U.S. DEPARTMENT OF ENERGY

Fiscal Year 2013 Methane Hydrate Program

Report to Congress
October 2014

United States Department of Energy
Washington, DC 20585

Message from the Secretary

The Department of Energy is required[1] to submit to Congress an annual report on the actions taken to carry out methane hydrate research.

I am pleased to submit the enclosed Report to Congress, *Fiscal Year 2013 Methane Hydrate Program*. 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.

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 Mary L. Landrieu**
  Chair, Senate Committee on Energy and Natural Resources
- **The Honorable Lisa Murkowski**
  Ranking Member, Senate Committee on Energy and Natural Resources
- **The Honorable Lamar Smith**
  Chairman, House Committee on Science, Space and Technology
- **The Honorable Eddie Bernice Johnson**
  Ranking Member, House Committee on Science, Space 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
- **The Honorable Barbara Mikulski**
  Chairwoman, Senate Committee on Appropriations
- **The Honorable Richard C. Shelby**
  Ranking Member, Senate Committee on Appropriations
- **The Honorable Harold Rogers**
  Chairman, House Committee on Appropriations
- **The Honorable Nita M. Lowey**
  Ranking Member, House Committee on Appropriations

[1] Section 968 of the Energy Policy Act of 2005

- **The Honorable Dianne Feinstein**
  Chairman, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Lamar Alexander**
  Ranking Member, Subcommittee on Energy and Water Development
  Senate Committee on Appropriations
- **The Honorable Mike Simpson**
  Chairman, Subcommittee on Energy and Water Development
  House Committee on Appropriations
- **The Honorable Marcy Kaptur**
  Ranking Member, Subcommittee on Energy and Water Development
  House Committee on Appropriations

If you need additional information, please contact me or Mr. Brad Crowell, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Ernest J. Moniz

Executive Summary

This report describes actions taken in Fiscal Year (FY) 2013 to implement the Interagency R&D Program in Methane Hydrates (the Program)[2]. The Energy Policy Act of 2005 stipulated that the Secretary of Energy provide this report to Congress annually. This report outlines key accomplishments of the Program during FY 2013 and provides a bibliography of peer-reviewed papers, articles, and conference presentations that appeared during the year.

The Program is managed within the Department of Energy (DOE) by the Office of Oil and Natural Gas and conducted through the National Energy Technology Laboratory (NETL). The fundamental goals and nature of the program remain as in prior years – conduct collaborative R&D to deliver the science and technology necessary to understand this energy resource and environmental implications of naturally-occurring methane hydrate.

A highlight for FY 2013 was the signing of a Memorandum of Understanding (MOU) between DOE's Office of Fossil Energy and the Alaska Department of Natural Resources. This MOU was motivated by the shared desire of the two organizations to further facilitate field-based gas hydrate R&D on the Alaska North Slope. Also in FY 2013, the DOE collaborated with two agencies of the Department of Interior (U.S. Geological Survey (USGS) and Bureau of Ocean Energy Management (BOEM)) to advance deepwater gas hydrate exploration and characterization through the acquisition of advanced geophysical data at gas-hydrate-bearing sites. These sites were discovered by the Program in prior collaborative exploration programs with industry. The Program also maintained active international R&D collaborations throughout FY 2013 highlighted by the continuing collaboration with Japan on the development and testing of marine gas hydrate sampling and analysis devices.

In FY 2013, the Program received $5 million (prior to general rescission) in direct appropriations. With this funding, the Program continued its cooperative efforts with industry, academic, National Laboratory, and international partners. The Program was able to expand its R&D portfolio through the award of three new cooperative R&D agreements in the area of resource characterization/production potential, and four new agreements related to gas hydrates' potential response to changing natural environments. The goal is to understand the methane hydrate resource potential and the role methane hydrates may play in the global cycling of carbon, and more specifically, the response of the natural environment to warming climates. These projects were integrated into an existing portfolio of 16 projects selected in prior fiscal years.

Going forward, the highest priorities for the program will be to develop additional opportunities for field-based projects to assess gas hydrate issues within the U.S., including both 1) an extended-duration test of reservoir response to depressurization (to be conducted in Alaska), and

[2] Authorized by the Methane Hydrate Research and Development Act of 2000 as amended by the Energy Policy Act of 2005 (EPAct)

2) multi-site drilling and/or coring programs to confirm marine resource occurrence (to be conducted on the U.S. Outer Continental Shelf). The Program will continue to evaluate options for conducting such field programs given future budget expectations and current conditions within the industry.

FISCAL YEAR 2013 METHANE HYDRATE PROGRAM

Table of Contents

I. Legislative Action

This report describes actions taken in Fiscal Year (FY) 2013 to implement the Methane Hydrate Research and Development Act of 2000, as amended by Section 968 of the Energy Policy Act of 2005 (EPAct). EPAct requires that the Secretary of Energy provide this report to Congress annually.

II. Summary of Accomplishments in FY 2013

In FY 2013, The Methane Hydrates Program (Program) continued to progress efforts toward conducting field-based evaluation of gas hydrate phenomena. Of particular note, DOE and the State of Alaska Department of Natural Resources signed a MOU designed to further advance opportunities for gas hydrate field-based research on the Alaska North Slope. The year was also marked by three key accomplishments:

1. Field testing of the program's pressured core evaluation technologies (in association with the Chevron-led Joint Industry Project) via collaborations with Japan and the USGS;
2. Selection and award of seven new projects, including three field-based efforts that will gather field data to assess gas hydrate response to environmental change; and
3. An interagency effort to collect advanced seismic data over known gas hydrate occurrences in the Gulf of Mexico.

The following sections describe the key technical accomplishments for the program on a project-by-project basis during FY 2013, organized by research topic area.

Gas Hydrate Characterization and Exploration Technologies

The Gulf of Mexico Gas Hydrates Joint Industry Project (JIP) is a cooperative research program between the DOE (in coordination with the USGS and BOEM) and an international consortium of industry partners under the leadership of Chevron. The objectives of the project are to understand the nature of gas hydrate occurrence in the deepwater Gulf of Mexico; assess its potential risks to deepwater drilling; develop technologies to improve the detection, delineation, and characterization of marine gas hydrate; and develop tools for deepwater gas hydrate sample acquisition and analysis.

The JIP has provided the U.S. national Methane Hydrate Program with the means to stage major deepwater field expeditions guided by broad participation from numerous U.S. federal agencies, private companies, and academic institutions.

The 2005 "Leg I" expedition and associated studies (full peer-reviewed scientific results volume published in FY 2009) resolved the issue of drilling safely through the most typical gas-hydrate

bearing sediments as readily managed with standard protocols. The 2009 "Leg II" expedition (with full peer-reviewed scientific results volume published in FY 2012) conducted drilling and logging programs that discovered resource-grade gas hydrates at two separate sites and provided initial confirmation of the BOEM's 2008 gas hydrate resource assessment that attributed more than 6,000 Tcf of potentially-recoverable gas hydrate in the Gulf of Mexico.

In 2012, the JIP, reflecting a growing tendency to reduce risk through the strict restriction of core businesses, announced that they would be unable to facilitate further marine exploration programs in cooperation with the DOE. Therefore, ongoing effort within the DOE-Chevron cooperative agreement is focused on completing tool development activities; in particular the design, build, and testing of deepwater pressure-coring tools and compatible pressure-core analyses devices.

***Figure 1**: In January, 2013, scientists from AIST, JOGMEC, Georgia Tech, and the USGS collaborated in the analysis of pressure cores of gas hydrate-bearing sand reservoirs collected offshore southeastern Japan using tools developed under the DOE Gulf of Mexico JIP. Photo courtesy USGS.*

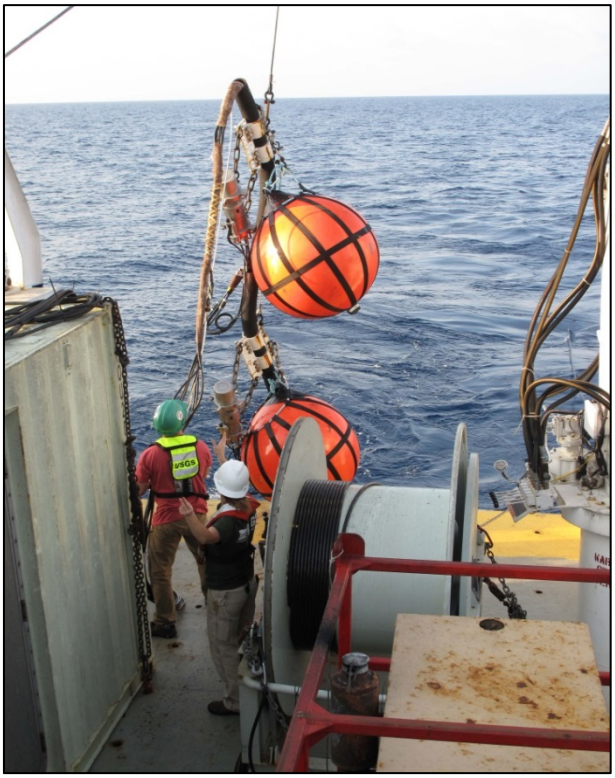
In the second quarter of FY 2013, field tests of the project-developed Instrumented Pressure Testing Chamber (IPTC) and Pressure Core Characterization Tools (PCCT) core analysis systems were conducted in Sapporo, Japan in collaboration with National Institute of Advanced Industrial Science and Technology (Japan), Japan Oil, Gas and Metals National Corporation (JOGMEC) (Japan), the USGS, and Georgia Tech. A team of international researchers used the instruments to manipulate and analyze methane hydrate pressure cores that were recovered by JOGMEC

during a research expedition to the Nankai trough area off the Japanese coast in July 2012. Construction of the Hybrid Pressure Coring System was completed in late summer 2013, utilizing a list of tool improvements developed through collaborations with Japan and the USGS, with land-based testing planned for the first quarter of FY 2014.

As part of the FY 2012 funding opportunity announcement, the program developed several new projects initiated in FY 2013 that are addressing the issue of gas hydrate exploration through seismic data interpretation. Two projects (with Oklahoma State University and Fugro GeoConsulting) are using log data acquired during the DOE-JIP 2009 expedition to:

1. Further the calibration of gas hydrate saturation estimation from seismic data;
2. Enhance the ability to determine the fine-scale occurrence and variation in concentration of gas hydrates; and
3. Improve the ability to delineate areas of potential free gas that may be masked by association with overlying gas hydrates.

In addition, a new experimental effort with the Colorado School of Mines is pursuing additional experimental data to elucidate the controls of gas hydrate habit and saturation on acoustic wave velocities. A fourth project, with the Ohio State University, is enabling a comprehensive evaluation of potential gas hydrate occurrence in more than 1,700 industry well logs from the deepwater Gulf of Mexico. These projects are scheduled for completion in FY 2014-15.



In FY 2013, DOE collaborated with BOEM and USGS to fund and plan an interagency field program (conducted by the USGS) to gather high-resolution 2-D reflection seismic - as well as ocean-bottom seismic (OBS) - over the gas hydrate deposits that had been discovered during the 2009 DOE-Chevron JIP drilling. This data acquisition represented the first acquisition of OBS data over known, high-concentration gas hydrates, and also the first to have available full, research-level logging data to enable seismic data calibration. The field program gathered high-quality data over both sites and that data are undergoing final processing. The data are expected to be very valuable for future efforts at those sites, including potential pressure-coring programs.

***Figure 2**: US Geological Survey technicians deploy instruments at the start of a seismic survey to characterize gas hydrate distribution at confirmed high-grade gas hydrate occurrences in the deepwater Gulf of Mexico (April-May 2013). Photo Courtesy USGS.*

New marine characterization projects added to the program portfolio late in FY 2013 include an effort with Georgia Tech to develop new tools for the in situ measurement of the geomechanical properties of gas hydrate-bearing sediments. Such data cannot be gathered from standard cores or from well logging devices, and likely highly impacted by pressure coring. A second project with UT-Austin, Ohio State, and Columbia U., is utilizing data obtained in the 2009 Gulf of Mexico drilling program to determine the nature of gas sourcing to resource-grade gas hydrates, including the potential for widespread contribution from deeper thermogenic gas sources. Current BOEM and other assessments generally rely solely on biogenic sources when estimating a region's gas hydrate potential.

Gas Hydrate Production Technologies

Since 2001, DOE has maintained a cooperative agreement with BP Exploration-Alaska with the goal of characterizing the nature and commercial implications of methane hydrate resources on the Alaska North Slope through the conduct of an extended-duration field production test based on the concept of reservoir depressurization. This project, which completed a major field program (the "Mt. Elbert" test well) in FY 2007 (with a full, peer-reviewed, scientific results volume published in FY 2011), has not received DOE funding since FY 2009, yet remained active through FY 2013 as both parties continue to explore options for cooperative research. This effort has been hindered due to a number of legal and operational factors.

In FY 2013, in an attempt to catalyze R&D opportunities in Alaska, the DOE and Alaska's Department of Natural Resources (ADNR) signed an MOU confirming the need and interest in gas hydrate field-based testing. ADNR subsequently set-aside a large area of unleased land adjacent to the Prudhoe Bay Unit (PBU) to provide an opportunity to assess their value to gas hydrate R&D. DOE anticipated soliciting private interest in evaluating hydrate occurrence on these lands in FY 2014. This is an important step for the Program towards developing additional opportunities for field-based projects to assess gas hydrate issues and could lead to an extended-duration test of reservoir response to depressurization in Alaska.

Figure 3: *Acting ASFE Christopher Smith and Alaska Department of Natural Resources Commissioner Dan Sullivan sign an MOU at the LNG 17 Global Conference in Houston, Texas (April, 2013). Among other topics, the MOU commits the organizations to work together to accelerate gas hydrate R&D in Alaska. Photo courtesy of LNG 17*

In FY 2012, DOE, in partnership with ConocoPhillips-Alaska and JOGMEC, conducted a field trial (in the PBU on the Alaska North Slope) of gas hydrate response to injection of CO_2+N_2 mixed gas. In FY 2013, ConocoPhillips delivered the full field datasets and final project technical report. These data have been transferred to and discussed with various research groups worldwide (U.S., Canada, Germany, and Norway) and have been made available for download from DOE websites. Through FY 2013 and going forward, these data are being examined to interpret the nature of the various processes that occurred during the conduct of the test. Initial project findings will be delivered at key conferences in FY 2014.

Gas Hydrate Environmental and Global Climate Studies

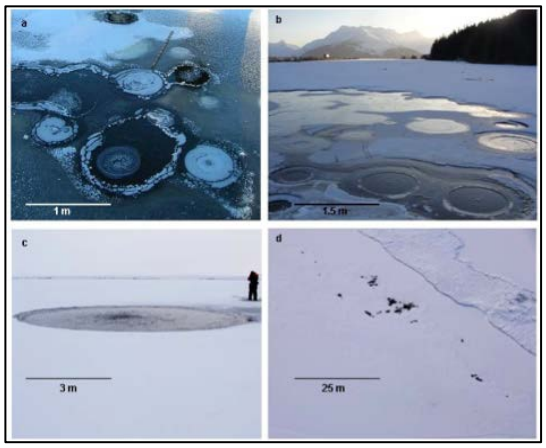
DOE continues to support a range of studies designed to determine the sources, sinks, and fluxes of methane in gas-hydrate-bearing environments. The goal is to understand what role gas hydrate plays in natural geohazards, in the global cycling of carbon over long time frames, and in the potential nearer-term feedbacks in response to warming climates. This program reflects DOEs continuing effort to be responsive to the intent of the original Methane Hydrate Research and Development Act, which directs the DOE to work with our interagency partners to enable research across a broad range of gas hydrate issues, including the impacts of natural degassing from hydrates.

In addition, DOE considers the effort fundamental to developing a sound understanding of the nature of gas hydrates, which could facilitate the eventual public acceptance of its utilization as an energy supply. The current DOE portfolio is focused on a mix of numerical modeling and field data collection efforts designed to (1) inform predictive models with accurate characterizations of gas hydrate occurrence in climate sensitive settings; (2) record evidence of gas hydrate formation and dissociation and link those phenomena to ongoing environmental change; and (3) determine the flux and fate of methane between sediments, the oceans, and the atmosphere.

In FY 2013, DOE added four new projects relevant to global environmental implications of gas hydrates (See Appendix A). Three of these new projects are field-based and leverage large external investments. Oregon State University will participate in a major European study in the Northern Atlantic designed to investigate gas hydrate system dynamics in response to recent changes in bottom-water temperature at the uppermost feather-edge of the deepwater gas hydrate stability zone. MIT, the University of New Hampshire, and the USGS will review existing datasets gathered by the National Oceanic and Atmospheric Administration to investigate similar phenomena along the western Atlantic Margins (off the U.S. east coast) and conduct support experimental studies to determine the potential for deepwater methane releases to reach the atmosphere. On the Pacific Margin, the University of Washington is utilizing data and field opportunities related to ongoing monitoring of tectonics to study gas hydrates dynamics in response to changing climates.

Several prior-year research efforts in this topic area continued throughout FY 2013. Oregon State University is adapting a kinetic transport-reaction model designed to simulate the biogeochemical processes occurring in the sediment column and estimate net seafloor fluxes of

solutes. The model was applied to quantify carbon cycling in present and past systems, using data collected during several DOE-supported drilling expeditions including the Ulleung Basin in South Korea, the Cascadia margin in the U.S., and several sites drilled offshore India on the Bay of Bengal and Andaman Sea.



One prior-year, gas hydrate-environmental project was completed in FY 2013. This project, with the University of Alaska-Fairbanks (UAF), utilized biogeochemical analyses of sediment cores, core pore fluids and lake water to help characterize methane sources and sinks associated with thermokarst lakes on the Alaska North Slope. A first-order estimate of 1.5 Tg/year (teragram or one trillion grams per year) of methane emissions from such seeps was derived; resulting in an increase of 50 to 70 percent over previous estimates.

Figure 4: *Range of methane-emission-related features observed in Alaskan lakes. Courtesy UAF.*

Offshore Arctic Alaska, Southern Methodist University, is collaborating with the USGS, Oregon State, and others to continue to gather data to constrain the current state and expected evolution of gas hydrates on the Beaufort Shelf and its linkages to ongoing methane flux to both the oceans and the atmosphere. A separate project with the Scripps Institute of Oceanography is contributing to this effort via the construction and deployment of controlled-source electromagnetic systems designed to map the contemporary state of submerged permafrost.

The University of Texas-Austin has initiated the development of conceptual and numerical models to analyze conditions under which gas may be expelled from existing accumulations of deepwater gas hydrate into the overlying ocean. The University of Oregon is contributing fundamental studies of the linkages of gas hydrate occurrence on sediment strength and potential natural geohazards such as gas venting and seafloor instability. In the Gulf of Mexico, the University of Mississippi will characterize the temporal changes in hydrate systems associated with sea-floor mounds in the Gulf of Mexico using time-lapse electric resistivity methods.

Fundamental Experimental and Modeling Studies

The Program continues to support focused experimental and numerical modeling studies to provide foundational science regarding the nature of hydrate-bearing sediments and their potential response to environmental changes, either natural or induced. Ongoing studies underway at Wayne State University are expected to provide improved parameterization of capillary pressure and relative permeability phenomena for use across the entire range of gas hydrate numerical simulation.

FY 2013 research conducted at NETL in partnership with NETL's Regional University Alliance was highlighted by development of new computer code to enable reservoir simulations that include injection of mixed gases during certain potential gas hydrate production approaches. This new code ("Mix3HydrateResSim") is the first open-source finite-difference reservoir simulation code capable of modeling a ternary gas mixture ($CH_4 + CO_2 + N_2$) which will facilitate the investigation of the reservoir response observed in the 2012 DOE-ConocoPhillips-JOGMEC Iġnik Sikumi Gas Hydrate Exchange Field Tests.

Laboratory studies conducted at NETL included (1) geomechanical compression tests and constitutive model development, (2) CH_4 - CO_2 exchange kinetics measurements, and (3) pore-scale visualization of hydrate distribution habits in sandy sediments. Initial results indicated that CO_2 or $CO_2 + N_2$ hydrate newly formed from free water might enclose native CH_4 hydrate and, therefore, inhibit exchange and release of CH_4. In addition, a new laboratory hydrate formation method was developed at NETL to create hydrate bearing sediment with similar hydrate formation habit to natural samples in a time-effective manner.

Improvement of simulation capabilities for evaluation of the response of gas hydrate deposits using depressurization continued throughout FY 2013 at Lawrence Berkeley National Laboratory (LBNL), including improvements to the Tough+-Hydrate code's capabilities to assess geomechanical implications of production, aided by advanced experimental studies. LBNL, along with Pacific Northwest National Laboratory (PNNL), also continued international collaborative research activities on hydrates with KIGAM (Korea) to assess gas hydrate reservoir data acquired during 2010 drilling in Korea for use in simulation. PNNL has expanded their STOMP-HYDT-KE simulator's capabilities to the evaluation of field-scale methane production strategies using injection mixtures of carbon dioxide and nitrogen.

One new simulation-laboratory based efforts were initiated in FY 2013. The project with Texas A&M and Georgia Tech focuses on integrating hydraulic/petrophysical with geomechanical modeling to expand the ability of models to capture not only fluid movement, but potential grain mobilization/reorganization as well.

International Collaboration

DOE maintained active engagement and discussion with the world's leading international gas hydrate R&D programs during FY 2013. Formal departmental-level agreements continued with the governments of Japan (Ministry of Economy, Trade, and Industry) and Korea (Ministry of Knowledge Economy). The MOU with India (Ministry of Petroleum and Natural Gas) expired during FY 2013; however, cooperation continues as the MOU is renegotiated. Industry organizations from each of these countries, as well as Norway, remain as participants in the DOE's Gulf of Mexico JIP lead by Chevron, and continue to demonstrate strong interest in future field testing opportunities. In addition to these Departmental-level agreements, NETL maintains active collaborations and communications with gas hydrate efforts in New Zealand, China, Canada, and Taiwan.

International collaboration in FY 2013 was highlighted by the cooperation with Japan in both the Iġnik Sikumi well data interpretation effort and in the ongoing development of marine pressure coring tools under the Gulf of Mexico JIP. NETL also continued to support the efforts of the Korean National Program, including support for evaluation of sites for proposed production testing in the Ulleung basin. Similarly, NETL supported the Indian National Gas Hydrate Program via participation in review of numerous potential deepwater drilling locations contemplated for their upcoming NGHP-02 expedition.

Fellowship Programs

NETL, in cooperation with the National Academies, has awarded National Methane Hydrate R&D Program Fellowships since 2007. The eighth fellow, Dr. Jeffrey Marlow was selected in FY 2013. Dr. Marlow will study the effects of microbial processes on the development and stability of methane hydrate deposits under the direction of Dr. Victoria Orphan at the California Institute of Technology.

Figure 5: *Dr. Jeffrey Marlow, FY 2013 recipient of the NETL-NAS National Methane Hydrate R&D Program Fellowship.*

Technology Transfer

DOE and its research partners continued to disseminate research results to the scientific community during FY 2013. Appendices A through C provide FY 2013 public press releases related to the gas hydrate program. Appendix D lists 21 peer-reviewed publications, 60 grey literature and government publications, and 36 professional conference presentations that occurred during the fiscal year and that resulted, in whole or in part, from DOE support. In addition, the DOE/NETL Methane Hydrate Newsletter, *Fire in the Ice*, continued to report on global developments in gas hydrate R&D in FY 2013. This periodic publication is distributed to approximately 1500 subscribers in more than 35 countries.

Figure 6*: The Consortium for Ocean Leadership published this report detailing the results of scientific workshops designed to prioritize remaining research opportunities related to marine gas hydrates*

NETL is also supporting an ongoing global assessment of gas hydrate science and technology issues being conducted by the United Nations Environmental Program (see www.methanegashydrates.org). A two-volume hard-copy book "Frozen Heat" and associated web-based products is scheduled for release in 2014. The steering committee includes representatives from NETL and the USGS, as well as from Canada, Japan, Korea, India, Germany, and Norway.

Figure 7: *NETL is a co-contributor to an ongoing assessment of gas hydrate R&D issues being conducted by the United Nations Environmental Program. Courtesy GRID-Arendal.*

Program Management and Oversight

Throughout FY 2013, DOE continued to manage a broad portfolio of R&D projects. The Program executed the solicitation, evaluation, award, and negotiation of seven new cooperative agreements (see Appendix A for NETL's press release related to these new projects), and continued to manage a range of ongoing projects, field work proposals, and interagency agreements. Program oversight activities in FY 2013 included two meetings of the program's Federal Advisory Committee (June 6-7, 2013 in Washington, DC, and July 16, 2013 via teleconference) and two meetings of the Interagency Technical Coordination Team (October 22, 2012 via teleconference; and February 14, 2013 hosted by the National Oceanic and Atmospheric Administration in Silver Spring, Maryland).

III. Conclusion

This report describes the accomplishments of the DOE-led national Methane Hydrate R&D Program in FY 2013. 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.

The signing of the MOU with the ADNR, motivated by the shared desire of the two organizations to further facilitate field-based gas hydrate R&D on the Alaska North Slope, was an important milestone for the Program. The DOE collaboration with the USGS and BOEM to advance deepwater gas hydrate exploration and characterization through the acquisition of advanced geophysical data at gas-hydrate-bearing sites discovered by the Program in prior collaborative exploration programs with industry is also significant.

The Program continued its cooperative efforts with industry, academic, National Laboratory, and international partners by expanding its R&D portfolio through the award of three new cooperative R&D agreements in the area of resource characterization/production potential, and four new agreements related to gas hydrates' potential response to changing natural environments. Finally, the Program maintained active international R&D collaborations with

Japan, India, and Korea throughout FY 2013 highlighted by the continuing collaboration with Japan on the development and testing of marine gas hydrate sampling and analysis devices.

Going forward, the highest priorities for the program will be to develop additional opportunities for field-based projects to assess gas hydrate issues within the U.S., including both 1) an extended-duration test of reservoir response to depressurization (to be conducted in Alaska), and 2) multi-site drilling and/or coring programs to confirm marine resource occurrence (to be conducted on the U.S. Outer Continental Shelf). The Program will continue to evaluate options for conducting such field programs given future budget expectations and current conditions within the industry.

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 regularly updated and can be found at http://www.netl.doe.gov/research/oil-and-gas/methane-hydrates. Further information on the Methane Hydrate Program, including program reports and activities of the Methane Hydrate Advisory Committee, are available at http://energy.gov/fe/science-innovation/oil-gas-research/methane-hydrate.

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Appendix A: Press Release (Nov 20, 2013) Regarding FY 2013 New Project Selections

Energy Department Expands Research into Methane Hydrates, a Vast, Untapped Potential Energy Resource of the U.S.

WASHINGTON – Today, U.S. Energy Secretary Ernest Moniz announced nearly $5 million in funding across seven research projects nationwide designed to increase our understanding of methane hydrates — a large, completely untapped natural gas resource—and what it could mean for the environment, as well as American economic competiveness and energy security.

"The recent boom in natural gas production - in part due to long-term Energy Department investments beginning in the 70's and 80's - has had a transformative impact on our energy landscape, helping to reduce greenhouse gas emissions and support thousands of American jobs," said Secretary Moniz. "While our research into methane hydrates is still in its early stages, these investments will increase our understanding of this domestic resource and the potential to safely and sustainably unlock the natural gas held within."

Methane hydrates are ice-like structures with natural gas locked inside, which can be found both onshore and offshore – including under the Arctic permafrost and in ocean sediments along nearly every continental shelf in the world. The substance looks remarkably like white ice, but it does not behave like ice. When methane hydrates are "melted," or exposed to pressure and temperature conditions outside those where the formations are stable, the solid crystalline lattice turns to liquid water, and the enclosed methane molecules are released as gas. In May 2012, the Energy Department, alongside our Japanese partners, announced a successful field trial of methane hydrate production technologies on Alaska's North Slope.

Managed by the Energy Department's National Energy Technology Laboratory, the new projects announced today will build on that success by researching alternative methods of extraction and the potential for commercialization, as well as the environmental impact of natural gas extraction from hydrate formations.

Project descriptions follow:

Georgia Tech Research Corporation (Atlanta, GA) — Researchers will design, build, and test a new borehole-sampling tool that will allow direct, in-place measurements of methane hydrate-bearing sediment properties by reaching beyond the zone disturbed by drilling. The tool will be field deployed to collect never-before-acquired data to evaluate resource recovery, seafloor stability, and gas hydrate responses to environmental changes. *DOE Investment: approximately $480,000*

The University of Texas at Austin (Austin, TX) — The University of Texas at Austin along with Ohio State University and Columbia University-Lamont Doherty Earth Observatory will examine what the primary influences are on the development of persistent, massive hydrate accumulations in deep sediments below the seabed. By extending a 3-D reservoir model to include methods of sediment deposits, compaction, pressure development, and methane creation, the project will provide valuable insights on the formation

of massive hydrate accumulations, the role of free gas in their persistence and locations where these massive accumulations might be possible. DOE Investment: approximately $1.68 million

Texas A&M Engineering Experiment Station (TEES) (College Station, TX) — TEES, in conjunction with the Georgia Institute of Technology, will develop a numerical model to address the many complexities associated with production from hydrate-bearing sediments. The project will provide a powerful new modeling tool to optimize future hydrate production-related testing and to provide a better understanding of how hydrate systems react to induced or natural changes in their environment. *DOE Investment: approximately $390,000*

Oregon State University (Corvallis, OR) — Oregon State University, in conjunction with a separate project funded by the EU through Universities of Bremen (Germany) and Tromso (Norway), will assess the response of methane hydrates to environmental changes at the Svalbard continental margin, part of Norway's continental shelf. Water and sediment core samples will be collected and analyzed to assess chemistry and microbiology changes from factors that constrain biochemical responses in high latitude (Arctic) settings. Results will provide insights into the response of gas hydrates to changing environmental conditions in zones susceptible to climate warming, the fate of methane in shallow subsurface and water columns, and the role gas hydrates play in carbon cycling. *DOE Investment: approximately $650,000*

Massachusetts Institute of Technology (MIT) (Cambridge, MA) — Conditions conducive for the development of natural gas hydrates generally occur between the seafloor and a relatively shallow, sub-bottom depth where temperatures become excessively warm because of geothermal influences. This depth interval is commonly called the Gas Hydrate Stability Zone (GHSZ). The fate of methane in the water column over places in the ocean floor where hydrogen sulfide, methane and other hydrocarbon-rich fluids seepage occurs, within and above the GHSZ, will be investigated to determine the likelihood of released methane reaching surface water or the atmosphere and the role that & "hydrate armoring" or coating of methane bubbles may have on that methane transport. MIT will work with the U.S. Geological Survey and the University of New Hampshire on the project. Study results should provide insights into conditions controlling methane bubble formation and fate, enhance the understanding of seafloor methane release relative to gas hydrate stability, and provide new information on an area of high interest for gas hydrate exploration. *DOE Investment: approximately $900,000*

University of Washington (Seattle, WA) — The University of Washington will study the effects of contemporary warming of bottom water temperatures on gas hydrate stability along the Washington Margin—the boundary between two continental plates. This study will be one of the first programs (outside the Arctic) focused on the response of a gas hydrate system located at the upper edge of the gas hydrate stability zone to environmental changes. The project will provide a geochemical evaluation of the origin of methane emissions and a quantitative estimate of methane flux and oxidation rates from the sediments, through the water column, and to the atmosphere. *DOE Investment: approximately $630,000*

University of Oregon (Portland, OR) — The University of Oregon plans to develop predictive models to enhance our understanding of how hydrates develop, environmental forces that cause them to dissociate and disrupt sedimentary structure, and better forecasting of hydrate associated slope failure, gas escape features, and the release of methane into the water column and potentially the atmosphere. *DOE Investment: approximately $280,000*

Appendix B: Press Release (May 14, 2013) Regarding Interagency Seismic Data Acquisition in the Gulf of Mexico

Expedition Provides New Insight on Gas Hydrates in Gulf of Mexico

Washington, DC — A joint-federal-agency 15-day research expedition in the northern Gulf of Mexico yielded innovative high-resolution seismic data and imagery that will help refine characterizations of large methane hydrate resources in the U.S. Outer Continental Shelf.

According to the U.S. Department of Energy's (DOE) Office of Fossil Energy (FE), the information will be used to refine estimates of the nature, distribution and concentration of gas hydrate in the vicinity of 2009 drill sites. Gas hydrates are ice-like substances formed when certain gases combine with water at specific pressures and temperatures, and represent a potentially vast future energy resource.

New data and imagery from the expedition, planned by DOE, the U.S Geological Survey (USGS) and the Bureau of Ocean Energy Management (BOEM) and conducted by the USGS, will also help assess how useful specialized seismic data may be to estimating hydrate saturations in deepwater sediments.

Deposits of gas hydrate are widespread in marine sediments beneath the ocean floor and in sediments within and beneath permafrost areas, where pressure-temperature conditions keep the gas trapped in the hydrate structure. Methane is the gas most often trapped in these deposits, making gas hydrates a potentially significant source for natural gas around the world.

"Understanding the nature and setting of deepwater gas hydrates is central to the National Methane Hydrates R&D Program, which is led by DOE and managed by FE's National Energy Technology Laboratory," said Christopher Smith, Acting Assistant Secretary for Fossil Energy. "Over the past 8 years, research carried out under this program has resulted in significant advances in our understanding of methane hydrates, their role in nature, and their potential as a future energy resource. This success is largely due to an unprecedented level of cooperation among federal agencies, industry, national laboratories, and academic institutions."

The recently completed expedition, planned jointly by DOE, USGS, and BOEM, was executed by USGS. Using low-energy seismic sources, USGS scientists collected details about the nature of the gas hydrate reservoirs and about geologic features of the sediment between the reservoirs and the seafloor. The new data also provide information about how much gas hydrate exists in a much broader area than can be determined from standard industry seismic data, which is typically designed to image much deeper geologic units.

"This expedition represents a significant milestone," said USGS Energy Resources Program Coordinator Brenda Pierce. "The data and imagery provide insight into the entire petroleum system at each location, including the source of gas, the migration pathways for the gas, the distribution of hydrate-bearing sediments, and traps that hold the hydrate and free gas in place. The USGS has a globally recognized research effort studying gas hydrates in settings around world, and this project combines our unique expertise with that of other agencies to advance research on this potential future energy resource."

The data were collected at two locations in the Gulf of Mexico where the three federal agencies partnered with an industry consortium to conduct a drilling expedition in 2009. That expedition discovered gas hydrate filling between 50 percent and 90 percent of the available pore space between sediment grains in sandy layers in the subsurface. These reservoirs are expected to be representative of the 6,700 trillion cubic feet of gas that BOEM estimates is housed in gas hydrates in sand-rich reservoirs in the northern Gulf of Mexico.

“The high-resolution nature of the data acquired through this interagency project will uniquely inform the BOEM effort to assess the resource potential of gas hydrates on the U.S. Outer Continental Shelf,” said Renee Orr, Chief, Strategic Resources Office, BOEM.

In coming years, DOE, USGS, and BOEM will continue their collaborative investigation of gas hydrates in the northern Gulf of Mexico and other locations across the world.

Appendix C: Press Release (April 11, 2013) Regarding Availability of 2012 Alaska Field Test Data

Data from Innovative Methane Hydrate Test on Alaska's North Slope Now Available on NETL Website
Test Demonstrated Ability to Inject CO_2, Nitrogen, and Initiate and Maintain Gas Production

Washington, D.C. —Data from an innovative test conducted last year that used carbon dioxide (CO_2) and nitrogen (N2) injection to release natural gas from methane hydrates at a well on the Alaska North Slope is now available to researchers and the public on the National Energy Technology Laboratory (NETL) website.

Methane hydrate – essentially molecules of natural gas trapped in ice crystals – represents a potentially enormous energy resource, possibly exceeding the combined energy content of all other fossil fuels. Hydrate resources in arctic sandstone reservoirs contain an in-place gas volume estimated to be in the 100's of trillions of cubic feet (TCF), while hydrate in marine sands is estimated to contain 1,000's to 10,000's of TCF, and hydrate dispersed through marine mud is estimated to contain 100,000's of TCF. In addition to the immense resource, CO_2 injection into methane hydrate deposits is a technology that can potentially both release an energy resource while permanently storing carbon dioxide, a major greenhouse gas.

The U.S. Department of Energy (DOE), in partnership with other nations and industry, has played a leading role in developing technologies to evaluate how to safely recover these methane hydrate energy resources in order to provide new supplies of clean-burning natural gas. These resources occur in a variety of forms in sediments within and below thick permafrost in Arctic regions, and in the subsurface of continental waters with a depth of 1,500 feet or greater. The U.S. Geological Survey (USGS) has estimated a potentially recoverable resource of 85 trillion cubic feet of gas in favorable hydrate accumulations on the Alaska North Slope alone.

NETL, the research laboratory of DOE's Office of Fossil Energy (FE), participated in gas hydrate field production trials in early 2012 in partnership with ConocoPhillips and the Japan Oil, Gas and Metals National Corp. (JOGMEC). This test well (known as Ignik Sikumi, Inupiat for "Fire in the Ice") represented the first test of a CO_2 exchange technology that was developed by ConocoPhillips and the University of Bergen, Norway. In the test, a small volume of CO_2 and nitrogen was injected into the well and then the well was produced back to demonstrate that this mixture of injected gases could promote production of natural gas.

The large volumes of raw data from the test are currently under evaluation. The data now available from the test program include the rates and composition of gases both injected and produced, and information on changes in the reservoir pressure and temperature during the test. ConocoPhillips has further augmented the raw data through extensive quality control checks and integration of the various measurements to a standard time framework. The data are now fully available to all researchers and the public for analysis and evaluation.

Both the U.S. and Japan have committed to utilizing Arctic gas hydrate research opportunities as an important step in assessing the potential for gas hydrate production in deepwater marine settings, the location of the vast majority of global resources. DOE and JOGMEC have also collaborated on the

development of specialized core sampling devices through the Gulf of Mexico Gas Hydrates Joint Industry Project (an industry consortium managed by Chevron) conducting research on deepwater gas hydrate characterization technology.

In addition to the U.S./Japan collaboration, FE scientists have worked actively with researchers in Korea, India, China, Canada and other nations, as well as with USGS, the Bureau of Ocean Energy Management (BOEM), and other federal agencies, to advance methane hydrate technology. The Methane Hydrate Research and Development Act of 2000 established DOE (through the efforts of FE and NETL) as the lead U.S. agency for methane hydrate research and development.

Appendix D: FY 2013 Publications and Reports

Peer-Reviewed Publications

1. Brothers, L.L., Van Dover, C.L., German, C.R., Kaiser, C.L., Yoerger, D.R., Ruppel, C.D., Lobecker, E., Skarke, A.R., Wagner, K.S., 2013. Evidence for extensive methane venting on the southeastern U.S. Atlantic margin. Geology, G34217.1.
2. Carrière, O. and Gerstoft, P., 2013. Deepwater subseafloor imaging using active OBS interferometry. Geophysics, v. 78, pp. Q15-Q24. dx.doi.org/10.1190/geo2012-0241.1
3. Cha, J. and Seol, Y., 2013. Increasing gas hydrate formation temperature for desalination of high salinity produced water with secondary guests. ACS Sustainable Chemistry and Engineering, v. 1 no. 10, pp 1218–1224 DOI**:** 10.1021/sc400160u
4. Coffin, R.B., Smith, J.P., Plummer, R.E., Yoza, B., Larsen, R.K., Millholland, L.C., and Montgomery, M.T., 2013. Spatial variation in shallow sediment methane source and cycling along the Alaskan Beaufort Sea. Marine Petroleum and Geology, v. 45, pp. 186-197.
5. Cook, A.E. and Malinverno, A., 2013. Short migration of methane into a gas hydrate-bearing sand layer at Walker Ridge, Gulf of Mexico. Geochemistry, Geophysics, Geosystems, v. 14 (2), pp. 283-291. doi: 10.1002/ggge.20040.
6. Dai, S., Santamarina, J.C., Waite, W., and Kneafsay, T., 2012. Hydrate morphology: Patchy hydrate saturation in sands. Journal of Geophysical Research- Solid Earth, v. 117, B11205, 12 pp.
7. Dai, S., Wuttke, F., and Santamarina, J.C., 2013. Coda wave analysis to monitor processes in soils. ASCE Journal of Geotechnical and Geoenvironmental Engineering, v. 139, no. 9, pp. 1504-1511.
8. Hamdan, L.J., Coffin, R.B., Sikaroodi, M., Greinert, J., Treude, T., and Gillevet, P.M., 2012. Ocean currents shape the microbiome of Arctic marine sediments. ISME Journal (2012), pp. 1-12.
9. Hunt, A.G., Stern, L.A., Pohlman, J.W., Ruppel, C., Moscati, R., Landis, G., 2013. Mass fractionation of noble gases in synthetic methane hydrate: Implications for the detection of naturally occurring methane hydrate dissociation. Chemical Geology, v. 239, pp. 242-250. doi: 10.1016/j.chemgeo.2012.09.033
10. Lapham, L.L., Wilson, R.M., Riedel, M., Paull, C.K., and Holmes, M.E., 2013. Temporal variability of *in situ* methane concentrations in gas hydrate-bearing sediments near Bullseye Vent, Northern Cascadia margin. Geochemistry, Geophysics, Geosystems, v. 14, pp. 2445-2459. doi: 10.1002/ggge.20167
11. Lapham, L.L., Wilson, R.M., MacDonald, I.R., and Chanton, J.P., 2013. Gas hydrate dissolution rates quantified with laboratory and seafloor experiments. Geochimica et Cosmochimica Acta, v. 125, pp. 492-503. doi: 10.1016/j.gca.2013.10.030
12. Lu, W.J., Guo, H.R., Chou, I.M., Burruss, R.C., and Li, L.L., 2013. Determination of diffusion coefficient of carbon dioxide in water between 268 and 473 K in a high-pressure capillary optical cell with *in-situ* Raman spectroscopic measurements. Geochimica et Cosmochimica Acta, v. 115, pp. 183-204.

13. Macelloni, L., Brunner, C., Caruso, S., Lutken, C., D'Emidio, M., and Lapham, L., 2013. Spatial distribution of seafloor biogeological and geochemical processes as proxies of fluid flux regime and evolution of a carbonate/hydrates mound, northern Gulf of Mexico. Deep Sea Research, Part 1, Manuscript Number: DSR1-D-12-00118R1.

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15. Moridis, G.J., Kim, J., Reagan, M.T., and Kim, S-J., 2013. Feasibility of gas production from a gas hydrate accumulation at the UBGH2-6 site of the Ulleung basin in the Korean East Sea. Journal of Petroleum Science and Engineering, v. 108, pp. 180-210. doi: 10.1016/j.cageo.2013.04.001.

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18. Simonetti, A., Knapp, J.H., Sleeper, K., Lutken, C.B., Macelloni, L, and Knapp, C.C., 2013. Spatial distribution of gas hydrates from high-resolution seismic and core data, Woolsey Mound, northern Gulf of Mexico. Marine and Petroleum Geology, v. 44, pp. 21-33.

19. Valentine, D.L., Mezić, I., Maćešić, S., Črnjarić-Žic, N., Ivić, S., Hogan, P.J., Fonoberov, V.A., and Loire, S., 2012. Dynamic autoinoculation and the microbial ecology of a deep water hydrocarbon irruption. Proceedings of the National Academy of Sciences, v. 109, no. 50, pp. 20286-20291. doi:10.1073/pnas.1108820109

20. Wagner, K.S., McEntee, M.H., Brothers, L.L., German, C.R., Kaiser, C.L., Yoerger, D.R., and Van Dover, C.L., 2013. Cold-seep habitat mapping; High-resolution spatial characterization of the Blake Ridge Diapir seep field. Deep Sea Research II: Topical Studies in Oceanography, v. 92, pp. 183-188, August, 2013. http://dx.doi.org/10.1016/j.dsr2.2013.02.008

21. Waite, W.F. and Spangenberg, E., 2013. Gas hydrate formation rates from dissolved-phase methane in porous laboratory specimens. Geophysical Research Letters, v. 40, 6 pp. doi:10.1002/grl.50809

Grey Literature (Articles in Newsletters, Magazines, and Trade Journals; Extended Abstracts; Conference Proceedings)

1. Brothers, L.L., Van Dover, C.L., German, C.R., Kaiser, C.L., and Yoerger, D.R., 2013. Re-examination of seep activity at the Blake Ridge Diapir. Fire in the Ice Newsletter, v. 13, no. 1, pp. 6-8.

2. Hart, P.E., Haines, S. and Ruppel, C., 2013. Seismic-imaging research cruise investigates deepwater gas hydrate deposits in the Gulf of Mexico. Sound Waves, USGS National Newsletter, July/August 2013.

3. Lee, M.W., 2013. Comparison of methods for predicting shear wave velocities of unconsolidated shallow sediments in the Gulf of Mexico. U.S. Geological Survey Scientific Investigations Report 2013–5141, 11 pp., http://pubs.usgs.gov/sir/2013/5141/.
4. Lewis, K.A. and Collett, T.S., 2013. Brookian sequence well log correlation sections and occurrence of gas hydrates, north-central North Slope, Alaska. U.S. Geological Survey Scientific Investigations Report 2013–5050, 23 pp., http://pubs.usgs.gov/sir/2013/5050/.
5. Ruppel, C., Robertson, J., and Pierce, B., 2013. Groundbreaking gas hydrate research. Sound Waves, USGS National Newsletter, March/April 2013.
6. Ruppel, C., 2013. Catching climate change in progress: Drilling on circum-Arctic shelves and upper continental slopes. USSSP Workshop Report, 44 pp.
7. Sanchez, M., Shastri, A., and Santamarina, J.C., 2013. Modeling gas hydrate bearing sediments using a coupled approach. Proceedings of the Pan-American Conference on Unsaturated Soils, Cartagena, Colombia, Eds. B. Caicedo, et al., pp. 545-550.
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9. Tost, B.C. and Cook, A.E., 2013. Do gas hydrates occur in Alaminos Canyon, Gulf of Mexico? Unconventional Resources Technology Conference, Denver Colorado, August 12-14, 2013. SPE-168887-MS. Conference Article.
10. Vagnetti, R., Boswell, R., Pratt, S., 2013. Researching the Climate-Change Implications of Methane Hydrates: *Eco* magazine, **1** (1), 28-33.

Government Reports

1. Balczewski, J., 2012. "Characterizing Natural Gas Hydrates in the Deep Water Gulf of Mexico: Applications for Safe Exploration and Production Activities." DOE Award No.: DE- DE-FC26-01NT41330, Semi-Annual Progress Report (April - September 2012). October 2012.
2. Batzle, M., 2013. "Measurement and Interpretation of Seismic Velocities and Attenuations in Hydrate-Bearing Sediments." DOE Award No.: DE-FE0009963, Quarterly Research Performance Progress Report (Period ending 12/31/2012). January 2013.
3. Batzle, M., 2013. "Measurement and Interpretation of Seismic Velocities and Attenuations in Hydrate-Bearing Sediments." DOE Award No.: DE-FE0009963, Quarterly Research Performance Progress Report (Period ending 3/31/2013). April 2013.
4. Batzle, M., 2013. "Measurement and Interpretation of Seismic Velocities and Attenuations in Hydrate-Bearing Sediments." DOE Award No.: DE-FE0009963, Quarterly Research Performance Progress Report (Period ending 6/31/2013). July 2013.
5. Beaudoin, Y.C., 2012. "Global Assessment of Methane Gas Hydrates." DOE Award No.: DE-FE0003060, Semiannual Progress Report (April – September, 2012). October 2012.
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7. Coffin, R.B., Boyd, T.J., Rose, P.S., Yosa, B., Millholland, L.C., Downer, R., and Woods, S., 2013. "Geochemical Cruise Report SO226/2 RV Sonne Chatham Rise Expedition." U.S. Naval Research Laboratory Technical Memorandum, NRL/MR/6110-13-9472.
8. Consortium for Ocean Leadership, 2013. "Methane Hydrate Community Workshop Report." June 4-6, Washington, D.C., http://oceanleadership.org/wp-content/uploads/2013/01/MH_Workshop_Rpt_Final.pdf
9. Constable, S., 2013. "Mapping Permafrost and Gas Hydrate using Marine CSEM Methods." DOE Award No.: DE-FE0010144, Quarterly Research Performance Progress Report (Period ending 12/31/2012). January 2013.
10. Constable, S., 2013. "Mapping Permafrost and Gas Hydrate using Marine CSEM Methods." DOE Award No.: DE-FE0010144, Quarterly Research Performance Progress Report (Period ending 3/31/2013). April 2013.
11. Constable, S., 2013. "Mapping Permafrost and Gas Hydrate using Marine CSEM Methods." DOE Award No.: DE-FE0010144, Quarterly Research Performance Progress Report (Period ending 6/30/2013). July 2013.
12. Cook, A., 2013. "Methane Hydrate Field Program." DOE Award No.: DE-FE0009949, Quarterly Research Performance Progress Report (Period ending December 31, 2012). January 2013.
13. Cook, A., 2013. "Methane Hydrate Field Program." DOE Award No.: DE-FE0009949, Quarterly Research Performance Progress Report (Period ending March 31, 2013). April 2013.
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15. Flemings, P.B., 2013. "Controls on Methane Expulsion During Melting of Natural Gas Hydrate Systems: Topic Area 2." DOE Award No.: DE-FE0010406, Quarterly Research Performance Progress Report (Period ending 12/31/2012). January 2013.
16. Hornbach, M.J., 2013. "Gas Hydrate Dynamics on the Alaskan Beaufort Continental Slope: Modeling and Field Characterization." DOE Award No.: DE-FE0010180, Quarterly Progress Report (October-December, 2012). January 2013.
17. Hornbach, M.J., 2013. "Gas Hydrate Dynamics on the Alaskan Beaufort Continental Slope: Modeling and Field Characterization." DOE Award No.: DE-FE0010180, Quarterly Progress Report (January-March, 2013). May 2013.
18. Hornbach, M.J., 2013. "Gas Hydrate Dynamics on the Alaskan Beaufort Continental Slope: Modeling and Field Characterization." DOE Award No.: DE-FE0010180, Quarterly Progress Report (April-June, 2013). August 2013.
19. Humphrey, G., 2013. "Planning of a Marine Methane Hydrate Pressure Coring Program for the Walker Ridge and Green Canyon Areas of the Gulf of Mexico." DOE Award No.: DE-FE0010175, Quarterly Research Performance Progress Report (Period ending 12/31/2012). July 2013.
20. Humphrey, G., 2013. "Planning of a Marine Methane Hydrate Pressure Coring Program for the Walker Ridge and Green Canyon Areas of the Gulf of Mexico." DOE Award No.: DE-FE0010175, Quarterly Research Performance Progress Report (Period ending 03/31/2013). July 2013.
21. Humphrey, G., 2013. "Planning of a Marine Methane Hydrate Pressure Coring Program for the Walker Ridge and Green Canyon Areas of the Gulf of Mexico." DOE Award No.: DE-FE0010175, Quarterly Research Performance Progress Report (Period ending 06/30/2013). July 2013.

22. Hunter, R. and Digert, S., 2013. "Resource Characterization and Quantification of Natural Gas Hydrate and Associated Free-Gas Accumulations in the Prudhoe Bay – Kuparuk River Area on the North Slope of Alaska." DOE Award No.: DE- DE-FC-01NT41332, 41st and 42nd Quarterly Reports, Semi-Annual Progress Report (4Q2012 – 1Q2013). April 2013.

23. Jang, J., 2012. "Verification of Capillary Pressure Functions and Relative Permeability Equations for Gas Production." DOE Award No.: DE-FE0009927, Quarterly Progress Report (October 2012 - December 2012). January 2013.

24. Jang, J., 2013. "Verification of Capillary Pressure Functions and Relative Permeability Equations for Gas Production." DOE Award No.: DE-FE0009927, Quarterly Progress Report (January 2013 - March 2013). April 2013.

25. Jang, J., 2013. "Verification of Capillary Pressure Functions and Relative Permeability Equations for Gas Production." DOE Award No.: DE-FE0009927, Quarterly Progress Report (March 2013 - June 2013). July 2013.

26. Kneafsey, T., 2013. "Properties of Hydrate-Bearing Sediments Subjected to Changing Gas Compositions," Field Work Proposal ESD12-011, Topical Report. February 2013.

27. Lutken, C.B., 2013. "Hydrate Research Activities that both Support and Derive from the Monitoring Station/Seafloor Observatory, Mississippi Canyon 118, Northern Gulf of Mexico." DOE Award No.: DE-FC26-06NT42877, Semiannual Progress Report (July – December 2012). February 2013.

28. Lutken, C.B., 2013, "Temporal Characterization of Hydrates System Dynamics beneath Seafloor Mounds: Integrating Time-Lapse Electrical Resistivity Methods and in situ Observations of Multiple Oceanographic Parameters." DOE Award No.: DE-FE0010141, Quarterly Progress Report (January – March 2013). April 2013.

29. Lutken, C.B., 2013, "Temporal Characterization of Hydrates System Dynamics beneath Seafloor Mounds: Integrating Time-Lapse Electrical Resistivity Methods and in situ Observations of Multiple Oceanographic Parameters." DOE Award No.: DE-FE0010141, Quarterly Progress Report (April – June 2013). July 2013.

30. Lutken, C.B., 2013. "Hydrate Research Activities that both Support and Derive from the Monitoring Station/Seafloor Observatory, Mississippi Canyon 118, Northern Gulf of Mexico." DOE Award No.: DE-FC26-06NT42877, Semiannual Progress Report (January – June 2013). August 2013.

31. McConnell, D., 2013. "Advanced Hydrate Reservoir Modeling Using Rock Physics Techniques." DOE Award No.: DE-FE0010160, Quarterly Research Performance Progress Report (Period ending 12/31/2012). January 2013.

32. Moridis, G., 2013. "Numerical Studies for the Characterization of Recoverable Resources from Methane Hydrate Deposits." Field Work Proposal ESD12-011, 2012 Annual Research Progress Report. February 2013.

33. Myers, G., 2013. "Methane Hydrate Field Program." *DOE Award No.: DE-FE0010195,* Quarterly Research Performance Progress Report (Period ending December 31, 2012). January 2013.

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36. Rose, P.S., Millholland, L.C., Plummer, R.E., Reed, A., Montgomery, M.T., Boyd, T.J., and Coffin, R.B., 2013. "Natural Gas at Seep Site on the UK Continental Shelf, North Sea." U.S. Naval Research Laboratory Technical Memorandum, NRL/MR/6110-13-9452.

37. Santamarina, J. C., 2012. "Hydrate-Bearing Clayey Sediments: Morphology, Physical Properties, Production and Engineering/Geological Implications." DOE Award No.: DE-FE0009897, Quarterly Progress Report (October-December 2012). December 2012.

38. Santamarina, J. C., 2013. "Hydrate-Bearing Clayey Sediments: Morphology, Physical Properties, Production and Engineering/Geological Implications." DOE Award No.: DE-FE0009897, Quarterly Progress Report (January-March 2013). March 2013.

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41. Schoderbek, D., Farrell, H., Hester, K., Howard, J., Raterman, K., Silpngarmlert, S., Martin, K.L., Smith, B., and Klein, P., 2013. "ConocoPhillips Gas Hydrate Production Test." DOE Award No.: DE-NT0006553, Final Technical Report for Period October 1, 2008-June 30, 2013. July 2013.

42. Seol, Y., 2013. "Natural Gas Hydrate Research." Award Number 2017.07.12, Fiscal Year 2013 Quarterly Progress Report (October – December, 2012). January 2013

43. Seol. Y., 2013. "Natural Gas Hydrate Research," Award Number 2017.07.12, Fiscal Year 2013 Quarterly Progress Report (January – March, 2013). April 2013

44. Seol., Y. 2013. "Natural Gas Hydrate Research", Award Number 2017.07.12, Fiscal Year 2013 Quarterly Progress Report (April – June, 2013). July 2013

45. Torres, M., 2013. "Application of Crunch-Flow Routines to Constrain Present and Past Carbon Fluxes at Gas-Hydrate Bearing Sites," DOE Award No.: DE-FE0010496, Quarterly Progress Report (October-December, 2012). February 2013.

46. Torres, M., 2013. "Application of Crunch-Flow Routines to Constrain Present and Past Carbon Fluxes at Gas-Hydrate Bearing Sites," DOE Award No.: DE-FE0010496, Quarterly Progress Report (January-March, 2013). March 2013.

47. Torres, M., 2013. "Application of Crunch-Flow Routines to Constrain Present and Past Carbon Fluxes at Gas-Hydrate Bearing Sites," DOE Award No.: DE-FE0010496, Quarterly Progress Report (April-June, 2013). June 2013.

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50. Wooller, M., 2013. "Source Characterization and Temporal Variation of Methane Seepage from Thermokarst Lakes on the Alaska North Slope in Response to Arctic Climate Change." DOE Award No.: DE-NT0005665, *Final Report*. May 2013.

Technical Presentations

1. Akasaka, C., Ohtsuki, S., and Terao, Y., 2012. CO_2-CH_4 gas exchange field trial in Alaska. Presented at JOGMEC 4th Comprehensive Symposium on Methane Hydrate (CSMH-4), Dec., 2012, Tokyo, Japan.
2. Anderson, B., Garapati, N., and McGuire, P., 2013. Reservoir modeling and numerical analysis of the Iġnik Sikumi gas hydrate field trial. Presented at 75th EAGE Conference & Exhibition Incorporating SPE EUROPEC 2013, June 9, London, England.
3. Boswell, R., Anderson, B., 2013. Natural Gas Hydrates – Status on Resource Potential. U.S. Assoc. Energy Economists Annual Meeting, Anchorage, AK, July.
4. Boswell, R., 2012. Gas hydrate research and development in the United States. JOGMEC-TRC Week 2012, Tokyo, Japan, November 29.
5. Brannon, E., Kroeger, K., Ganju, N., Pohlman, J.W., and Green, A., 2013. Investigating time variations in DOC concentrations for salt marsh carbon budgets: Testing continuous CDOM measurements as a proxy for DOC. Presented at the Aquatic Sciences Meeting, Feb. 17-22, New Orleans, LA.
6. Brothers, L.L., Van Dover, C.L., German, C.R., Kaiser, C.L., Yoerger, D.R., Ruppel, C.D., Lobecker, E., Skarke, A.D., 2012. Evidence of extensive gas venting at the Blake Ridge and Cape Fear diapirs. Presented at American Geophysical Union Fall Meeting, Dec. 3-7, San Francisco, CA.
7. Brothers, L.L., Hart, P.E., and Ruppel, C., 2013. Subsea permafrost on the US Beaufort Sea Margin. Presented at Permafrost & Gas Hydrates Workshop, Jan. 14-15, Helsinki Finland.
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33. Tost, B.A. and Cook, A.E., 2013. Do gas hydrates occur in Alaminos Canyon, Gulf of Mexico? Presented at the Unconventional Resources Technology Conference, Aug. 12-14, Denver, CO.

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Theses and Dissertations

1. Tost, Brian C., 2013. Low porosity mistaken for natural gas hydrate at Alaminos Canyon, Gulf of Mexico: Implications for gas hydrate exploration in marine sediment reservoirs. Masters Thesis. Ohio State University.