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Fire in the Ice

2012 Vol. 12, Issue 2 Methane Hydrate Newsletter

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U.S. DEPARTMENT OF ENERGY

Pressure Core Sampling in the Eastern Nankai Trough

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As part of the reservoir characterization effort for a planned gas production test from methane hydrate deposits in the Eastern Nankai Trough (Masuda et al., FITI, v. 9, n. 4), Japan Oil, Gas and Metals National Corporation (JOGMEC) and Japan Petroleum Exploration Company (JAPEX) conducted core sampling operations at the test site from June 29th to July 4th, 2012.

The test site is located on the north slope of Daini Atumi Knoll off Atsumi and Shima peninsulas (Figure 1), where water depth is approximately 1000m. Seismic surveys, and core and geophysical log data collected at this location during an exploratory drilling campaign in 2004 (Takahashi and Tsuji, 2005) identified a zone of turbiditic sediments several tens of meters thick, containing concentrated methane hydrate. These deposits are approximately 300 meters below the seafloor (Tsuji et al., 2009), as shown in the seismic section in Figure 2.

In preparation for the planned production test that will occur in early 2013,

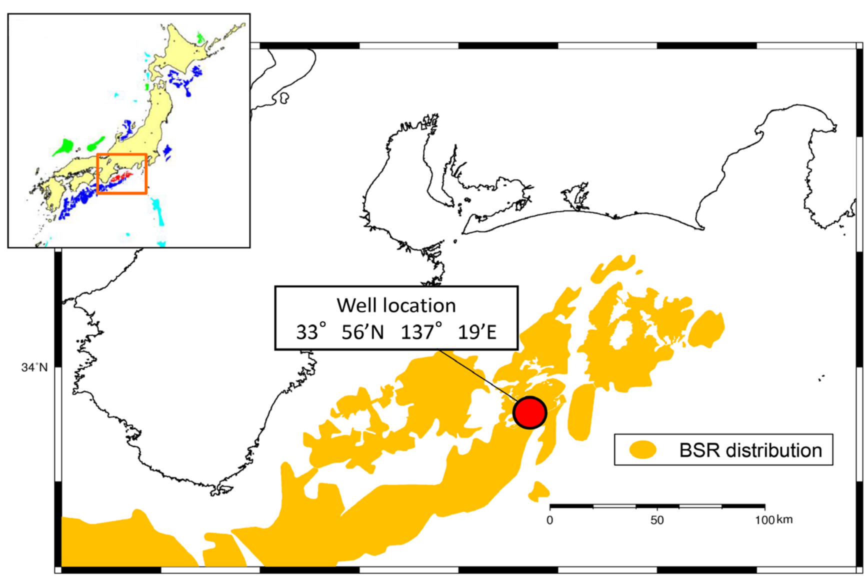

Figure 1. The drilling location of the first methane hydrate offshore production test, Daini Atsumi (Atumi No.2) Knoll in the Eastern Nankai Trough.

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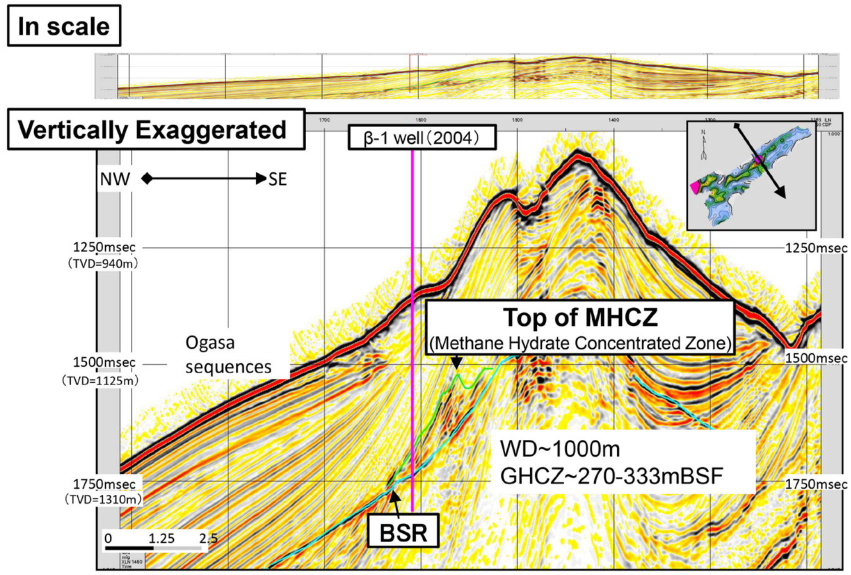

Figure 2. Seismic section of Daini Atumi Knoll area with the location of Beta-1 well (2004).

a part of the production well (AT1-P) and two temperature monitoring boreholes (AT1-MC/MT1) were drilled in February and March, 2012, as shown in Figure 3. During drilling operations, intensive geophysical logging was conducted in one of the monitoring wells (AT1-MC). Additionally, to obtain knowledge about the geology, geomechanics, geochemistry, microbiology, and petrophysics of the hydrate-bearing sediments, the Research Consortium for Methane Hydrate Resources in Japan (MH21), sponsored by the Ministry of Economy, Trade and Industry (METI) drilled a dedicated borehole in the same area to recover pressure cores. The shipboard scientist team, which was composed of scientists and engineers from JOGMEC, National Institute of Advanced Industrial Science and Technology (AIST), and other organizations, designed the work flow for collecting these rare pressure core samples and conducted the field operations.

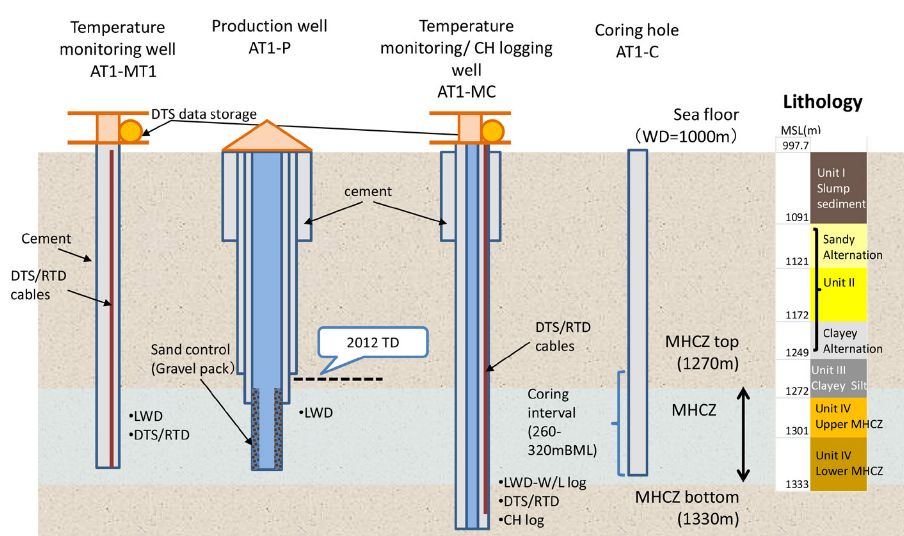

Figure 3. Schematics of the wells for the upcoming offshore production test. The shallow sections of the production well and two temperature monitoring wells were drilled in February-March of 2012. An additional borehole was drilled for pressure coring. The 60-m coring interval includes an overburden clayey silt zone and a sandy Methane Hydrate Concentrated Zone (MHCZ).

Coring Operations

The deepwater drilling vessel D/V *Chikyu*, which belongs to the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), was employed for the coring operations. JOGMEC and JAPEX (the drilling operator) used a coring tool called the Hybrid Pressure-Coring System (Hybrid PCS), which was developed by JAMSTEC and Aumann and Associates Inc. as an improved version of the JOGMEC-developed Pressure-Temperature Coring System (PTCS) tool (Kawasaki et al., 2006), employed in the 2004 coring operations. The new tool is compatible with other coring elements used for International Ocean Drilling Program (IODP) operations of the D/V *Chikyu*. All of the tools can be lowered and retrieved by wireline and use a common outer barrel and drill bit, so each tool is exchangeable as necessary. The maximum length of a Hybrid PCS core is 3.5m, and the diameter is 5.1cm. After cutting a core, the ball valve at the bottom of the pressure vessel (core autoclave) is closed, so that pressure is preserved inside the vessel during wireline retrieval.

The pressure coring work flow is shown in Figure 4. During our expedition, 21 cores were recovered from a 60m interval of the hole. Sampled lithologies range from clay-rich sediments in the overburden formation to sandy layers with high concentrations of methane hydrate in the targeted interval. Along with the Hybrid PCS, the conventional coring tool known as the Extended Shoe Coring System (ESCS) was used in some intervals. On retrieval, the core autoclave for the Hybrid PCS was connected to Geotek's Pressure Core Analysis and Transfer System (PCATS) (Schultheiss et al., 2011), which can transfer the core through an X-ray CT scanner for non-destructive measurements of density and P-wave velocities. Following testing, PCATS cut the long core sections into smaller pieces for transfer into pressure chambers. Some of these pressurized specimens were set aside for long-term preservation and future analysis. Others were quickly depressurized to obtain data on geochemistry and microbiology (gas and water sampling), geomechanics (stress measurement by anelastic strain recovery technique), paleomagnetic signatures, and geological characteristics. In addition, the PCATS triaxial system (Schultheiss et al., 2009) was set up aboard the ship for mechanical and physical testing of the cores under in-situ pressure and effective stress conditions. A subset of the pressure core sections was depressurized and stored in liquid nitrogen for further analysis.

Table 1. Coring results of the JOGMEC-JAPEX methane hydrate production test AT1-C well.

Net coring time	17:30 hours
Number of cores	
ESCS cores	3m x 3 (9m)
Hybrid PCS cores	3m x 16 + 1.5m x 2 (51m)
Recovery rate	
Entire interval	36.82m (out of 60m), recovery rate = 61%
Hybrid PCS section	34.99m (out of 51m), recovery rate = 69%
Pressure condition	
Pressure conserved cores(≥1750psi)	8 cores
Partially pressure conserved cores (≥800psi)	4 cores
Pressure lost (<800psi)	6 cores

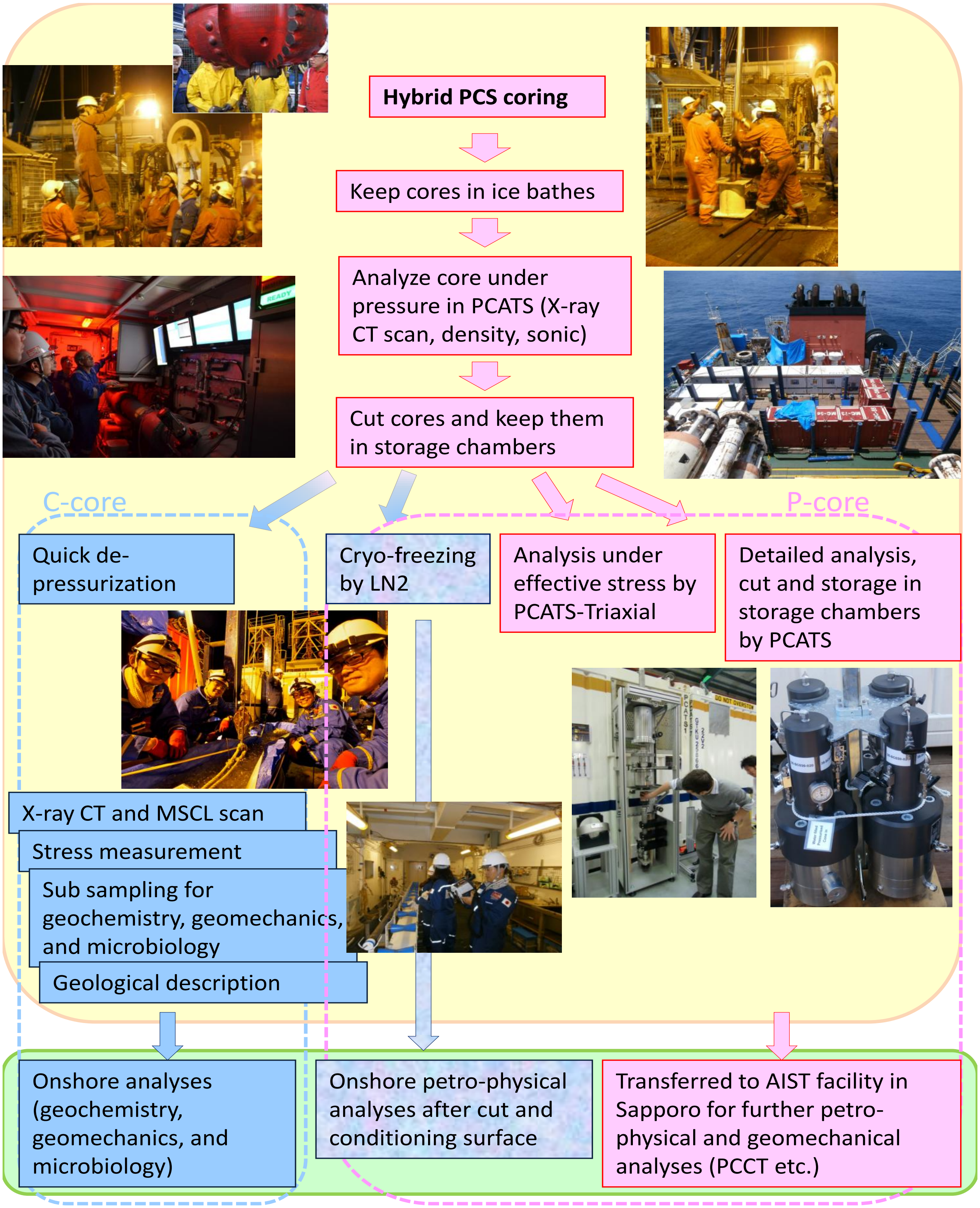

Figure 4. Work flow for core handling and on-board and post-cruise analyses. The recovered core autoclaves were sent to PCATS after cooling in ice baths. PCATS scanned the cores and made non-destructive measurements (X-ray, ultrasonic and gamma ray density), and the PCATS triaxial instrument was also used to obtain geomechanical data. The cores are being studied in 3 different ways: 1) quickly depressurized and turned into conventional cores, 2) kept in cryo-freeze conditions with liquid nitrogen (LN2), and, 3) kept in 0.3m or 1.2m storage chambers under pressure.

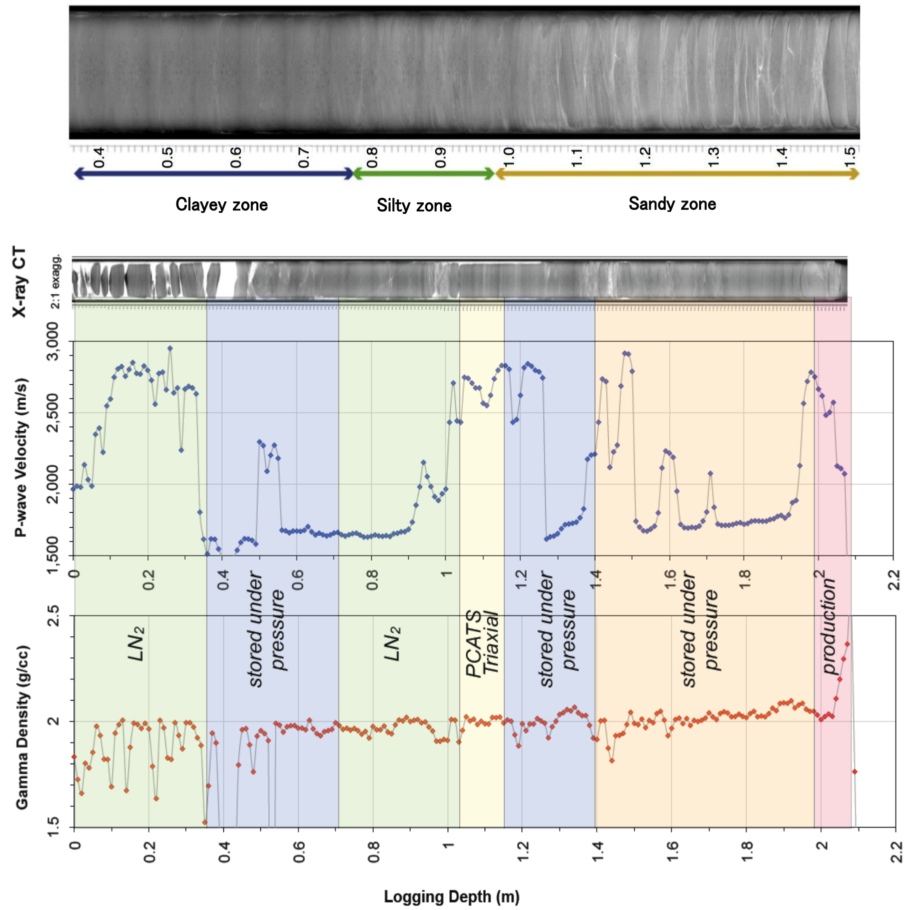

Figure 5. X-ray CT image and P-wave velocity and gamma-ray density data from a pressure core, based on data recorded in PCATS. Very clear sedimentary structures can be observed in the data, and sandy and clay layers are identified.

Outcomes and Future Work

We encountered several mechanical problems in recovering well-preserved core, but the total recovery rate was about 70 percent. The pressure in some portions of the cores was partially or entirely lost (Table 1), but the overall condition of the cores was quite good. The X-ray CT scans (Figure 5) show that the structure of the sediments is quite well preserved. Careful examination of these images may provide new insights about the methane hydrate occurrence and its relationship to other sediment characteristics.

The MH21 scientist team is still working on integrating the core data and finalizing interpretations. AIST has developed technologies to analyze the frozen and pressurized samples for reservoir characterization. Some of the samples preserved under pressure will be analyzed using Pressure Core Characterization Tools (PCCTs) developed by the Georgia Institute of Technology and the U.S. Geological Survey (USGS) (Santamarina, et al., 2012; PCCT Development Team, this issue). These tools include the instrumented pressure testing chamber for determining seismic, electromagnetic, and strength properties, an effective stress device, and instrumentation for monitoring production tests during controlled depressurization. We expect that further analysis will provide accurate physical, mechanical, and hydraulic characteristics of the gas hydrate-bearing sediments under near in-situ conditions and add value to the planned production test.

Acknowledgements

The authors wish to acknowledge JOGMEC and AIST managements, METI, JAPEX, JAMSTEC, Japan Drilling Company, Mantle Quest Japan Company, Aumann and Associates, Geotek, Marine Works Japan, and all other parties and personnel who made efforts to realize a safe and successful coring expedition.

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Pressure Core Characterization Tools to Enhance Gas Hydrate Field Programs

The PCCT Development Team

THE PCCT DEVELOPMENT TEAM:

Georgia Tech: J. C. Santamarina, S. Dai, J. Jang, M. Terzariol, and E. Papadopoulos

USGS: W.J. Winters, D. Mason, W. Waite, and E. Bergeron

The physical properties, fine-scale structure, and geotechnical properties of hydrate-bearing sediments can be dramatically altered, if gas hydrate dissociates during sampling, core recovery, or subsequent testing. To address this issue, pressure coring has been developed as a systematic method of retrieving hydrate-bearing sediments from subsurface deposits and preserving the samples at in-situ, hydrostatic pressure conditions. The Deep Sea Drilling and Ocean Drilling Programs originated the first pressure coring technologies in the 1980s and 90s, and these tools have been refined subsequently by worldwide, hydrate-focused drilling programs managed by national governments and private sector firms.

Starting in 2004, Georgia Tech, with support from the DOE/Chevron Cooperative Agreement and the Chevron-led Gulf of Mexico Gas Hydrate Joint Industry Project (JIP), designed the Instrumented Pressure Testing Chamber (IPTC) to measure seismic, strength, and electrical properties of hydrate-bearing sediments recovered in pressure cores (Figure 1). The IPTC was the first tool of its kind and was subsequently used in conjunction with the Geotek Pressure Core Analysis and Transfer System (PCATS) to characterize pressure cores obtained from the Gulf of Mexico (from the JIP

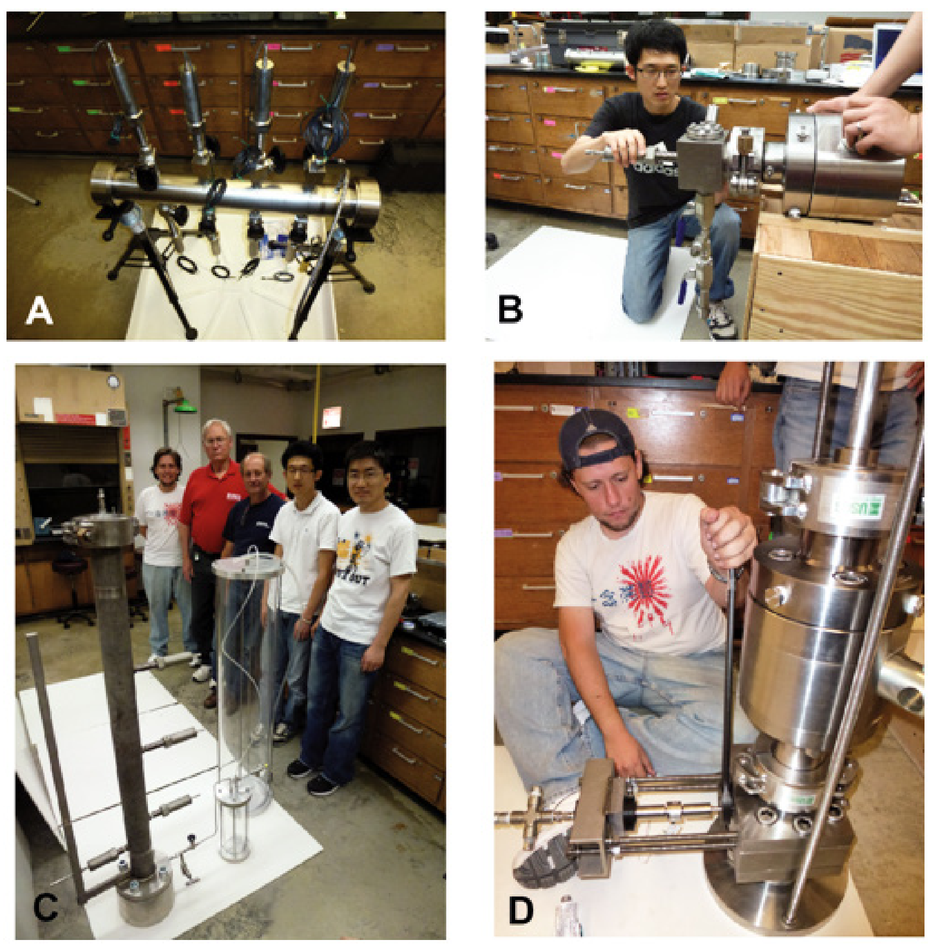

Figure 1. (A) The Instrumented Pressure Testing Chamber (IPTC) showing probe ball valves, drive arms, and the ends of the instrumented probes. The manipulator and IPTC can accommodate core sections up to 1.2 m long. (B) The biological incubation chamber (bottom) can be prepared with a chosen set of nutrients and then receive a core subsection from the bio-sampler (center), which subsamples core material fed through the ball valve (right). A window permits observation of the sample during subsampling. (C) Some members of the Georgia Tech and USGS teams standing with the controlled depressurization chamber. The metal chamber is filled with a hydrate-bearing sediment core that produces water (collected in the small chamber) and methane gas (collected in the large chamber) during controlled dissociation. (D) The direct shear device.

Leg I expedition), offshore India (collected by India's National Gas Hydrate Program), and offshore Korea (sampled by the Ulleung Basin Gas Hydrates program).

In 2009, the Physical Properties Lab of the USGS Gas Hydrates Project assumed primary responsibility for the IPTC. The USGS has taken the lead in meeting JIP requirements that the instrumentation sustain a maximum fluid pressure of 35 MPa (5000 psi), in preparation for eventual analysis of hydrate-bearing sediment cores from the deep-water Gulf of Mexico. In addition to enhancing the sensors and electronic peripherals, the USGS has developed a fluid handling system for regulating cell pressures in pressure coring devices. Meanwhile, Georgia Tech has worked under JIP sponsorship to develop a new suite of testing and core manipulation devices that, together with the IPTC, are known as the Pressure Core Characterization Tools (PCCT). The PCCT suite is designed to be fully compatible with pressure coring devices currently in use and in development in Japan and the U.S., as well as with the PCATS, developed and operated by Geotek.

The PCCT collection includes cutting, subsampling, and transfer devices that allow core subsections of specific lengths needed by the PCCT measurement cells to be cut and positioned appropriately for testing. The PCCT instrument suite, described in more detail in Table 1, also includes an effective stress device, a direct shear chamber, a controlled depressurization chamber for sediment preservation and production testing, a biological incubation chamber, and a water sampler that can withdraw pore fluids from several of the chambers. Taken together, the IPTC and new PCCT tools are capable of measuring seismic properties,

	Device	Description/Function	Measurements/Notes
Position	Manipulator	Longitudinal position control of core position	Maximum extension: 2.6 m Location precision: <1 mm
	Rotation	Rotates core within the chamber	Added in series as needed
Sub-sampling	Cutter	Cuts core liner and sediment at selected locations	Cutter 1: guillotine-type Cutter 2: saw-type
Characterization	Instrumented Pressure Testing Chamber IPTC	Determines sediment properties along the length of a core through holes drilled in the liner under pressure	P-wave velocity S-wave velocity Electrical resistivity Strength (penetration resistance)
	Effective Stress Cell	Flexible jacketed sample is axially loaded	Strength-related parameters Hydraulic conductivity
	Direct Shear Cell	Double shear planes are induced across a linerless sample	Large-strain strength parameters
	Bio-Sampler	Sampled sediment is placed into individual pressure cylinders for subsequent testing	Optical window allows visual observation of pressurized core during incubation
	Controlled Depressurization Chamber	Quantifies gas and water expulsion during controlled dissociation process	Can be used with collection chambers or flow meter. Pressure and temperature monitoring

Table 1. Pressure Core Characterization Tools (PCCT) – Primary capabilities.

hydraulic conductivity and permeability, strength parameters, and electrical resistivity. These tools also permit direct sampling of cores for geochemical and microbiological studies.

The first deployment of the PCCT devices will be in January 2013, through collaboration with the JIP, the Japan Oil, Gas and Metals National Corporation (JOGMEC), and Japan's National Institute of Advanced Industrial Science and Technology (AIST). The tools will be used to conduct analyses of pressure cores recovered in the Eastern Nankai Trough during the summer of 2012 (See Yamamoto et al., this issue).

Acknowledgements

Previous Georgia Tech students and postdocs were critical to the development of the IPTC and the effective stress device. Peter Schultheiss of Geotek, Ltd. has provided vital assistance during previous field expeditions. The DOE/Chevron Cooperative Agreement and the Chevron-led Gulf of Mexico JIP is supporting this effort through agreements with both Georgia Tech and the USGS. Additional funding for the effective stress device was provided to Georgia Tech by the Joint Oceanographic Institutions.

Suggested Reading

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P-Cable High-Resolution 3D Seismic Imaging of Hydrate Occurrences Over Unusually Large Gas Chimneys in the SW Barents Sea

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The Barents Sea is a large hydrocarbon-prone basin in the Norwegian Arctic region (Fig. 1). In the SW Barents Sea, a significant volume of hydrocarbons is thought to have leaked or migrated upward from deeper portions of the basin into the shallow subsurface, where it is now trapped in gas hydrate and free gas reservoirs (Laberg et al., 1996; Chand et al., 2012). The widespread distribution of these shallow hydrocarbon accumulations was not previously recognized. In addition, the complex nature of these deposits and their mechanism of formation were not known. An extensive seismic mapping project was carried out at the University of Tromsø to better understand the nature and distribution of these shallow gas accumulations and associated fluid flow features in the SW Barents Sea.

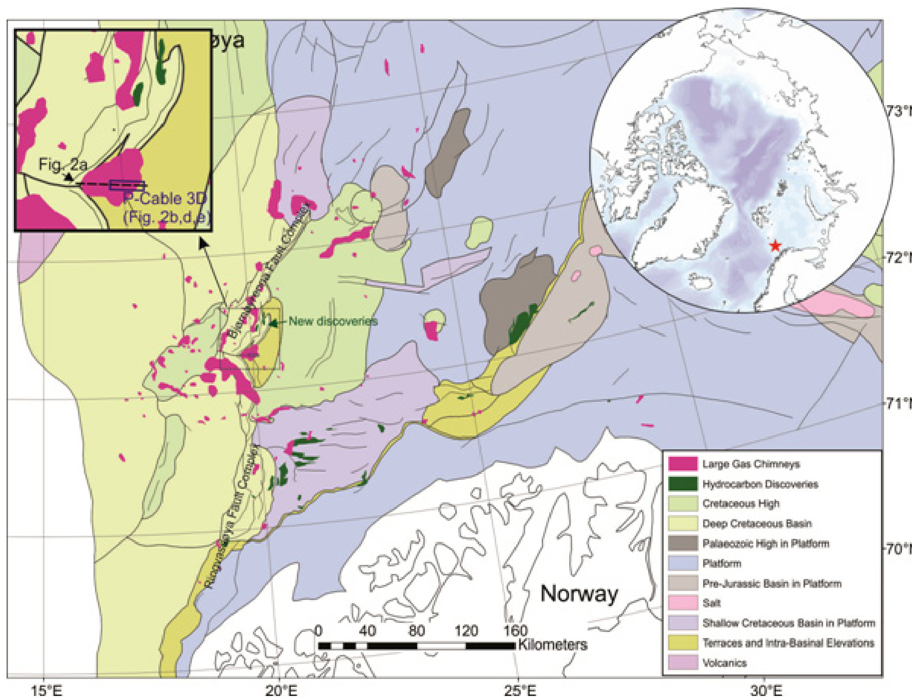

Figure 1. Structural map of the SW Barents Sea with mapped giant gas chimneys indicated in bright pink color. The giant chimneys occur mostly along N-S trending fault complexes and adjacent basins and platforms. The small inset figure shows the location of the seismic examples in Fig. 2.

The interpretation of more than 3000 2D seismic lines in the SW Barents Sea revealed the presence of various subsurface fluid flow features, amongst which gas chimneys are the most common. These gas chimneys originate mainly in Triassic and Permian successions and have typical diameters of a few hundred meters. However, the dense seismic coverage used in this project allowed the identification of a total of 93 exceptionally large gas chimneys, varying from 1 to 600 km^2 in area and displaying

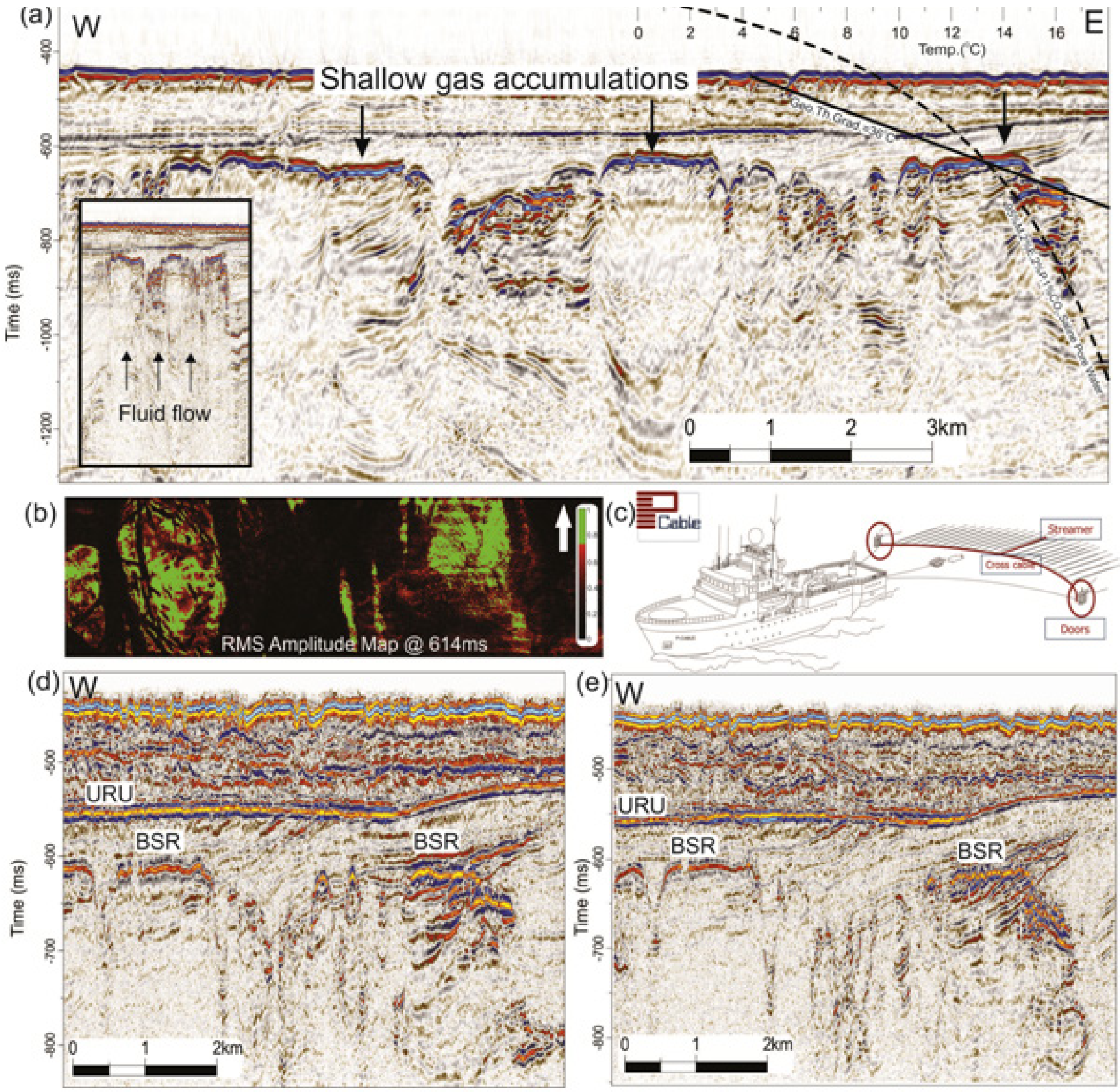

Figure 2. (a) 2D multi-channel seismic profile across one of the exceptionally large gas chimneys showing high-amplitude anomalies interpreted as shallow gas accumulations at the upper termination of the chimney. The small inset figures show that these chimneys extend to great depth and connect with Triassic and Permian sedimentary strata. (b) Root mean square (RMS) amplitude map derived from the high-resolution 3D seismic data at a depth of 614 ms two-way-travel-time that coincides with the predicted base of hydrate stability. (c) Sketch of the P-Cable high-resolution 3D seismic system. (d,e) Seismic examples from the high-resolution 3D seismic data clearly showing that amplitude anomalies cross-cut sedimentary strata and document the presence of a bottom simulating reflector (BSR) indicating the presence of gas hydrates within sediments above giant gas chimneys.

peculiar areal shapes (Figs. 1 and 2a). These gas chimneys occur mostly along major structural boundaries, in particular along the large fault complexes that stretch from south to north in this part of the basin (Fig. 1). This suggests a close relationship to the structural development of the Barents Sea. It is likely that fault reactivation and glaciotectonics during Late Cenozoic time have led to the depletion of deep-seated hydrocarbon reservoirs and upward migration of hydrocarbon gases through gas chimneys (Henriksen et al., 2011).

We also observe reversed-polarity, high-amplitude anomalies in shallow stratigraphic horizons, suggesting the presence of free gas and gas hydrates (Fig. 1). The observed amplitude anomalies occur mainly in Tertiary sediments below a prominent reflection, the upper regional unconformity (URU) a widespread erosional surface separating glaciogenic from pre-glacial sediments. It is likely that hydrocarbon gases that migrated upward are being trapped in these shallow stratigraphic formations.

In order to better understand the complex nature of the shallow gas accumulations, the University of Tromsø, in cooperation with P-Cable 3D Seismic AS and Lundin Norge AS, who funded parts of the cruise, acquired high-resolution 3D seismic data using the P-Cable system (Fig. 2c; Planke et al.; 2010; Pedersen et al., 2010). The P-Cable system is a high-resolution 3D seismic imaging tool. It consists of a cable towed perpendicular to the ship's steaming direction and a cross-cable that is spread behind the vessel by two large trawl doors. Up to 20 multi-channel streamers with a length of 25 m and a separation of 12.5 m are attached to the cross-cable. The streamer array acquires 20 seismic lines simultaneously, thus covering an approximately 200 m-wide swath with close in-line spacing in a cost efficient way. GPS antennas are mounted on both the gun float and the trawl doors to ensure accurate navigation, with uncertainties of less than 1 meter. The spatial resolution of such a system is at least one order of magnitude higher than conventional 3D seismic, whereas the temporal resolution is improved 3-5 times using high-frequency airgun systems. The increase in image resolution facilitates better target identification and allows for more accurate imaging of shallow subsurface structures.

The high-resolution 3D seismic data clearly revealed for the first time that the high-amplitude anomalies that terminate the giant chimneys cross-cut the up-dipping Tertiary sedimentary strata in various parts and mimic the seafloor (Figs. 2d and 2e). This is typical of a Bottom Simulating Reflector, or BSR. The occurrence of a BSR at this depth indicates the presence of gas hydrates in the pore spaces of these shallow sediments. Bottom water temperatures and geothermal gradient information in the area were used to assess the stability conditions for gas hydrate in the region. These predictions match very well with the observed sub-bottom depth of the BSR assuming a gas composition that contains a small amount of high-order hydrocarbons (Chand et al., 2008). Further studies of BSR occurrences and hydrate stability show a highly variable BSR depth in the SW Barents Sea that might be controlled by structural elements and fluid flow through the giant chimneys. Spatial analysis of the distribution of high amplitudes at the top of the chimneys shows a very peculiar shape (Fig. 2b). Further analysis of the high-resolution 3D seismic data is necessary to better understand these complexities and the mechanisms controlling the distribution of the gas hydrate and free gas accumulations.

One may expect that large quantities of hydrocarbons have been released from deep-seated reservoirs in this region. A high flux of gas-rich fluids through the chimneys could have led to significant accumulations of gas hydrates and free gas as recently demonstrated on the Hydrate Ridge, offshore the western coast of the U.S. (Hornbach et al., 2012). Given that the total area covered by the giant chimneys is approximately 3000 km^2, these concentrated occurrences might contain substantial gas hydrate resources. In addition, these gas hydrate and free gas accumulations may pose a hazard to hydrocarbon exploration and exploitation in an area of future development, where two significant oil discoveries have been made during the last two years (Fig. 1). Therefore, it is important to better understand these accumulations and the potential effects of climate change in this environmentally sensitive part of the Arctic region. Future work will focus on the quantification of fluid flow and hydrate resources occurring above the giant gas chimneys.

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GAS VENTS OFF SPITSBERGEN OLDER THAN EXPECTED

Preliminary Results from GEOMAR Expedition to the Greenland Sea

Jan Steffen (GEOMAR), jsteffen@geomar.de

Marine scientists from the GEOMAR Helmholtz Centre for Ocean Research Kiel, together with colleagues from Bremen, Great Britain, Switzerland, and Norway, spent four and a half weeks examining methane emanation from the sea bed off the coast of Spitsbergen with the German research vessel MARIA S. MERIAN. There they gained new insights about the gas vents—some of which appear to have been active for hundreds of years

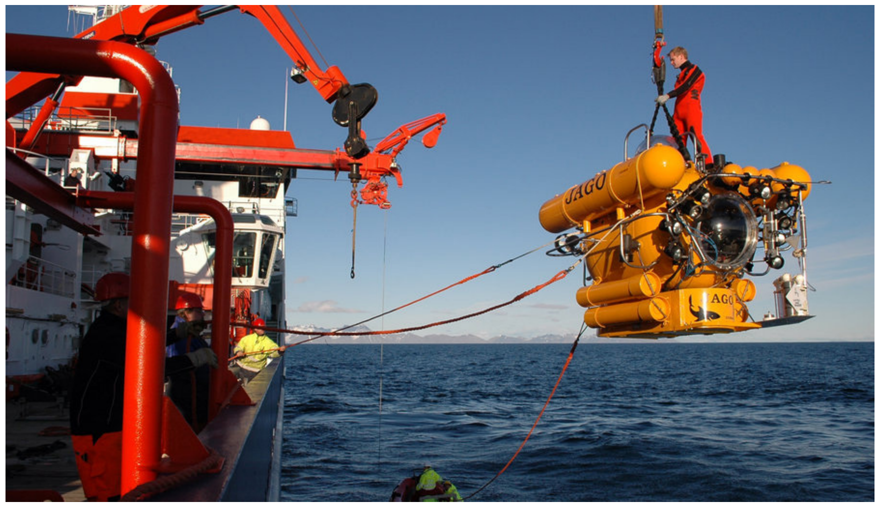


Figure 1. The submersible JAGO and the German research vessel MARIA S. MERIAN off the coast of Spitsbergen. Photo: Karen Hissmann, GEOMAR

Nature drove the marine research team to their limits, as they encountered frequent storms and sub-zero temperatures. Nevertheless, the participants were very pleased with the achievements of the expedition. According to the expedition's Chief Scientist, Dr. Christian Berndt: "We were able to gather many samples and data in the affected area. With the submersible JAGO, we even managed to form an impression of the sea bed and the gas vents."

The reason for the expedition was the supposition that methane hydrate stored in the sea bed was dissociating due to rising water temperatures. "Methane hydrate is only stable at very low temperatures and under very high pressure. The gas outlets off Spitsbergen lie approximately at a depth which marks the border between stability and dissolution. Therefore we presumed that a measurable rise in water temperature in the Arctic could dissolve the hydrates from the top downwards," explained Dr. Berndt. Methane could then be released into the water or even into the atmosphere, where it would act as a stronger greenhouse gas than CO_2.

In fact, what the researchers found in the area offers a different picture. Above all, the fear that the gas emanation is a consequence of the current rising sea temperature does not seem to apply. At least some of the gas outlets existed prior to recent increases in ocean temperatures. Carbonate deposits, which form when microorganisms convert the escaping methane, were found on the vents. "At numerous emergences we found deposits that might already be hundreds of years old. This estimation is indeed only based on the size of the samples and empirical values as to how fast such

THE EXPEDITION AT A GLANCE

Research Vessel: R/V MARIA S. MERIAN

Head of Expedition: Dr. Christian Berndt, GEOMAR

Length of Expedition: 13th Aug. 2012-11th Sept. 2012

Place of Departure: Reykjavik, Iceland

Research Area: West of Spitsbergen, Greenland Sea

Place of Arrival: Emden, Germany

deposits grow. On any account, the methane sources must be older," said Professor Berndt.

The exact age of the carbonate deposits will be determined by analyzing samples obtained during the expedition in GEOMAR's laboratories. "Details will only be known in a few months when the data has been analyzed; however the observed gas emanations are probably not caused by human influence," said Berndt. There are two other possible explanations for the gas vents. One is that they are manifestations of a long-term, natural rise in the ocean temperature in the basin. Alternatively, they may have formed from seasonal changes in temperature that cause gas hydrates to melt and reform on an annual cycle.

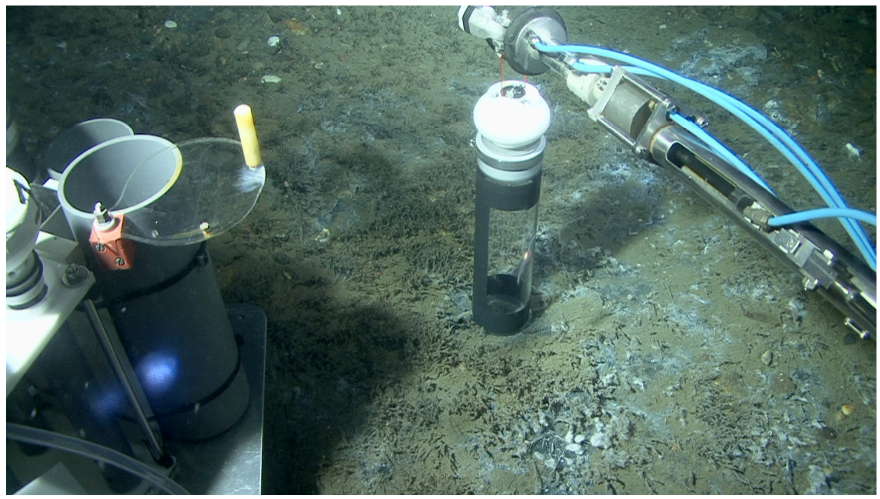


Figure 2. Microbial community that consumes the methane has established itself on the sea bed. Photo: JAGO Science Team, GEOMAR

Another interesting observation made on the expedition was that a very active microbial community that consumes the methane has established itself on the sea bed in this part of the Greenland Sea. "We were able to detect high concentrations of hydrogen sulfide, which is an indication of methane consuming microbes in the sea bed, and, with the help of JAGO, we discovered typical biocoenoses (ecological communities) that we recognized from other, older methane outlets" according to Dr. Tina Treude of GEOMAR. Dr. Treude is a microbiologist who participated in the expedition, and she explained that "methane-consuming microbes grow only slowly in the sea bed, thus their high activity indicates that the methane has not just recently begun effervescing."

Colleagues from Bremen, Switzerland, Great Britain and Norway worked alongside marine scientists from GEOMAR and from the Cluster of Excellence "The Future Ocean." Dr. Berndt stressed that "the study of the gas outlets in the Norwegian Sea is a good example for combined European research." As part of the expedition, German scientists recovered a seafloor observatory installed by a British research vessel during a prior joint expedition of the National Oceanography Centre Southampton and the Institut Français de Recherche pour l'Exploitation de la Mer. "Understanding the ocean as a system is a challenge that only works in international cooperations" emphasized Berndt. The analysis of the gathered data will also be carried out internationally.

SUGGESTED LINKS:

For further Information on the GEOMAR expedition, visit: www.geomar.de/forschen/expeditionen

For more information on GEOMAR Helmholtz Centre for Ocean Research Kiel: www.geomar.de

For more information on the Cluster of Excellence the Future Ocean: www.ozean-der-zukunft.de

SUGGESTED READING:

Westbrook, G.K et al., 2009, Escape of Methane Gas from the Seabed Along the West Spitsbergen Continental Margin: Geophys. Res. Lett., v. 36, L15608.

Beaufort Sea Cruise Examines Geohazards and Geologic Processes Near the Continental Shelf Edge

Scott Dallimore, Geological Survey of Canada
Charles Paull, Monterey Bay Aquarium Research Institute
Humfrey Melling, Department of Fisheries and Oceans Canada

A research cruise was carried out in late September and early October of this year in the Beaufort Sea, using the Canadian Coast Guard Icebreaker Sir Wilfrid Laurier (Fig. 1).

Figure 1. Canadian Coast Guard Icebreaker Sir Wilfrid Laurier

This cruise effort is part of a continuing collaboration between Natural Resources Canada, Fisheries and Oceans Canada, and Monterey Bay Aquarium Research Institute. The objectives of this collaborative study are to characterize geohazards and geologic processes along the shelf edge and upper continental slope of the Canadian Beaufort Sea (Fig. 2).

Past surveys by the research team have documented a remarkable coalescence of geologic features in this area including pingo-like-features (conical features found in arctic permafrost regions), pockmarks, landslides, and deep water sediment expulsion features. Investigations of water column acoustic anomalies and sea bed gas release on ROV dives have suggested that free gas is emanating from the seafloor as methane seeps. It is likely that the methane seeps in this region are generated from the decomposition of underlying permafrost and gas hydrate deposits, which are unique components of this system and may influence many aspects of the seafloor processes (Fig. 3).

The recent cruise was designed to exploit a variety of techniques, including using an ROV to characterize the sea bed and sample the gas vents, piston coring for lithologic and geochemical analyses, high resolution seismic data collection, and an oceanographic mooring to monitor gas release over a sea floor expulsion feature.

Figure 2. These maps show the area studied during the recent expedition. The lower map shows the continental shelf and continental slope of the Beaufort Sea. The upper image shows detailed seafloor bathymetry of a portion of the continental slope that was studied during the recent cruise, as well as three seafloor mounds that were explored using a new ROV. Lower image modified from Google Maps. Upper image: Natural Resources Canada and ArcticNet.

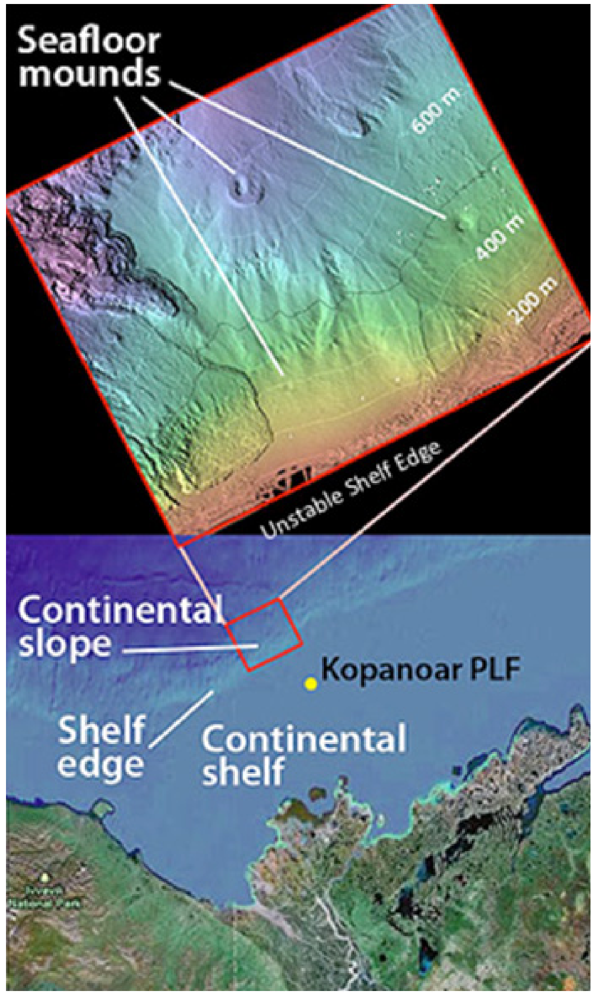
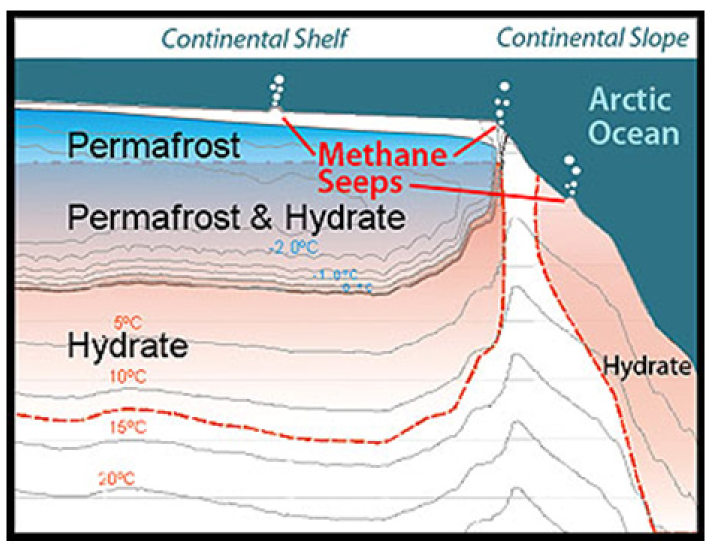


Figure 3. This idealized cross section of the continental shelf and continental slope in the Beaufort Sea shows zones in the seafloor where permafrost and methane hydrate are likely to exist, as well as locations of known methane seeps. Ocean depths not shown to scale.



Further information on the MBARI portion of the research cruise is available at: http://www.mbari.org/news/homepage/2012/paull-arctic/paull-arctic.html

DOE's FY2012 Gas Hydrate Program Continues Focus on Resource and Environmental Issues

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) has finalized plans for allocating Methane Hydrate Program funding received in FY2012. The resulting program portfolio integrates work to be done in the field, in the lab, and through numerical simulation. Taken together, the selected projects are designed to increase our understanding of methane hydrates in the context of future energy supply and changing climates. The program will continue to be managed via regular consultation with members of the Program's Interagency Technical Coordination Team-- including scientists from NETL, the USGS, the Bureau of Ocean Energy Management (BOEM), the Naval Research Lab, the National Oceanic and Atmospheric Administration, the Bureau of Land Management, and the National Science Foundation. The following provides a summary of the program portfolio going forward.

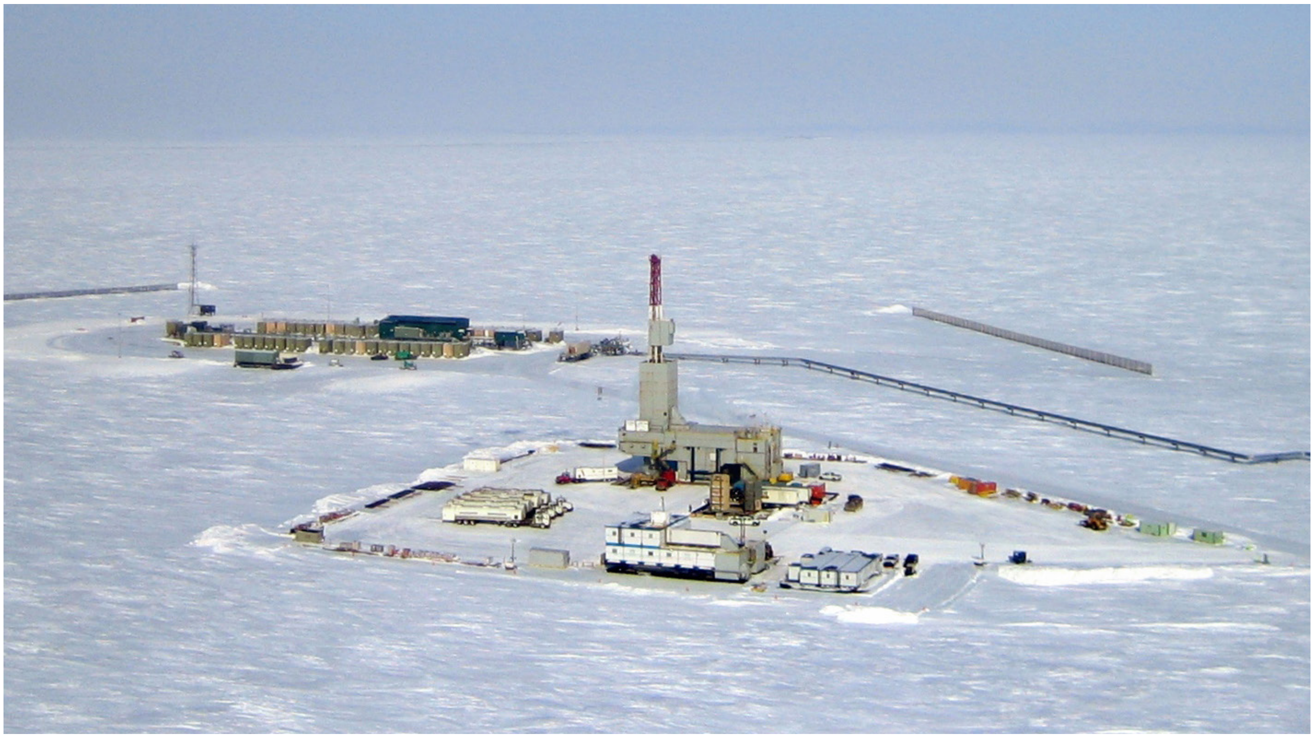
Gas Hydrate Production Technology

The DOE and its interagency partners will continue to pursue opportunities for extended-duration gas hydrate field tests through discussions with oil and gas operators, the State of Alaska, and other interested parties. In addition, ConocoPhillips will refine, analyze, and make publicly available field data acquired during 2011 and 2012 field programs in Alaska (Schoderbek and Boswell, FITI, 2011; Iġnik Sikumi Gas Hydrate Exchange Trial Project Team, FITI, 2012). DOE will engage the research community to identify further analyses of these data that could provide insights into the response of natural gas hydrate reservoirs to chemical injection and subsequent depressurization.

Marine Gas Hydrate Characterization

Since 2001, the DOE-funded Gulf of Mexico Joint Industry Project (JIP) has worked collaboratively with industry, international groups, and U.S. federal agencies to determine the scale, nature, and implications of gas hydrates in the U.S. Outer Continental Shelf. The Gulf of Mexico JIP (see Birchwood et al., FITI, 2008; Boswell et al, FITI, 2009) has led two research expeditions, laboratory work, and an array of technology development activities. These efforts were designed to address gas hydrate resource characterization and drilling safety issues in the Gulf of Mexico. The results have served to demonstrate the value of conducting gas hydrate exploration via integrated geological and geophysical prospecting for gas hydrate-bearing sand reservoirs. This project is scheduled to end within the next year, after developing and testing a suite of pressure core acquisition and analysis devices (see PCCT Development Team, this issue).

The DOE has a strong interest in utilizing sites discovered during the JIP's 2009 Leg II expedition to further the science and technology of marine gas hydrate appraisal. The following new projects will begin in FY2012: 1) Fugro GeoConsulting, Inc. will develop detailed scientific and operational plans and recommendations for all aspects of a future offshore



Iġnik Sikumi #1 well, Prudhoe Bay Unit, Alaska, in April 2011. (courtesy ConocoPhillips)

drilling, logging and pressure coring campaign targeting reservoirs and seals at the JIP leg II sites; 2) The Consortium for Ocean Leadership will coordinate scientific input and develop scientific plans for a future marine hydrate expedition(s) to conduct scientific drilling, coring, logging, and analytical activities to assess the geologic occurrence, regional context, and characteristics of methane hydrate deposits along the continental margins of the U.S., with potential emphasis on the Gulf of Mexico and the Atlantic margin; 3) the USGS, the BOEM, and NETL will collaborate on a USGS-led effort to acquire high-resolution, multi-component seismic data needed to characterize gas hydrate-bearing sediments at the JIP sites; 4) Ohio State University will conduct research in collaboration with the BOEM to access well date from more than 1,700 deepwater wells to evaluate indications of gas hydrate in the northern Gulf of Mexico; 5) Oklahoma State University will further analyze the structural and stratigraphic controls on hydrate occurrence and distribution at the JIP sites using new techniques to interpret gas hydrate occurrence in existing seismic and well data collected during prior DOE research efforts at those sites; and 6) Fugro GeoConsulting, Inc. will develop analytical techniques that will enable more robust and reliable identification and delineation of methane hydrate accumulations and their complex potential interfaces with free gas accumulations in seismic data.

Assessing the Response of Gas Hydrate-Bearing Sediments to Environmental Change

DOE continues to promote a broad-based R&D program to advance fundamental science on the response of gas hydrate-bearing sediments to changes in the environment. Such work illuminates a range of issues ranging from geohazards assessment to the role of gas hydrates in nature.

An initial suite of projects, funded in 2008, are now concluding and have been successful in catalyzing scientific research to inform speculation on the response of gas hydrates to ongoing climate change and other issues.

In FY2012 and going forward, DOE will continue this effort with projects that include field sampling, modeling, and geophysical detection of methane hydrate in areas where gas hydate destabilization is occurring. New projects have been selected that will further constrain the nature and occurrence of gas hydrate in settings impacted by changing climates. In addition, these projects will improve our understanding of the dynamic response of hydrate to climate change and its potential impact of on seafloor stability, ocean ecology, and global climate. The following projects address these issues: 1) Southern Methodist University will lead a program in numerical modeling, field data collection, and laboratory analyses to characterize gas hydrates at the landward feather edge of stability on the Alaskan Beaufort continental slope; 2) Oregon State University will generate computer models that will enable researchers to constrain modern day methane fluxes and reconstruct past episodes of methane flux in gas hydrate-bearing regions from shallow geochemical data; 3) the University of New Hampshire will study the dynamic nature of methane flux by using lithostratigraphic data to reconstruct the paleo-positions of the sulfate-methane transition at three sites on the Cascadia margin; 4) the University of Texas-Austin will develop conceptual and numerical models to analyze conditions under which gas will be expelled from existing accumulations of deepwater gas hydrate into the overlying ocean; 5) University of California at San Diego will design, build, and test an electromagnetic detection system for shallow water use and will utilize the system to determine the extent of offshore permafrost on the U.S. Beaufort inner continental shelf; 6) the University of Mississippi will investigate the potential use of time-series, direct current resistivity methods to investigate temporal variations in gas hydrate occurrence at cold vent sites on the continental slope of the northern Gulf of Mexico; 7) the U.S. Geological Survey will continue to collect and analyze new geophysical and biogeochemical data on the Alaskan Beaufort Sea continental shelf and slope as part of an ongoing effort to understand the response of shallow-water, permafrost-associated gas hydrate and upper continental slope gas hydrate to short- and long-term environmental change; 8) the Naval Research Laboratory will provide geochemistry expertise in a collaborative field program with New Zealand and Germany investigating climate-driven changes in gas hydrate stability on the Hikurangi margin, offshore New Zealand; and 9) Lawrence Berkeley National Lab and Los Alamos National Lab will complete an ongoing effort to couple gas hydrate reservoir simulators and ocean circulation models to enable predictions of the response of marine gas hydrates to changing conditions and the potential impact of methane hydrate destabilization on ocean ecology.

Fundamental Properties of Gas Hydrate-Bearing Sediments

Effective pursuit of the program's resource and environmental science goals will be built on a foundation of fundamental data acquired through laboratory and modeling studies. The following six efforts will support NETL goals of enabling the optimal analysis and interpretation of data collected in various scientific field experiments. These projects are designed to assess the nature of potential gas hydrate production technologies, most notably depressurization and /or chemical exchange: 1) Georgia Tech will examine the behavior of gas hydrates hosted in fine-grained sediments and will evaluate phenomena relevant to potential gas production from such sediments; 2) Colorado School of Mines will conduct laboratory experiments that will help to calibrate the seismic response of hydrate-bearing sediments; 3) Wayne State University will investigate improved parameterization of capillary pressure and relative permeability phenomena in the numerical simulation of gas hydrate dissociation and gas production; 4) Lawrence Berkeley National Lab will continue its program of integrated laboratory and numerical modeling efforts designed to enable the accurate prediction of gas hydrate response to depressurization-induced production; 5) NETL will conduct a range of experimental and numerical modeling studies designed to enable improved planning for a range of scientific field programs related to gas hydrate resource potential; and 6) Pacific Northwest National Lab will complete ongoing modeling efforts focused primarily on the evaluation of CO_2-CH_4 exchange.

Click here to link to NETL-National Academies National Methane Hydrate Graduate Fellowship Program

In addition to the above projects, NETL will continue its commitment to supporting opportunities for the nation's brightest young scientists to contribute to gas hydrate research through continuing support to NETL-National Academies National Methane Hydrate Fellows.

AGU FALL MEETING
San Francisco | 3–7 December 2012

AGU's 2012 Fall Meeting Gas Hydrate Sessions

The American Geophysical Union (AGU) Fall Meeting will be held from Monday, December 3 thru Friday, December 7 in the North, South, and West buildings of the Moscone Center, in San Francisco. As in past years this meeting will include a number of sessions devoted to gas hydrate research.

The Wednesday (December 5th) schedule includes three sessions at Moscone West Rm. 3024 presenting a total of 23 papers: Marine and Permafrost Gas Hydrate Systems I convened by Seung-Ho Kim and Michael Riedel from 8:00 to 10:00 AM; Marine and Permafrost Gas Hydrate Systems II convened by Se-Joon Kim and Timothy Collett from1:40 to 3:40 PM; and Marine and Permafrost Gas Hydrate Systems III convened by Byong-Jae Ryu and Jang-Jun Bahk from 4:00 to 6:00 PM.

The Thursday (December 6th) schedule includes two paper sessions (also at Moscone West Rm. 3024) and three poster sessions (in Hall A-C Moscone South) presenting a total of seven papers and 36 posters. The sessions include: Fluid Flow and Gas Hydrates in Continental Margins I convened by Christian Berndt and Sverre Planke from 8:00 to 10:00 AM; Fluid Flow and Gas Hydrates in Continental Margins II convened by the same from10:20 to12:20 PM; Fluid Flow and Gas Hydrates in Continental Margins III Posters from1:40 to 6:00 PM; Marine and Permafrost Gas Hydrate Systems IV Posters from 1:40 to 6:00 PM; and On the Role of Gas- or Hydrate-Containing Sediments in Deformation and Slope Stability Posters from 1:40 to 6:00 PM.

For more information, check out the AGU Fall Meeting website at http://fallmeeting.agu.org/2012/general-information/

Last year's meeting was attended by more than 20,000 people, who listened to more than 12,000 papers and viewed than 6,000 posters.

Iġnik Sikumi #1 2011 Well Log Data Available

Digital well log data are currently available from 2011 logging activities carried out at the Iġnik Sikumi #1 gas hydrate test well. The well was drilled and logged in the Prudhoe Bay unit on Alaska's North Slope during April, 2011, in preparation for production testing conducted in 2012. The 2011 drilling and logging operations were carried out under the direction of ConocoPhillips, Alaska, Inc. as part of a cooperative research agreement with the U.S. Department of Energy. For more information on the 2011 drilling and logging program , see Schoderbek and Boswell, FITI, 2011.

The prime data set from the Iġnik Sikumi #1 2011 testing includes: caliper, combinable magnetic resonance (CMR), hostile environment gamma ray sonde (HNGS), Schlumberger's Platform Express suite (PEX), Express Pressure Tool (XPT), and Modular Formation Dynamics Tester (MDT), an oil-based micro-imager (OBMI), and scanning tools (SSCAN and RT-SCAN).

The logs are available in both Graphics and LAS formats. We hope to be able to provide data from the 2012 testing operations in the near future.

Requests for well log data should be emailed to Karl Lang (karl.lang@contr.netl.doe.gov), with a cc to Ray Boswell (ray.boswell@netl.doe.gov). In our response to your request, we will ask that you provide some general information regarding your planned use of the data, so that we can help facilitate collaboration among researchers with related interests.

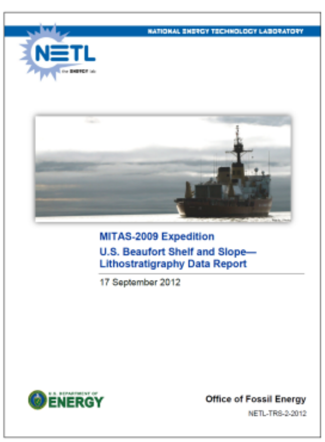
For more information on the Iġnik Sikumi #1 well, please visit:

http://www.netl.doe.gov/technologies/oil-gas/FutureSupply/MethaneHydrates/projects/DOEProjects/MH_06553HydrateProdTrial.html

MITAS - 2009 Expedition Reports and Data Available

In 2009, an international, multi-disciplinary science party aboard the U.S. Coast Guard icebreaker Polar Sea successfully completed a trans-U.S. Beaufort shelf expedition investigating the sources and volumes of methane across this region. The Methane in the Arctic Shelf/Slope (MITAS) expedition, led by researchers with the U.S. Naval Research Laboratory (NRL), the Royal Netherlands Institute for Sea Research (NIOZ), and DOE/NETL, included a shipboard science team of 33 scientists.

A full expedition summary, "Beaufort Sea Methane Hydrate Exploration: Energy and Climate Change," is available at http://www.dtic.mil/dtic/tr/fulltext/u2/a550138.pdf. This report is focused on geochemical results reported by NRL.


NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL

MITAS-2009 Expedition
U.S. Beaufort Shelf and Slope—
Lithostratigraphy Data Report

17 September 2012

U.S. DEPARTMENT OF ENERGY

Office of Fossil Energy

NETL-TRS-2-2012

NETL researchers led the expedition's initial core processing and lithostratigraphic evaluations, which are the focus of a report published in September "2012: MITAS-2009 Expedition U.S. Beaufort Shelf and Slope—Lithostratigraphy Data Report." The report is available online at http://www.netl.doe.gov/onsite_research/

The primary datasets discussed in this report can be found in their original file formats, at http://www.netl.doe.gov/onsite_research/. They can also be accessed via NETL's Energy Data eXchange (EDX) online system (https://edx.netl.doe.gov), using "MITAS" as a search term.

Spotlight on Research

YOSHIHIRO KONNO

Production Technology Team
Methane Hydrate Research Center
National Institute of Advanced Industrial Science and Technology (AIST)
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Dr. Yoshihiro Konno grew up in Okayama, Japan, in the southwestern part of Honshu Island. When he was young, his father, a biochemist, instilled in him a deep and lasting interest in natural science. Dr. Konno says that he knew, from his early childhood days, that he would become a scientist. In college, the young Konno studied natural science, and for his PhD he chose Geosystem Engineering at the University of Tokyo. It was there that he met Dr. Yoshihiro Masuda and became interested in methane hydrate research.

Dr. Masuda taught him about the methane hydrate present in the offshore regions surrounding Japan, and he explained that these deposits had huge potential as an energy resource. Dr. Masuda encouraged his student to join a research effort aimed at future development of this vast methane hydrate resource. As part of this effort, Dr. Konno became involved in the development of numerical models used to predict gas production from hydrates. This work resulted in a powerful simulation tool called MH21-HYDRES, which is used to analyze mechanisms of dissociation responsible for methane hydrate production.

In 2009, Dr. Konno moved to Sapporo and began his work at Japan's National Institute of Advanced Industrial Science and Technology. His work there is aimed at optimizing production strategies such that methane hydrate development can become commercially viable. He notes that, although depressurization has shown promise as a methane hydrate production method, it still needs to be enhanced to become a reality. Dr. Konno explains "my goal is to develop Enhanced Methane Hydrate Recovery that results in 10 times the production rate and twice the recovery ratio of current depressurization strategies."

Dr. Konno asserts that understanding the behavior of natural hydrate requires careful recovery of samples preserved under in situ conditions. Recent coring in the Eastern Nankai Trough, for example, will provide a critical piece of the puzzle. Along with JOGMEC/AIST colleagues, he is currently collaborating with scientists from the USGS and Georgia Tech to analyze samples taken there and preserved at near in situ pressures. These studies are critical, because the results will be used to inform strategies for methane hydrate production testing in the Eastern Nankai Trough this winter. Much of this work is achieved through international collaboration—which Dr. Konno believes is a key to successful methane hydrate research.

When he is not engaged in methane hydrate research, Dr. Konno enjoys tea with his wife. He visits tea shops whenever he travels abroad, so that he can bring a variety of tea blends home for tasting.