U.S. DEPARTMENT OF ENERGY

FY 2011 Methane Hydrate Program

Report to Congress
October 2012

United States Department of Energy
Washington, DC 20585

Message from the Secretary

Section 968 of the Energy Policy Act of 2005 requires the Department of Energy to submit to Congress an annual report on the results of methane hydrate research.

I am pleased to submit the enclosed report entitled *U.S. Department of Energy FY 2011 Methane Hydrate Program Report to Congress*. The report was prepared by the Department of Energy's Office of Fossil Energy and summarizes the progress being made in this important area of research. Pursuant to statutory requirements, this report is being provided to the following Members of Congress:

- **The Honorable Joseph R. Biden**
  President of the Senate

- **The Honorable John Boehner**
  Speaker of the House of Representatives

- **The Honorable Jeff Bingaman**
  Chairman, Senate Committee on Energy and Natural Resources

- **The Honorable Lisa Murkowski**
  Ranking Member, Senate Committee on Energy and Natural Resources

- **The Honorable Ralph M. Hall**
  Chairman, House Committee on Science and Technology

- **The Honorable Eddie Bernice Johnson**
  Ranking Member, House Committee on Science and Technology

- **The Honorable Fred Upton**
  Chairman, House Committee on Energy and Commerce

- **The Honorable Henry A. Waxman**
  Ranking Member, House Committee on Energy and Commerce

If you need additional information, please contact me or Mr. Jeff Lane, Assistant Secretary, Office of Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Steven Chu

The Secretary of Energy
Washington, D.C. 20585

October 5, 2012

The Honorable Joseph R. Biden
President of the Senate
Washington, DC 20515

Dear Mr. President:

Enclosed please find the report entitled *U.S. Department of Energy FY 2011 Methane Hydrate Program Report to Congress.* The report was prepared by the Department of Energy's Office of Fossil Energy and summarizes the progress being made in this important area of research.

The Methane Hydrate Research and Development Act of 2000, as amended by section 968 of the Energy Policy Act of 2005, requires the Department of Energy to submit to Congress an annual report on the results of actions to carry out the specified methane hydrate research. The enclosed report outlines key accomplishments of the DOE-led methane hydrate program during FY 2011.

If you need additional information, please contact me or Mr. Jeff Lane, Assistant Secretary, Office of Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Steven Chu

Enclosure

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The Secretary of Energy
Washington, D.C. 20585

October 5, 2012

The Honorable John Boehner
Speaker of the House of Representatives
Washington, DC 20515

Dear Mr. Speaker:

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If you need additional information, please contact me or Mr. Jeff Lane, Assistant Secretary, Office of Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Steven Chu

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Enclosure

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Executive Summary

This report describes actions taken in Fiscal Year (FY) 2011 to implement the Methane Hydrate Research and Development Act of 2000, as amended by the Energy Policy Act of 2005. The Energy Policy Act requires that the Secretary of Energy provide this report to Congress annually.

Since 2001, the Department of Energy's Methane Hydrate Research and Development (R&D) Program has pursued a range of science and technology development efforts designed to determine energy resource and environmental implications of the potentially vast occurrence of gas hydrate in nature. In a congressionally mandated report released in January 2010, the National Research Council concluded that the National Energy Technology Laboratory has been *consistent and effective in leading* a *high quality research portfolio that has enabled significant progress toward the Program's long term goals*. In 2011, the Massachusetts Institute of Technology Energy Initiative issued its report *The Future of Natural Gas*, and recommended that *[t]he U.S. government should continue to sponsor methane hydrate research, with a particular emphasis on the demonstration of production feasibility and economics*. Later in 2011, the National Petroleum Council, as part of its report *Prudent Development – Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, recommended that *the Department of Energy should lead in identifying, in some cases funding, and in other cases supporting public-private partnerships for research and development on energy and certain environmental issues of national interest. Examples where federal involvement is needed include science and pre-commercial technology relating to methane hydrates*. These comments reflect a broad consensus that the Program continues to conduct relevant research in an efficient and effective manner, thereby maintaining the U.S. position at the forefront of this important area of research.

The Program did not receive direct appropriation for gas hydrate research and development in FY 2011; nonetheless, we were successful in maintaining and advancing our major cooperative programs with industry, academia, and with international programs. In FY 2011, the Program's energy resource evaluation efforts remained focused on the Alaska North Slope and the Gulf of Mexico. With respect to research in Alaska, key accomplishments included the successful drilling, completion, and evaluation of a fully-instrumented scientific well in the western Prudhoe Bay Unit. This well was suspended in preparation for extended field scientific testing slated for FY 2012. In addition, plans for long-term depressurization tests have been developed and approved in concept by the Alaska North Slope operators, yet await resolution of legal and logistical issues related to access to the chosen field location. In the Gulf of Mexico, the program completed the evaluation of 2009 drilling data and have proceeded in the construction and testing of new coring and core analysis devices designed to support future deepwater gas hydrate field programs. The Program also maintained active international R&D collaborations with Japan, India, and Korea and continued its effort to report on results of work funded in prior years to better understand the potential role of gas hydrate with respect to ongoing climate change.

This report outlines key accomplishments of the DOE-led Methane Hydrate Program during FY 2011, and provides a bibliography of referenced papers, articles, and conference presentations that appeared during the year.

FY 2011 METHANE HYDRATE PROGRAM REPORT TO CONGRESS

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FY 2011 METHANE HYDRATE PROGRAM REPORT TO CONGRESS

I. Legislative Action

This report describes actions taken in Fiscal Year (FY) 2011 to implement the Methane Hydrate Research and Development Act of 2000, as amended by section 968 of the Energy Policy Act of 2005 (EPAct). The Energy Policy Act requires that the Secretary of Energy provide this report to Congress annually.

II. Summary of Accomplishments in FY 2011

During FY 2011, DOE's Methane Hydrate Program received no direct appropriation. Accomplishments discussed below are related to ongoing work enabled exclusively by prior year funding. The program was also successful in ensuring continuity of its Alaska gas hydrate field testing effort through development of a Field Work Proposal (FWP) to the Department of Energy's (DOE) Office of Science and expanded collaboration with partners in Alaska and Japan that ensured that planned FY 2012 field testing utilizing the scientific borehole established in FY 2011 could proceed, avoiding the premature abandonment of that well.

Gulf of Mexico Field Projects

Chevron-led Joint Industry Project

The Gulf of Mexico Joint Industry Project (JIP) is a cooperative research program between the DOE and an international consortium of industry partners under the leadership of Chevron. The overall objectives of the project are to understand the nature of gas hydrate occurrence in the deepwater Gulf of Mexico, to develop technology to detect, delineate, and characterize methane hydrate accumulations, and to assess the implications of naturally-occurring gas hydrate for drilling safety and future energy supply.

During 2011, the project team completed the evaluation of field data acquired during the FY 2009 exploration drilling program (JIP Leg II). JIP Leg II confirmed the existence of gas hydrate in sand reservoirs in the Gulf of Mexico, validated the prospecting approaches employed by the JIP science team, and provided an initial calibration of earlier FY 2008 Department of Interior Gulf of Mexico gas hydrate resource assessment. Thirteen detailed technical *Initial Results* reports were provided to the public in FY 2010 on the National Energy Technology Laboratory's (NETL) website; the reports were published (and made available via *ScienceDIrect*) as peer-reviewed reports in FY 2011 (see Appendix A for a list of these and all 2011 papers).

The success of the 2009 drilling program (in which resource-grade gas hydrates were found in four of seven wells drilled) spurred agreement between the JIP and the DOE to develop plans to conduct a follow-on expedition designed to collect and maintain sediment samples of gas-hydrate-bearing sands and associated sediments under *in situ* pressures and conduct specific wireline evaluation programs, including limited pressure testing in the newly-discovered reservoirs. Planning for this expedition continues to address uncertainty in deepwater regulatory environments and emerging industry deepwater drilling protocols in the aftermath of the 2010 *Deepwater Horizon* disaster. A major development in FY 2011 was the significant expansion in collaboration between the U.S. DOE/JIP effort and the Japanese national research and development (R&D) effort with respect to deepwater pressure coring technology development. This collaboration includes direct engagement in the design and testing of a potentially common suite of tools to be used both during 2012/2013 testing activities offshore Japan as well as in future U.S. drilling programs.

Mississippi Canyon 118 Seafloor Observatory

The University of Mississippi continues to lead a consortium working to establish and maintain a seafloor observatory for long-term monitoring of gas hydrate occurrences in Mississippi Canyon Block 118 in the Gulf of Mexico and their response to ongoing environmental changes. This project is conducted in conjunction with the National Oceanic and Atmospheric Administration and the Bureau of Ocean Energy Management and Resource Evaluation.

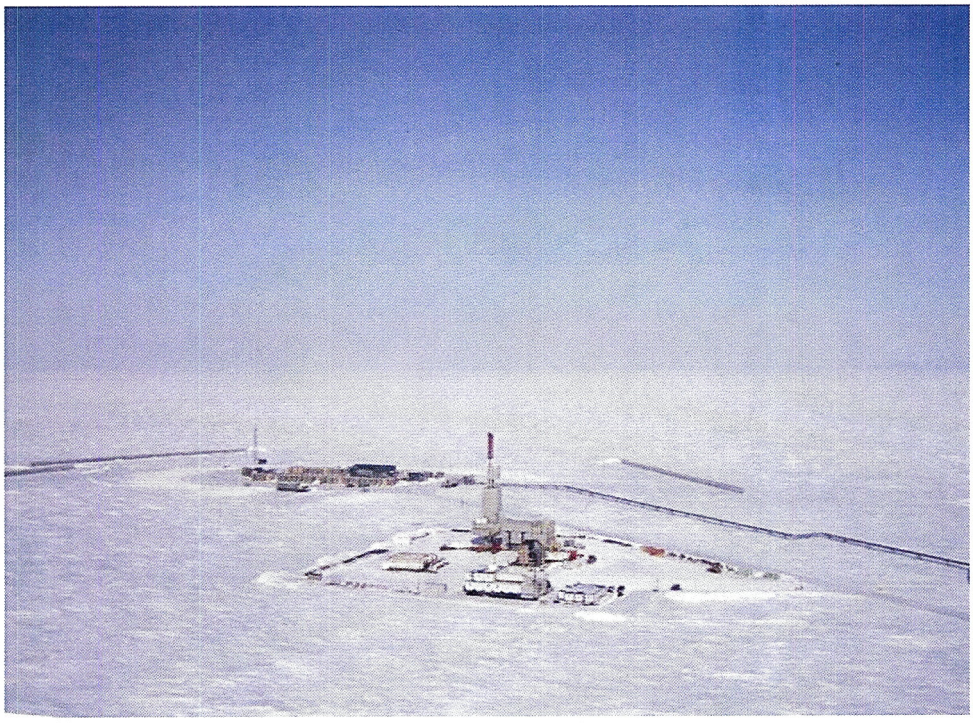
During FY 2011, DOE-funded activities continued to focus on design and deployment of instrumentation for collection of geophysical, geochemical, and biological data at the Mississippi Canyon 118 hydrate observatory site. Key accomplishments during the year included collection of jumbo piston cores, and the acquisition of four component ocean bottom seismometer data both of which aid in the characterization of the geology and hydrate occurrence at the site. Poster and oral presentations were made at national and international meetings and consortium research results were documented through scientific literature (See Appendix A).

Alaska North Slope Field Projects

CO_2-CH_4 Exchange Field Trial

NETL is continuing to work with ConocoPhillips Alaska to advance the science of chemical exchange in gas hydrate reservoirs for the purpose of simultaneous production of methane and permanent storage of carbon dioxide. In FY 2009, the ConocoPhillips project team identified the western part of the Prudhoe Bay Unit as the most appropriate field test site and in 2010 gained the necessary partner approvals to conduct testing within the existing oil and gas production and gathering infrastructure. As ConocoPhillips is not the operator in the Prudhoe Bay Unit, a new ice pad was built, necessitating that operations occur in two separate winter field seasons. The drilling, logging, and instrumentation of the borehole occurred during FY 2011, and downhole injection and production experiments are scheduled in FY 2012. See Figure 1.

Figure 1: Foreground: Nordic #3 Drill Rig at site of Iġnik Sikumi #1 well, Prudhoe Bay Unit (PBU), Alaska, in April 2011. The PBU L-pad is in the background (courtesy ConocoPhillips).

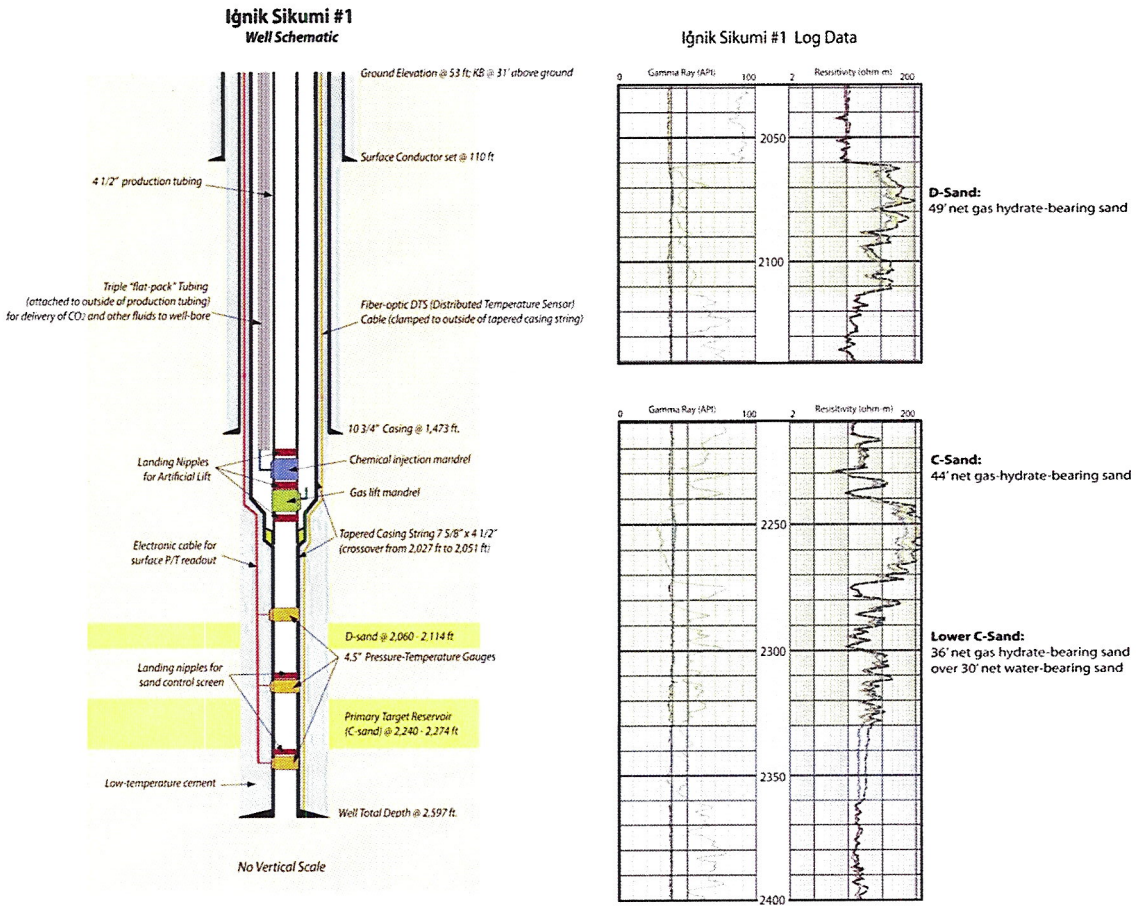


The field operations were conducted from April 5 to April 28, 2011. The surface hole was drilled using water-based mud and Logging While Drilling (LWD) measurements to a depth of 1,482 feet, where 10' ¾" surface casing was run, cemented, and pressure tested. LWD operations then continued using chilled oil based drilling fluid to minimize thermal disturbance of the permafrost and hydrate-bearing formations. The well was drilled to a total depth of 2,597 feet and a full suite of wire line well logs were then obtained (see Figure 2); followed by a series of short-duration wire line pressure tests utilizing Schlumberger's Express Pressure Tool (XPT) and Modular Formation Dynamics Tester (MDT) tools.

Upon conclusion of the data acquisition program, a well completion was installed consisting of a fully-instrumented tapered casing string that included multiple downhole temperature and pressure gauges and a continuous fiber-optic DTS (Distributed Temperature Sensor) cable (see Figure 2). All equipment was fully functional and monitored throughout cementing operations. The upper completion was then installed, which included a chemical injection mandrel and gas-lift mandrel. The well has been temporarily suspended, with the rig moving off location April 28, 2011. When the ice pad can be re-constructed in FY 2012, the well will be re-entered and the testing will take place.

Wire line data collected during the FY 2011 field program indicate that four gas-hydrate-bearing sand horizons were encountered at the site, as expected. The primary test target, the Sagavanirktok "Upper "C" sandstone (2214 to 2274 ft below the rig floor), was confirmed to contain 44 ft of clean, high-porosity sandstone with very high gas hydrate saturations and to be within the optimal pressure-temperature conditions to conduct the planned field trial. The XPT successfully obtained data at 16 locations to provide insight into the ambient reservoir pressure and potential injectivity of various stratigraphic units, while the MDT tool was used primarily to conduct "mini-frac" tests, designed to measure breakdown pressures, the pressure at which fluids may be injected before the formation will fail via extensional fracturing. The DTS cable recorded the temperature perturbances related to drilling and completion, and has subsequently been recording the temperature re-equilibration to ambient conditions, providing valuable information on the thermal properties of the reservoirs.

Figure 2: Left: Schematic of the well completion for the Iġnik Sikumi #1 well; Right: Summary of key log data acquired during the FY 2011 field program (from Schoderbek and Boswell, 2011).



Throughout FY 2011, it remained uncertain as to whether the testing portion of the planned program would be conducted. While industry remained unable to justify significant expenditure

on the testing portion of this R&D program and inability to support long-term liabilities related to indefinite suspension, there was concern that the well would need to be cemented and abandoned. To avoid abandonment of the test, NETL worked with ConocoPhillips to engage international partners, ultimately securing the participation (including $7 million in funding) of the Japan Oil Gas and Metals National Corporation (JOGMEC) as a direct project cost share partner to ConocoPhillips. JOGMEC required, as a condition of their participation, ongoing U.S. federal involvement, which was made possible with DOE's Office of Science's acceptance of a FWP from NETL.

Extended-duration Depressurization Testing Program

The main goals of this project, conducted in partnership with BP Exploration-Alaska (BPXA), are to characterize the nature and commercial implications of methane hydrate resources on the Alaska North Slope through the ultimate conduct of an extended-duration depressurization test. This project is designed to provide critical information with which to estimate the potential productivity and environmental impacts associated with this most-promising gas hydrate production technology. Progression toward this test has been hindered due both to lack of funding as well as ongoing EPA-imposed debarment of BPXA's Prudhoe Bay element due to pipeline failures and resultant spills in 2006. DOE continues to work with BPXA, other partners in the Prudhoe Bay Unit, and our international collaborators to develop a feasible project structure and rigorous scientific design for the testing program.

Gas Hydrate Exploration Technologies

In addition to the work ongoing within the major field programs to advance the geophysical evaluation of gas hydrates using existing datasets (see Appendix A for key 2011 publications), a number of projects in partnership with universities are nearing completion. These include:

- Baylor University, in 2011, completed reconfiguration of a direct current resistivity array and performed shallow water testing of the system in preparation for performance of a high resolution 3-D resistivity scan of the MC118 seafloor observatory in the summer of 2012.
- Scripps Institution of Oceanography at the University of California San Diego completed experimental efforts of hydrate bearing soil conductivity and continued dissemination of project results through journal articles and presentations at scientific/technical meetings, including the 7th International Conference on Gas Hydrates.
- Researchers at Oregon State University completed their project investigating the relationship of residual heat flow anomalies to fluid flow and gas hydrate distribution in the subsurface and submitted a final project scientific report.

Global Environmental and Climate Studies

DOE continues to support a range of studies designed to determine the sources, sinks, and fluxes of methane in arctic and marine gas-hydrate-bearing environments. The portfolio of projects are

now concluding, including field work in a range of geologic settings, as well as lab based analyses and initial attempts to incorporate gas hydrate into global climate and environmental process models. The portfolio of projects includes:

- In FY 2011, researchers at Lawrence Berkeley and Los Alamos National Laboratories scaled up basin and regional scale models to simulate hydrate dissociation and methane release on a global scale. Preliminary results were presented at the 7th International Conference on Gas Hydrates and at the 2011 Arctic Technology Conference.
- The University of Texas A&M – Corpus Christi, in conjunction with Florida State University and Scripps Institution of Oceanography, completed project efforts evaluating new satellite based techniques for assessing methane flux from oceanic environments with project results reported in numerous publications, including a manuscript in the Journal of Geophysical Research. A final report detailing the results of the project will be provided to DOE in 2012.
- The University of Chicago and the University of California – Berkeley completed development of a 2-D basin scale model to assess the sensitivity of the hydrate inventory to various parameters and the vulnerability of hydrates to potential climatic warming. Project results are expected to be disseminated through Journal articles and a DOE final project report in 2012.
- Researchers at the University of Delaware completed megagenomic analyses of sediment core samples collected in the Beaufort Sea in 2009. These analyses were used to provide insight into the biological communities responsible for methane oxidation in shallow Arctic waters.
- The University of Alaska – Fairbanks, in partnership with the U.S. Geological Survey (USGS), completed field studies of methane ebullition in Arctic lakes, including geophysical profiling of lakes, sampling of lake sediments and water chemistry, and detailed data analysis and integration. Project results, disseminated through multiple journal articles, are adding scientific insight into the role of permafrost thawing and methane release during past climate change events.
- The USGS, under an interagency agreement with DOE, continued efforts to better define the changing permafrost boundary in the shallow shelf of the Beaufort Sea.
- The University of California – Santa Barbara (UCSB) has completed field studies in the Santa Barbara and Santa Monica basins to evaluate the interactions of basin currents and water column methane oxidation. Final results, expected in 2012, will help to frame methane's role in atmospheric accumulation of greenhouse gases and climate change. UCSB researchers under the project also participated in a broad scientific assessment of the environmental impacts resulting from the Macondo/Deepwater Horizon oil spill in the Gulf of Mexico in 2010. UCSB findings, published widely in FY 2011 and incorporated into a National Academy of Science volume, suggest that microbiological communities were successful at consuming essentially all of the methane and other hydrocarbons in the water column prior to escaping to the atmosphere.

Fundamental Experimental and Modeling Studies

In prior years, the program has supported a number of experimental and modeling efforts within the DOE National Laboratory system, universities, and other federal agencies. Limited efforts continued during FY 2011, and release of results from prior year efforts occurred. Publications and presentations in FY 2011 resulting from these efforts are contained in Appendix A and include:

- Research conducted directly at NETL in FY 2011 focused on the development of fundamental relationships and viable numerical simulation codes related to CO_2-CH_4-N_2 interactions in natural systems.
- Efforts at the Georgia Institute of Technology focused on experiments to identify, understand, and model processes involved in methane production from hydrate-bearing sediments to contribute to new insight into: hydrate formation and growth, hydrate-mineral bonding, and gas production by chemo-driven methods with emphasis on the fundamental understanding of CO_2-CH_4 exchange. Project results were highlighted through multiple journal articles during FY 2011.
- The University of Texas at Austin, in collaboration with the Massachusetts Institute of Technology, completed project efforts modeling interactions of gas, water, and hydrate in sediments. Project results are expected to aid in improvement of existing reservoir models and thus prediction of in-place hydrate accumulations and saturations.
- Efforts under an interagency agreement between DOE and the USGS continue to provide multi-disciplinary scientific support to the Methane Hydrate Research Program, including progress towards development of a novel fingerprinting method to identify methane gas originating from hydrates and leadership in an inter-lab comparison of key geomechanical attributes of lab synthesized samples of methane hydrates bearing sediments.
- Modelers at Lawrence Berkeley National Laboratory continued performing, and publishing, simulations aimed at better understanding the production potential and geomechanical impacts of production from various classes of hydrate in marine and arctic settings from around the globe, including simulations of potential long term hydrate production test scenarios.
- Pacific Northwest National Laboratory researchers continued code development and computer simulations with their STOMP model focused on CO_2/CH_4 exchange in hydrates as a part of collaborative research with the Korean National Hydrate Program.
- Lawrence Berkeley National Laboratory continued investigating and publishing on the mechanical and geophysical properties of hydrate-bearing sands, the capillary controls of hydrate formation in North Slope sediments, and the effects of hydrate saturation.

International Collaboration

DOE maintained active engagement and discussion with the world's leading international gas hydrate R&D programs in FY 2011. Formal departmental-level agreements continued with government entities in Japan, Korea, and India. Entities from each of these countries are

participants in the DOE's Gulf of Mexico JIP lead by Chevron, and continue to demonstrate strong interest in future Alaska North Slope extended duration field tests. A U.S.-Korea workshop to report the findings of prior year collaborative programs occurred in Daejeon, Korea, in early 2011. In addition to these Departmental-level agreements, NETL maintains active collaborations with gas hydrate efforts in New Zealand, China, Canada, and Taiwan.

NETL is also supporting an ongoing global assessment of gas hydrate science and technology issues being conducted by the United Nations Environmental Program which is scheduled to release its report in the summer of 2012. The steering committee includes representatives from NETL and the USGS, as well as from Canada, Japan, Korea, India, Germany, and Norway.

Fellowship Programs

DOE was unable to award an NETL-NAS National Methane Hydrate R&D Program Fellowship in FY 2011. Six fellowships have been awarded since the fellowship program was initiated in 2007. A seventh fellow is expected to be selected early in FY 2012 to Dr. Laura Brothers. Dr. Brothers, who received her Ph.D. in Earth Sciences from the University of Maine in 2010, will work with the USGS to conduct geophysical studies. She was previously stationed at the USGS Woods Hole Sciences Center, where her work included research on permafrost degradation and potential hydrate dissociation in nearshore Beaufort Sea.

Program Management and Oversight

Throughout FY 2011, DOE/NETL continued to monitor a broad portfolio of R&D projects, as specified by EPAct. The effectiveness of this management was positively reviewed in a report released by the National Academies in January 2010. However, no meetings of the Federal Advisory Committee were held during FY 2011. DOE/NETL continued to engage its interagency partners, however, through regular meetings of the Interagency Technical Coordination Team.

In a 2011 review of "*The Future of Natural Gas*," the MIT Energy Initiative reviewed the state of gas hydrate R&D and remarked "methane hydrate represents a vast potential resource for the long term," and "DOE... has partnered with other government agencies, academe, and industry in field, modeling, and laboratory programs that have produced numerous successes." The MIT report included the following summary recommendation: "Continue methane hydrates research program to develop methods for remote detection of highly concentrated deposits; conduct formal resource assessments; and prove the resource potential through long-term production testing" (MITEI, 2011).

Also in FY 2011, the National Petroleum Council released its study "*Prudent Development – Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*" and remarked "substantial methane hydrate resources have also been identified,

particularly in the Gulf of Mexico and portions of the Arctic. These could be available for development in the long term, beginning in 2030–2050 period, leading to production of 1–10 trillion cubic feet per year by 2050, and with the potential for sustained growth over the remainder of the century" (NPC, 2011).

Technology Transfer

DOE and its research partners continued to disseminate research results to the scientific community during FY 2011. Appendix A provides a list of 85 peer-reviewed publications, 116 grey literature and government publications, and 65 professional conference presentations during the fiscal year that resulted, in whole or in part, from DOE supported projects. In particular, 13 peer-reviewed articles detailing the Scientific Results of the 2009 DOE/Gulf of Mexico JIP Leg II drilling program were released on-line in FY2011 in advance of compilation into a *Special Issue of Marine and Petroleum Geology (Elsevier)* that will be published in hard copy form in 2012. A similar special volume on the 2007 DOE/BPXA Mt Elbert (Alaska) field test program was published in February 2011 (Boswell et al., eds., 2011). The DOE/NETL Methane Hydrate Newsletter, *Fire in the Ice*, continued to report on global developments in gas hydrate R&D in FY 2011. This periodic publication is distributed to 1,500 subscribers in more than 40 countries.

Information on the DOE Methane Hydrate Program, including detailed summaries of all active and completed projects and reports and publications resulting from DOE-funded investigations, are available at www.netl.doe.gov. Additional information, such as program reports and activities of the Methane Hydrate Advisory Committee, is available at www.fe.doe.gov.

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III. Conclusion

This report describes the accomplishments of the DOE-lead Methane Hydrate R&D Program in FY 2011. DOE effectively managed ongoing work funded in prior years to further advance science and technology development activities designed to determine the resource potential and environmental implications of gas hydrate.

Work in 2011 was highlighted by the successful drilling, logging, and completion of a fully-instrumented scientific well-bore within the Prudhoe Bay infrastructure area of the Alaska North Slope. In addition, the Department's efforts to maintain and expand industry and international collaborations was successful in assuring that the field testing portion of the Program could be conducted in FY 2012, avoiding the premature abandonment of the test well. This well will be a critical milestone in advancing the scientific understanding of gas hydrate reservoir response to alternative gas hydrate production strategies and provide vital information to the future planning of extended-duration production tests.

In the Gulf of Mexico, evaluation of the data acquired in the Program's landmark 2009 exploration was completed and reported to the public, and expanding international collaboration continues to advance the preparations for further future marine resource sampling and characterization. The Program also continued its effort to work with academia, DOE national laboratories and other federal agencies to better understand the potential response of gas hydrate to ongoing climate change. Finally, the Program maintained active international R&D collaborations with Japan, India, and Korea throughout FY 2011.

Appendix A: FY 2011 Publications and Reports

Peer-Reviewed Publications

Anderson, B., Hancock, S., Wilson, S., Enger, C., Collett, T., Boswell, R., Hunter, R., 2011. Formation pressure testing at the Mount Elbert Gas Hydrate Stratigraphic Test Well, Alaska North Slope: Operational summary, history matching, and interpretations. *J. Mar. Pet. Geo.,* 28(2), p. 478-492.

Anderson, B., Kurihara, M., Wilson, S., Pooladi-Darvish, M., White, M., Moridis, G., Gaddipati, M., Masuda, Y., Collett, T., Hunter, R., Narita, H., Rose, K., Boswell, R., 2011. Regional long-term production modeling from a single well test, Mount Elbert Gas Hydrate Stratigraphic Test Well, Alaska North Slope. *J. Mar. Pet. Geo.,* 28(2), p. 493-501.

Bhatnagar G., Chatterjee, S., Chapman, W., Dugan, B., Dickens, G, Hirasaki, G., 2011. Analytical theory relating the depth of the sulfate-methane transition to gas hydrates distribution and saturation. *Geochemistry, Geophysics, Geosystems,* 12.

Boswell, R., Rose, K., Collett, T., Lee, M., Winters, W., Lewis, K., Agena, W., 2011. Geologic controls on gas hydrate occurrence in the Mount Elbert prospect, Alaska North Slope, *J. Mar. Pet. Geo.,* 28(2), p. 589-607.

Boswell, R., Collett, T., Frye, M., Shedd, B., McConnell, D., Shelander, D., 2011. Subsurface gas hydrates in the northern Gulf of Mexico. *J. Mar. Pet. Geol.,* 27 pp.

Boswell, R., Frye, M., Shelander, D., Shedd, B., McConnell, D., Cook, A., 2011. Architecture of gas hydrate-bearing sand reservoirs from Walker Ridge 313, Green Canyon 955, and Alaminos Canyon 21: Northern Gulf of Mexico. *J. Mar. Pet. Geol.,* 16 pp.

Boswell, R., 2011. Gas Hydrates: Research Status and Potential Source of Future Energy Supply for the United States: Topical Paper #1-11: NPC 2011 natural gas report. *National Petroleum Council.* Washington, D.C., 24 pp.

Boswell, R., Collett, T., 2011. Current perspectives on gas hydrate resources. *Energy and Environmental Science,* 4, 6 pp.

Briggs, B., Pohlman, J., Torres, M., Riedel, M., Brodie, E., Colwell, F., 2011. Macroscopic Biofilms in Fracture-Dominated Sediment that Anaerobically Oxidize Methane. *Applied and Environmental Microbiology*, 77, 7 pp.

Brunner, C., Ingram, W., Meyers, S., Lutken, C., 2011. Sedimentation at the Woolsey gas-vent complex in the northern Gulf of Mexico. *J. Miss. Acad. Sci.*, 56(1), p. 69.

Chatterjee S., Dickens, G., Bhatnagar, G., Chapman, W., Dugan, B., Snyder, G., Hirasaki, G., 2011. Pore water sulfate, alkalinity and carbon isotope profiles in shallow sediment above marine gas hydrate systems: A numerical modeling perspective. *J. Geophys. Res. - Solid Earth*, 116.

Choi, J., Seol, Y., Boswell, R., Juanes, R., 2011. X-ray computed-tomography imaging of gas migration in water-saturated sediments: From capillary invasion to conduit opening. *Geophys. Res. Lett.,* 38, 5 pp.

Collett, T., Lee, M., Agena, W., Miller, J., Lewis, K., Zyrianova, M., Boswell, R., Inks, T., 2011. Permafrost-associated natural gas hydrate occurrences on the Alaska North Slope. *J. Mar. Pet. Geo.,* 28(2), p. 279-294.

Collett, T., Lewis, R., Winters, W., Lee, M., Rose, R., Boswell, R., 2011. Downhole well log and core montages from the Mount Elbert Gas Hydrate Stratigraphic Test Well, Alaska North Slope. *J. Mar. Pet. Geo.,* 28(2), p. 561-577.

Colwell, F., Briggs, B., Schwartz, A., 2011. Microbial community distribution in sediments from the Mount Elbert Gas Hydrate Stratigraphic Test Well, Alaska North Slope. *J. Mar. Pet. Geo.,* 28(2), p. 404-410.

Dai, S., Lee, C., Santamarina, A., 2011. Formation history and physical properties of sediments from the Mount Elbert Gas Hydrate Stratigraphic Test Well, Alaska North Slope. *J. Mar. Pet. Geo.,* 28(2), p. 427-438.

Daigle, H., Dugan, B., 2011. Capillary controls on methane hydrate distribution and fracturing in advective systems. *Geochemistry, Geophysics, Geosystems,* 12.

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