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Research Performance Progress Report (Period Ending 09/30/2018)

Alaska Natural Gas Hydrate Production Testing, Test Site Selection, Characterization and Testing Operations Project Period (09/01/2014 – 08/31/2019)

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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 (IA) 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 (04/1/2018 - 9/30/2018), the USGS has continued to contribute to the DOE- and industry-sponsored cooperative gas hydrate production testing project in northern Alaska. The major USGS contributions and recent accomplishments under this cooperative research effort with DOE include the following:

- The USGS is leading the technical efforts within a USGS, USDOE, and JOGMEC partnership to conduct a long-term (18-24 months) gas hydrate production test in northern Alaska.
- The drilling of the PBU Kuparuk 7-11-12 stratigraphic test well is now proposed for early FY-2019. The stratigraphic test well is part of a proposed three well program that also includes the drilling of a geoscience focused research well, and production test well.
- During this reporting period the USGS has worked with DOE and JOGMEC to develop an integrated Operator "Statement of Requirements" or SOR for the proposed Stratigraphic Test Well, which is now named the Hydrate-01 Well. This SOR systematically reviews the "operational and engineering requirements" that are being used to design the "Hydrate-01 Well Drill Plan".
- The USGS has worked with DOE and JOGMEC to develop a detailed plan for the potential long-term gas hydrate production test at the PBU Kuparuk 7-11-12 site with an emphasis on the data acquisition requirements for the proposed test well program.

- In FY-2019, the USGS will continue to (1) provide technical and scientific leadership for the formulation of a research drilling and production testing program designed to assess the production potential of 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/geologic characterization studies.

During this reporting period, the USGS has continued to lead the geologic research effort in support of the test site selection and characterization efforts. The USGS has also provided technical information and reviews of specific components of the potential future drilling and production testing program, including, but not limited to, drilling operations, analysis of physical properties of conventional and pressure cores, planning for post-field testing of cores, core flow, and downhole logging and coring plans. The USGS has recently participated two production test well design meetings that were convened in Anchorage, Alaska and the USGS also continues to contribute to a series of weekly and biweekly web style meetings in support of the project planning effort.

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EXECUTIVE SUMMARY

Project Scope and Accomplishments

Work conducted under this Interagency Agreement (IA) 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.

The cooperative research conducted under this IA is built on the strengths of a well-established applied research program and information obtained from a long history of highly successful field research projects in Alaska and other areas. The overall objective of the research conducted under this IA is to understand the ultimate energy resource potential of gas hydrates and to evaluate the technologies required to safely produce gas hydrate. These objectives are being achieved through a highly integrated research program structure that is built on a foundation of gas hydrate field and modeling studies, which contribute directly to the research activities associated with development of gas hydrate field characterization techniques which provide the information and data needed to identify and characterize the occurrence of gas hydrates suitable for gas hydrate production testing and analysis. The ongoing gas hydrate production test design part of this IA has been established to provide the production technologies to safely produce gas hydrates in Alaska and other settings.

In general, the goals of the task and subtasks under this IA remained the same over this reporting period (04/1/2018 - 9/30/2018) 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 has continued to play a key role in the planning for a potential 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 test well program. The USGS geologic and geophysical studies of the Eileen Gas Hydrate Trend have determined that the PBU Kuparuk 7-11-12 test site contains known gas hydrate occurrences and the existing infrastructure required for a successful production test.

The USGS geologic and geophysical studies of the Eileen Gas Hydrate Trend on the Alaska North Slope have determined that the PBU Kuparuk 7-11-12 test site contains known gas hydrate occurrences and the existing infrastructure required for a successful production test. The PBU 7-11-12 prospect was shown to contain three distinct gas-hydrate-bearing stratigraphic units (totally > 300 ft of reservoir section), which elevated

this prospect as the lead site for proposed Alaska North Slope gas hydrate production test.

The USGS has been leading the technical efforts within the USGS and DOE partnership to plan a potential long-term (18-24 months) gas hydrate production test in northern Alaska. The proposed gas hydrate testing program is designed to first confirm the conditions of the targeted reservoirs at the PBU Kuparuk 7-11-12 site with the drilling and LWD logging of a "stratigraphic test well". Assuming the confirmation of viable reservoir conditions, the stratigraphic test well would be converted to a monitoring well. The project would move ahead with the drilling of a "geoscience well" that would be used to acquire pressure cores and advanced log data; this well would also be converted to a monitoring well. The third well to be drilled at the test site would be the main "production test hole". During the testing phase, the test well would be produced through a series of reservoir depressurization tests. Gas and water production rates would be closely monitored and samples collected. The tests would proceed for sufficient time such that reservoir deliverability could be confidently determined. In addition, a series of interventions and stimulations could be deployed as warranted, depending on the nature of the reservoir response.

DOE, the Japan Oil, Gas and Metals National Corporation (JOGMEC), and the USGS have established a formal working relationship with the Prudhoe Bay Unit Working Interest Owners that deals with the development of a joint "Project Screening Study" or PSS that is designed to assess the feasibility of conducting a long-term production test at the PBU Kuparuk 7-11-12 site. The PSS has continued through this report period with most of this effort being led and coordinated through the consulting firm Petrotechnical Resources of Alaska (PRA). The USGS contribution to this effort has included technical input on G&G concerns and gas hydrate production test design. In addition, the USGS has played a key oversight role in the PSS by tracking the technical aspects of the operational plan being developed under this effort and ground truthing the budget being developed in support of the PSS.

During this report period the new USDOE-USGS-JOGMEC Working Group has continued their work. This work group is responsible for developing the "Base Plan" for the planned Alaska North Slope gas hydrate production test. The test "Base Plan" planning documents and reports have included the following: (1) An updated version of the project prospectus that deals with the major goals and design aspects of the planned Alaska North Slope gas hydrate production test; (2) A comprehensive outline of the gas hydrate production test data acquisition requirements (i.e., SOR); and (3) The development and refinement of a detailed depressurization well test plan and a contingency test well intervention plan.

As noted above, the PSS and Working Group efforts are also looking beyond the stratigraphic test well phase of the project, to determine design requirements for the testing phase. Cooperative gas hydrate production modeling studies are being conducted within the project partnership to determine what flow rates are required to understand the gas hydrate reservoir properties and production potential. These studies are also considering the test well design requirements (completion design, sand control,

flow assurance systems, gauges/measurement and control systems, production monitoring systems, etc.) to implement a successful production test.

Within the gas hydrate field test planning effort, the USGS has led the effort to develop and maintain the project "Statement of Requirements" or SOR for the proposed test well program. This documented systematically reviews the "scientific and engineering requirements" that need to be addressed under the planned three well testing program. This SOR also contains an assessment of the relative importance of the listed "scientific and engineering requirements" to achieving the overall goals of the planned production test. This SOR also includes a detailed list and analysis of the measurements and systems to be used to obtain the required samples and data during this testing program. Most recently this SOR has become the foundational planning document for the ongoing PSS and Working Group project planning efforts.

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 includes known gas hydrate occurrences and the existing infrastructure (i.e., gravel pad) required for a successful production test. The USGS in cooperation with JOGMEC, DOE, and SOA Department of Natural Resources (SOA-DNR) led the effort that identified and characterized the PBU 7-11-12 prospect, which elevated this prospect as the lead site for the proposed production test pilot. Under the current PSS, the project leadership group of DOE, JOGMEC, and the USGS met with Prudhoe Bay Unit Working Interest Owners in Anchorage, Alaska over the week of July 9-13, 2018 to further develop and finalize the SOR in support of the development of the drilling and completion plan for the Hydrate-01 stratigraphic test well. The SOR review meeting also included a workshop focused on a new G&G review of the PBU 7-11-12 test site. The project partners had gained access to a newly acquired and processed 3D seismic data volume from PBU 7-11-12 test site area. This new G&G test site review effort featured the use of the best available 3D seismic data volumes from the Greater Prudhoe Bay Unit area to validate conclusions from the State of Alaska (DNR) and USGS led Alaska North Slope site review efforts from 2015 and 2016. This new test site review study, yielded new products including higher resolution structure and fault maps of the primary (Unit B) and secondary (Unit D) test stratigraphic units, depth and position of the targeted test units, and the analysis of the types of pore-filling fluids (hydrate, gas, and/or water) associated with the targeted reservoirs.

In support of the Hydrate 01 Well SOR, a decision was made to deploy the Halliburton CoreVault system in the upcoming stratigraphic test well to acquire sidewall pressure cores from the primary and secondary reservoirs targeted at the PBU 07-11-12 test site to provide the measurements and data needed to support the design of the "completion" for the proposed production test well associated with this project. Because of the vast experience in the USGS with both conventional and pressure coring operations we were asked to coordinate the CoreVault acquisition plan for the Hydrate 01 Well. The USGS has hosted more than a dozen working meetings and discussions in Denver and Houston in support of the CoreVault planning effort. USGS scientists are also working with Weatherford to develop the commercial core analysis plan and contract in support of the post field study of the CoreVault acquired pressure cores.

USGS staff have also been working with JOGMEC and various service providers to develop the DTS and DAS fiber optic monitoring program for the Hydrate 01 stratigraphic test well. The goals of the DAS program in the Hydrate 01 Well has also been expanded to include the acquisition of a high resolution (more than 300 shot points) VSP after the completion of the well in late February 2019. USGS geophysicists have also been assigned to this project and are working with JOGMEC staff to review and refine the acquisition plan for the Hydrate 01 Well VSP survey.

During this reporting period, the USGS has continued to contribute to the PBU 7-11-12 test site gas hydrate production response modeling effort by providing the required geologic and engineering input data and assumptions needed to build accurate reservoir production models for both the Unit B and D targeted reservoirs at the PBU 7-11-12 test site. The USGS has also continued to lead the efforts to evaluate the advanced drill site and borehole acquisition systems needed to monitor the response of the gas hydrate reservoirs and completion systems to the production of hydrates over the duration of the planned field test.

Project Meetings, Outreach, and Presentations (for the period 4/1/2018 - 9/30/2018)

April 1, 2018 through September 30, 2018: USGS staff organized and/or contributed to the following regular weekly and biweekly meetings and briefings in support of USGS and DOE funded/participating project efforts:

- Alaska North Slope Gas Hydrate Production Testing project sponsor meetings with representatives from DOE, NETL, USGS, JOGMEC, PRA, and various project members and leadership. These meetings have mostly dealt with the Alaska North Slope Gas Hydrate Test Program PSS and the development of the SOR in support of the Hydrate 01 Well operational plan (SOR).
- University of Texas, Gulf of Mexico 2 Gas Hydrate Project planning meetings with representatives from DOE, NETL, USGS, LDEO, Geotek, and various project members and leadership.

April 9-15, 2018: USGS staff co-hosted and participated in a technical review and project planning workshop in support of the India National Gas Hydrate Program (New Delhi, India). (DOE funds were not used to support this travel, included for informational purposes)

June 3-6, 2018: Tim Collett participated in a IODP and University of Tromsø sponsored Magellan Workshop that focused on the development of a proposal to conduct scientific drilling of an expected gas hydrate accumulation on the Vestnesa-Svyatogor Ridge, which is located east of Greenland near Svalbard. (DOE funds were not used to support this travel; IODP funded the USGS staff travel in support of this workshop)

June 9-13, 2018: The USGS staff participated in a high-level workshop in Anchorage, Alaska with representatives from the US Department of Energy (DOE), Japan Oil, Gas and Metals National Corporation (JOGMEC), SOA Department of Natural Resources and the Prudhoe Bay Unit Working Interest Owners, to develop an integrated Operator

“Statement of Requirements” or SOR for the now scheduled Hydrate 01 Stratigraphic Test Well.

September 12-14, 2018: The USGS staff participated in a CoreVault operational workshop and field test hosted by Halliburton in Houston, Texas. This workshop and field test focused on the development of an operational plan to acquire sidewall pressure cores in the Alaska North Slope Hydrate 01 stratigraphic test well.

September 24-25, 2018: USGS staff (Collett, Waite, Junbong) participated in a University of Texas Gulf of Mexico Gas Hydrate Drilling Program workshop hosted at Ohio State University in Columbus, Ohio. The goals of this workshop included the review of the scientific results of the 2017 Gulf of Mexico Gas Hydrate 2-2 Expedition and the development of a scientific and operation plan for the next Gulf of Mexico scientific drilling expedition now scheduled for 2021.

Publications (for the period 4/1/2018 - 9/30/2018)

Flemings, P.B., Phillips, S.C, Collett, T.S., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018, Expedition UT-GOM2-1 of the vessel Helix Q-4000 from Brownsville, TX (USA), to Port Fourchon, LA (USA) Sites GC 955 H002 (API # 608114068600) and GC 955 H005 (API # 608114068700) 2-May-2017 to 24-May-2017; work was supported by the U.S. Department of Energy under Contract No. DE-FE0023919. <https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/expedition-scientists>

Qian, J., Wang, X., Collett, T.S., Guo, Y., Kang, D., and Jin, J., 2018, Downhole log evidence for the coexistence of structure II gas hydrate and free gas below the bottom simulating reflector in the South China Sea: *Journal of Marine and Petroleum Geology*, v. 98, p. 662-674

Boswell, Ray, Myshakin, Evgeniy, Moridis, George, Konno, Yoshihiro, Collett, T.S., Ajayi, Taiwo, and Seol, Yongkoo, (in press), India National Gas Hydrate Program Expedition 02 summary of scientific results: Numerical simulations of gas hydrate reservoirs: *Journal of Marine and Petroleum Geology*.

Boswell, Ray, Yoneda, Jun, and Waite, William, (in press), India National Gas Hydrate Program Expedition 02 summary of scientific results: Evaluation of natural gas hydrate-bearing pressure cores: *Journal of Marine and Petroleum Geology*.

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*, 125 p.

Collett, T.S., Boswell, Ray, Waite, William F., Kumar, Pushpendra, Pratap, Mahendra, Roy, Sandip Kumar, Chopra, Krishan, Singh, Sunil Kumar, Yamada, Yasuhiro, Tenma, Norio, Pohlman, John, Zyrianova, M.V., and NGHP Expedition 02 Scientific Party, (in review), India National Gas Hydrate Program Expedition 02 summary of scientific results: *Gas*

hydrate systems along the eastern continental margin of India: Journal of Marine and Petroleum Geology.

Kumar, Pushpendra, Collett, T.S., Shukla, K. M., Yadav, U. S., Lall, M. V., Vishwanath, Krishna, and NGHP-02 Expedition Scientific Party, (in press), India National Gas Hydrate Program Expedition 02 operational and technical summary: Journal of Marine and Petroleum Geology.

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: Bulletin of the American Association Petroleum Geology, 64 p.

Project Near-Term Work Plan

If approved, the USGS will provide staff and technical support for the Hydrate 01 stratigraphic test well that is scheduled to be drilled in early FY-2019. In addition, the USGS will continue to provide technical and scientific leadership for the formulation of the research drilling and production testing program design. In support of the proposed Alaska production test well project, the USGS will conduct field and laboratory analyses of material recovered by conventional and pressure core systems, and partner in the synthesis of data from logging, direct sampling, and geophysical and geologic characterization studies.

In the near-term, the USGS will continue to work with providers of proven industry developed distributed wellbore monitoring systems to finalize the deployment plan for these systems. The USGS will also continue to lead the detailed planning efforts associated with logging-while-drilling (LWD), wireline logging (WLL), and sidewall coring operations as being designed for the Hydrate 01 stratigraphic test well.

COST STATUS

The total funds spent from this account during the period from 10/01/2014 through 09/30/2018) are summarized below along with the current project account balance.

Total DOE Award FY2015	\$ 51,608.00
Total DOE Award FY2016	\$ 45,367.00
Total DOE Award FY2017	\$ 47,197.00
Total DOE Award FY2018	\$ 86,528.00
Total DOE Award (FY2015-FY2017)	\$ 230,700.00
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)
Expenses 10/1/2016 through 8/1/2017	\$ (9,333.00)
Overhead 10/1/2016 through 8/1/2017	\$ (5,350.00)
Overhead 10/1/2017 through 5/22/2018	\$ (1,538.00)
Expenses 4/1/2018 through 9/30/2018	\$ (3,263.00)
Overhead 4/1/2018 through 9/30/2018	\$ (1,874.00)
Project Account Balance (5/22/2018)	\$ 165,312.00

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