

DOE Award No.: DE-FE0022898

Research Performance Progress Report (Period Ending 9/30/2016)

Alaska Natural Gas Hydrate Production Testing, Test Site Selection, Characterization and Testing Operations Project Period (09/01/2014 – 12/31/2017)

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Prepared for:
United States Department of Energy
National Energy Technology Laboratory

November 1, 2016



U.S. DEPARTMENT OF
ENERGY

**NATIONAL ENERGY
TECHNOLOGY LABORATORY**

Office of Fossil Energy

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ABSTRACT

Alaska Natural Gas Hydrate Production Testing, Test Site Selection, Characterization and Testing Operations

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The objective of this Department of Energy (DOE)-United States Geological Survey (USGS) Interagency Agreement is to provide geologic and geophysical technical support to identify and characterize gas hydrate production test sites on the Alaska North Slope as specified in the goals of the 2005 Energy Act for National Methane Hydrates R&D, the DOE-led US Interagency Roadmap for Gas Hydrate Research, and elements of the USGS mission related to energy resources.

This effort is addressing critical issues associated with production of gas hydrates, and is contributing to our understanding of the geologic nature of the gas hydrate accumulations, the geophysical characteristics of in-situ natural gas hydrates, and helping develop plans for an extended gas hydrate production testing program in northern Alaska. This project is designed as a cooperative research effort, with USGS providing technical geoscience support in a partnership that has included so far the DOE, the Alaska Department of Natural Resources, the Japan Oil Gas and Metals National Corporation (JOGMEC), and Petrotechnical Resources Alaska (PRA).

During this reporting period (4/1/2016 - 9/30/2016), the USGS has continued to contribute to the DOE- and industry-sponsored cooperative gas hydrate production testing project in northern Alaska. The USGS leads the geologic and geophysical research effort in support of the test site selection and characterization efforts. Over this reporting period, most of our test site review effort was refocused to assess gas hydrate prospects in the Westend of the Prudhoe Bay Unit (PBU) including the PBU Kuparuk 7-11-12 proposed test site. The USGS geologic and geophysical studies of the Eileen Gas Hydrate Trend in the greater PBU area have determined that the PBU Kuparuk 7-11-12 test site is characterized to possess known gas hydrate occurrences and the existing infrastructure (i.e., gravel pad) required for a successful production test.

Formal engineering and operational planning for the next gas hydrate production-related testing project in northern Alaska has also continued, with the USGS providing guidance and technical support to the DOE, JOGMEC, and PRA. During this reporting period, the USGS co-hosted a test site review and production well test design meeting in Anchorage, Alaska that was attended by JOGMEC and DOE geoscience technical staff. During this reporting period, the USGS also contributed to a series of monthly web style meetings in support of this effort.

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EXECUTIVE SUMMARY

Project Scope and Accomplishments

Work conducted under this Interagency Agreement is intended to provide support to the DOE and its research partners in understanding, predicting, and testing the recoverability and potential production characteristics of onshore natural gas hydrate in the Greater Prudhoe Bay area on the Alaska North Slope or other areas deemed suitable, through mutual agreement of DOE and USGS, for potential long term production testing of gas hydrate. To do so, this project is designed to evaluate the occurrence and resource potential of the known gas hydrate accumulations in the Eileen Gas Hydrate Trend. This project consists of one task that includes two subtasks. The first subtask involves the geologic and engineering assessment of gas hydrate accumulations in the Eileen Gas Hydrate Trend. The second subtask supports DOE and their industry partners with evaluation, planning and preparations for drilling and testing of gas hydrate research wells in northern Alaska.

In general, the goals of this task remained the same over this reporting period with the USGS leading the geoscience aspects of the DOE sponsored effort to conduct an extended gas hydrate production test on the Alaska North Slope. The USGS in cooperation with the Japan Oil, Gas and Metals National Corporation (JOGMEC) and the DOE have further characterized 12 new gas hydrate prospects on State of Alaska lands east of the Milne Point Unit. The USGS has also worked with State of Alaska Department of Natural Resources (SOA-DNR) to identify and characterize the Prudhoe Bay Unit (PBU) Kuparuk 7-11-12 prospect. This cooperative research effort with the SOA-DNR has elevated the PBU Kuparuk 7-11-12 prospect as the lead site for the proposed production test pilot. The consortium led by DOE, JOGMEC, and the USGS are also currently working with various industry operators in northern Alaska to develop a gas hydrate test well operational plan and identify an operator for the proposed gas hydrate production test pilot. The current plan for the pilot production test includes the drilling of a stratigraphic test well at the PBU Kuparuk 7-11-12 prospect in 2017 followed by a multi-year production test likely commencing in 2018.

As introduced above, in FY-2016 the USGS also acquired the responsibility to work with SOA-DNR geoscientists to further characterize the recently identified PBU Kuparuk 7-11-12 test prospect. Because of our close working relationship between the USGS and the SOA-DNR, the Prudhoe Bay Unit Working Interest Owners (PBU-WIO) allowed the SOA-DNR to share with the USGS proprietary 3D seismic data from the area of the PBU Kuparuk 7-11-12 gravel drill pad to further assess the proposed test site. During this reporting period, the USGS participated in a technical site review workshop with the SOA-DNR geoscience team in support of the Alaska North Slope cooperative gas hydrate test site review effort (this workshop was continuation of two previous working meetings convened earlier in FY-2016). USGS and SOA-DNR geoscientists have characterized the seismic response of all the targeted reservoirs and has defined a bottom-hole location that will test the most promising hydrate-bearing reservoirs at the PBU Kuparuk 7-11-12 site. The primary target interval (Unit B-sands) is anticipated to occur at a depth of about 2,900 ft, roughly 1,000 ft below the base of ice-bearing permafrost. This unit is the primary

target given its greater depth and warmer temperature (10 degrees C), both of which are favorable conditions for the proposed testing objectives. The secondary target interval (Unit C-sand), lies at about 2,550 ft drilling depth. The relatively shallow Unit-D sands is also interpreted to be hydrate-bearing at this site. Units B and D are assessed to be 30- to 50-ft-thick, with high gas hydrate saturations (60% or more).

The June 2016 workshop co-hosted by the USGS in Anchorage, Alaska, that focused on the assessment of the PBU Kuparuk 7-11-12 test, also led to the development of a comprehensive Alaska North Slope gas hydrate test well engineering and operational plan. The proposed gas hydrate testing program is designed to first (1) confirm the occurrence of the target reservoirs at the PBU Kuparuk 7-11-12 site via a stratigraphic test well; (2) observe and measure the reservoir response to extended duration depressurization; and (3) observe system behavior through continuous monitoring via both surface and downhole equipment.

The USGS publication efforts have continued to focus on supporting the ongoing gas hydrate production testing research efforts. These contributions included a comprehensive review of the 2013 Eileen Trend gas hydrate production test, titled the "Ignik Sikumi Field Experiment, Alaska North Slope: Design, Operations, and Implications for CO₂-CH₄ Exchange in Gas Hydrate Reservoirs." The USGS also contributed to a production modeling journal article that focused on simulating gas production from the gas hydrates in the National Petroleum Reserve Alaska (NPRA).

Project Meetings, Outreach, and Presentations (for the period 4/1/2016 - 9/30/2016)

April 4-8, 2016: The USGS hosted a high-level workshop in Denver, Colorado with representatives from the Korea Gas Hydrate Development Organization (GHDO), the US Department of Energy (DOE), and other US research organizations, which had the goal to develop new US-Korea cooperative gas hydrate research opportunities. As a result of this workshop, a series of 8 new cooperative US-Korea projects were defined and approved by DOE and the GHDO. The USGS is leading two of these new efforts, including a cooperative gas hydrate assessment effort and a laboratory gas hydrate reservoir study.

April 17-18, 2016: USGS staff participated in a technical review and project planning workshop in support of the India National Gas Hydrate Program (Houston, Texas). (DOE funds were not used to support this travel, included for informational purposes)

April 19-20, 2016: USGS staff participated in a University of Texas Gulf of Mexico Gas Hydrate Drilling Program planning and organizational meeting (Austin, Texas).

May 3-5, 2016: USGS staff coordinated and chaired a Special Luncheon at the 2016 Offshore Technology Conference that featured the first public release of the results of the India National Gas Hydrate Program Expedition 02. The simultaneous USGS web post and a USGS News Release on NGHP-02, resulted in the posting of more than 250 international news articles on the

NGHP-02 expedition. (DOE funds were not used to support this travel, included for informational purposes)

June 5-10, 2016: Co-hosted with the State of Alaska Department of Natural Resources a technical site review and project planning meeting in Anchorage, Alaska with members of the JOGMEC and DOE gas hydrate project geoscience teams in support of the Alaska North Slope cooperative gas hydrate production testing project. This meeting finalized the bottom-hole location for the proposed Alaska North Slope Gas Hydrate Production Test Stratigraphic Test Well.

June 21, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

July 1-29, 2016: USGS scientific staff participated in a marine 3D seismic survey in the North Atlantic, in and around the Svalbard region. This expedition was sponsored and led by the Center for Arctic Gas Hydrate, Environment and Climate, University of Tromsø (Norway). (DOE funds were not used to support this publication, included for informational purposes)

July 12, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

July 26, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

August 2, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

August 16, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

August 30, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

September 6-8, 2016: USGS staff participated in a University of Texas, Gulf of Mexico Gas Hydrate Drilling Program, planning and organizational workshop that dealt with the development of the detailed operational and science program plan in support of the Gulf of Mexico Marine Test drilling and coring project planned for the Gulf of Mexico in March-May, 2017 (Houston, Texas).

September 13, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

September 27, 2016: Hosted an Alaska North Slope gas hydrate test site review meeting (web meeting).

Publications (for the period 4/1/2016 - 9/30/2016)

Boswell, R., Bünz, S., Collett, T.S., Frye, M., Fujii, T., McConnell, D., Meinery, J., Pecher, I., Reichel, T., Ryu, B.-J., Shelander, D., and Shin, K.-S., 2016, Introduction to special section: Exploration and characterization of gas hydrates: Interpretation Journal Volume 4, Issue 1, 21 p.

Boswell, R., and Collett, T.S., 2016, Emerging Issues in the development of geologic models for gas hydrate numerical simulation: Fire in the Ice U.S. Department of Energy Newsletter, v. 16, p. 19-22.

Kumar, P., Collett, T.S., Vishwanath, K., Shukla, K.M., Nagalingam, J., Lall, M.V., Yamada, Y., Schultheiss, P., and Holland, M., 2016, Reservoir systems in the offshore of India: Results of the India National Gas Hydrate Program Expedition 02: Fire in the Ice U.S. Department of Energy Newsletter, v. 16, p. 1-8. (DOE funds were not used to support this publication, included for informational purposes)

Wang, X., Collett, T., Shi, H., Yang, S., Wang, Z., Chen, D., Li, Y., and Yan, C., 2016, Characterization of gas hydrate distribution using conventional three-dimensional seismic data in the Pearl River Mouth Basin, South China Sea: Interpretation Journal Volume 4, Issue 1, 12 p. (DOE funds were not used to support this publication, included for informational purposes)

Boswell, R., Schoderbek, D., Anderson, B., Collett, T.S., Ohtsuki, S., and White, M., (in review), The Iñnik Sikumi field experiment, Alaska North Slope: design, operations, and implications for CO₂-CH₄ exchange in gas hydrate reservoirs: Journal of Energy & Environmental Science.

Collett, T., Bahk, J.-J., Baker, R., Boswell, R., Divins, D., Frye, M., Goldberg, D., Husebo, J., Koh, C., Malone, M., Morell, M., Myers, G., Shipp, C., and Torres, M., (in review), Historical methane hydrate project review: Journal of Marine and Petroleum Geology.

Haines, S., Hart, P., Collett, T., Shedd, W., Frye, M., Weimer, P., and Boswell, R., (in review), High-resolution seismic characterization of the gas and gas hydrate system at Green Canyon 955, Gulf of Mexico, USA: Journal of Marine and Petroleum Geology.

Nandanwar, M., Anderson, B., Ajayi, T., Collett, T., and Zyrianova, M., (in press), Evaluation of gas production potential of hydrate deposits in National Petroleum Reserve Alaska using numerical simulations.

Zyrianova, M.V., and Collett, T.S., (in review), Well log characterization and of natural gas hydrate accumulations in the Eileen Trend, Alaska North Slope: Journal of Energy & Environmental Science.

Project Near-Term Work Plan

Over the next project reporting period, the USGS will continue to play a key role in the planning for a DOE-JOGMEC-USGS sponsored gas hydrate production test on the Alaska North Slope, focusing on further characterizing the PBU Kuparuk 7-11-12 gas hydrate test site and contributing to the design of the actual test well program. The field program as currently conceived would consist of four primary phases. In Phase 1, a stratigraphic test well will be drilled and logged to confirm reservoir occurrence and condition. Assuming confirmation of viable reservoirs, the proponents would wish to proceed into a second Phase 2 to accomplish the establishment of the test site, including the installation of surface air and subsidence monitoring equipment, drilling of one or more monitoring wells including a full scientific logging, borehole geophysics, and coring program, and drilling and completion of a production test well. In Phase 3, the test well will be produced through a series of reservoir depressurization tests utilizing downhole pumps. Gas and water production rates will be closely monitored and samples collected. All samples will be analyzed in offsite labs. The tests will proceed for sufficient time (up to two years) such that reservoir deliverability can be confidently determined. In addition, a series of interventions and stimulations may be deployed as warranted, depending on the nature of the reservoir response. Should the well behave exceptionally well, planned events may be implemented to test approaches for maintaining and re-starting gas hydrate wells during well shut-ins and other mechanical disruptions. In Phase 4, the site will be abandoned per regulatory protocols.

In summary, the USGS will continue to (1) provide technical and scientific leadership for the formulation of research drilling and production testing program designed to assess the nature and production potential of gas hydrates on the Alaska North Slope, (2) provide personnel and resources to conduct field and laboratory analyses of material recovered by conventional and pressure core systems, and (3) partner in the synthesis of data from logging, direct sampling, and geophysical and geologic characterization studies.

COST STATUS

The total funds spent from this account during the period from 9/30/2014 through 9/30/2016) are summarized below along with the current project account balance.

Total DOE Award	\$	96,975.00
Expenses 10/1/2014 through 9/30/2015	\$	(23,927.00)
Overhead 10/1/2014 through 9/30/2015	\$	(11,034.00)
Expenses 10/1/2015 through 3/31/2016	\$	(2,771.00)
Overhead 10/1/2015 through 3/31/2016	\$	(1,564.00)
Expenses 4/1/2016 through 9/30/2016	\$	(3,026.00)
Overhead 4/1/2016 through 9/30/2016	\$	(1,708.00)
Project Account Balance (carryover)	\$	52,945.00

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