and demonstration of production technologies in the field that can sustain the flow of methane gas from methane hydrate deposits over long periods of time; (2) evaluation and prediction of environmental and safety issues related to production of methane from methane hydrate; and (3) reduction of the uncertainty that remains in locating and identifying the size of methane hydrate deposits, including the potential volume of methane that might be extracted, and the way methane hydrate might behave or change during production.

• Although many scientific, engineering, and environmental questions in methane hydrate research remain to be answered before methane from methane hydrate can be considered a proven energy source, the technical challenges identified in the report were found not to be insurmountable, as long as sustained, national commitment and support for the necessary research continue.

• Announcements

• **AAPG Memoir 89: *Natural Gas Hydrates – Energy Resource Potential and Associated Hazards* now available for online purchase**

• The American Association of Petroleum Geologists (AAPG) has co-published, with the U.S. Department of Energy, National Energy Technology Laboratory; the AAPG Foundation and the AAPG Energy Minerals Division, a comprehensive treatise on the geology of gas hydrates which is titled *Natural Gas Hydrates – Energy Resource Potential and Associated Hazards*.

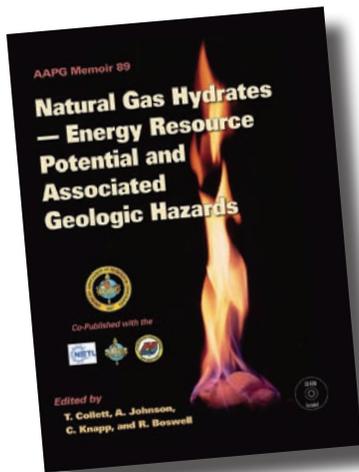
• AAPG Memoir 89 had its start back in September 2004 when the AAPG convened a Hedberg Research Conference in Vancouver, Canada on natural gas hydrates. As a continuation of the Hedberg Research Conference in Vancouver, the conveners of the conference and the editors of this Memoir have worked with more than 150 authors and coauthors to prepare this Memoir on gas hydrates. This publication follows the goals of the Hedberg conference; however, the contents of this Memoir were expanded to include all aspects of gas hydrates in nature. This Memoir contains 39 individual contributions, ranging from long topical summaries to shorter focused research papers.

• This Memoir has been published in two parts, with digital versions of all the complete research papers included on an CD. The hardcopy portion of the Memoir includes abstracts and several key figures for each of the contributions. The digital portion of this Memoir has been organized into a series of topical sections consisting of review articles, marine and permafrost related gas hydrate research papers, and gas hydrate laboratory and modeling studies.

• AAPG Memoir 89 can be purchased through the AAPG Bookstore web site at <http://bookstore.aapg.org/>.

• **Initial Scientific Results of the Gulf of Mexico Gas Hydrates JIP Leg II Now Available Online**

• In April and May of 2009, the Gulf of Mexico Gas Hydrates Joint Industry Project, a cooperative research program between the U.S. Department of Energy and an international industrial consortium under the leadership of Chevron, conducted its “Leg II” logging-while-drilling (LWD) operations. The Initial Scientific Results of the expedition, containing detailed information on well location selection, LWD operations, and preliminary interpretations of collected data, are now available online. For more information or to access copies of these interactive reports, please visit <http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/JIPLegII-IR/>.





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• Announcements

• Four gas hydrate sessions at OTC 2010 – Houston, Texas

• The Offshore Technology Conference will be held May 3-6, 2010 at the Reliant Center in Houston, Texas. The conference will include four sessions on gas hydrates. The first session is scheduled to begin at 9:30 on May 5 and will highlight the preliminary scientific results from the 2009 Gulf of Mexico Gas Hydrate Joint Industry Project Leg II. Other sessions will focus on resource evaluation and production estimates, sampling, well design, geomechanical analysis, and laboratory, simulation, and fundamental studies. More details, including registration and travel arrangements, can be found at <http://www.otcnet.org/2010/index.html>.



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• Announcements

• Gas hydrates session at the CURIPC 2010 – • Calgary Canada

• The Canadian Society for Unconventional Gas (CSUG) and the Society
• of Petroleum Engineers (SPE) are co-sponsoring the first Canadian
• Unconventional Resources and International Petroleum Conference
• (CURIPC), 19-21 October 2010 in Calgary, Alberta, Canada. This conference
• will include a session on the research and development of gas hydrates
• as a potential clean energy resource for the future. This session will
• highlight the state-of-the-art of gas hydrates science and engineering
• in Canada and around the world, and will consider a wide range of
• issues related to the exploration and future commercial production
• of gas hydrates. Details of the conference, including sub-categories of
• interest within the gas hydrate session, can be found at <http://www.spe.org/events/curipc/2010/>. The deadline for submission of abstracts for
• conference papers/presentations is March 29, 2010. Please contact the
• session chair (fwright@nrcan.gc.ca) for additional information.

• Upcoming Meetings of Interest for the Gas • Hydrate Community

• April 2010

• 4th-11th American Association of Petroleum Geologists Annual
• Convention & Exhibition, Morial Convention Center, New Orleans, LA <http://www.aapg.org/neworleans/>

• May 2010

• 3rd - 6th Offshore Technology Conference, Reliant Park, Houston, TX
<http://www.otcnet.org/2010/index.html>

• 10th - 12th Fiery Ice from the Sea: 7th International Workshop on Methane
• Hydrate Research & Development, Te papa, Wellington, New Zealand
<http://www.gns.cri.nz/fieryice/index.html>

• June 2010

• 6th - 11th Gordon Research Conference: Natural Gas Hydrate Systems,
• Colby College, Waterville, ME ***Application deadline is May 16, 2010.***
<http://www.grc.org/programs.aspx?year=2010&program=naturalgas>

• 13th-18th Goldschmidt 2010, Knoxville Convention Center, Knoxville, TN
<http://www.goldschmidt2010.org/index>

Spotlight on Research



BRIAN J. ANDERSON

Assistant Professor of Chemical Engineering
West Virginia University
NETL Institute for Advanced Energy Studies Fellow

Math and music are all about deciphering patterns. Utilizing the unique language of each, one is able to uncover the solution to an unsolvable problem or move a cold-hearted person to tears. For Brian Anderson, an assistant professor of chemical engineering at West Virginia University (WVU), his ability to see and decipher patterns has been honed over years of academic and musical training. It is a gift that gets quite a workout as Brian is also a co-coordinator of the International Methane Hydrate Reservoir Simulator Code Comparison study.

After completing high school, where he first learned of how methanol is used as a hydrate inhibitor, Brian enrolled at WVU and in 2000 obtained his Bachelor's degree in chemical engineering. During a grad school visit to the Massachusetts Institute of Technology (MIT) he "learned that Jefferson Tester and Bernhardt Trout had a project in gas hydrate thermodynamics and inhibition and knew my mind was made up."

Brian's grad school days were very busy. As a part of his studies he participated in a various projects, with one in particular being a chocolate lover's dream. "While at MIT I took some time to do what is called the Practice School for my Masters," he explains. "One project was at M&M Mars trying to determine the optimum process for their chocolate manufacturing. Another was at Cargill in Minnesota analyzing their potential biofuel production processes. Everything that really interests me has to do with energy and energy resources."

In addition to his studies at MIT, Brian made his Boston opera debut as the lead tenor Don José in Carmen in 2003. He was also a soloist for the Boston Pops and has shared the stage with a variety of musicians, including Vince Gill, Amy Grant, and Van Halen's David Lee Roth. His talented voice can also be heard on the movie soundtracks of the dark drama Mystic River and the political satire Silver City.

After obtaining both his Masters (2004) and PhD (2005) in chemical engineering from MIT, he completed a short post-doctoral research project co-authoring The Future of Geothermal Energy: Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century report that was released by MIT in 2007. Brian accepted his current teaching position at WVU after the completion of this research project.

For Brian, the rewards that the study of gas hydrates provides are numerous. Witnessing the recent explosion in interest surrounding methane hydrate and the fascination that gas hydrate holds for so many with different backgrounds are just two. "Hydrates can intrigue and frustrate everyone, from the theoretical chemist to the geologist to the reservoir engineer," says Brian. "I might fall somewhere in that list, but I haven't determined where just yet."

However, the major rewards appear after the countless calculations and simulations that are a part of the experimentation process are successful. "From a scientific standpoint, minute details such as the intermolecular interactions between methane and water, make methane the perfect fit for the formation of hydrate," he says. "I have spent a lot of time calculating the interaction energies of molecules from first-principles, but to be able to start with two molecules - one methane and one water - and predict the stability zone using ab initio calculations and some hard-core thermodynamics still amazes me."

His opinion on the biggest challenges facing gas hydrates research? "Wow, tough one. I would have to say determining producibility. There is a lot that goes in producibility: production methods, multiphase flow, potential secondary hydrate formation, ice formation, sand production, and geomechanical effects just to name a few."