Oil & Natural Gas Technology

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Quarterly Progress Report
(Period ending March 31th, 2014)

Gas Hydrate Dynamics on the Alaskan Beaufort Continental Slope: Modeling and Field Characterization
Project Period: October 1, 2012 – September 30, 2015

Submitted by:

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ABSTRACT

FY2014 2nd quarter research associated with the DE-FE0010180 grant required progress on four fronts. The first involved the development of revised FY2014 milestones and deliverables resulting from a 1 year delay in the research cruise. The revised FY2014 milestones consist of three components and two deliverables. These include (1) the initial development of methane hydrate models comparing 1977 USGS legacy data with 2012 USGS data, (2) further experimental development of synthetic methane seeps for integration with future cruise results, and (3) the identification of a potential ship that we might use as a research platform by 9/1/2014. We have made progress on each of these three milestones. Specifically, for milestone one, SMU spent the second quarter of FY2014 dedicating significant effort towards the revision of the numerical model so that it will be easily implemented with USGS 2012 data that we have begun analyzing. For the second milestone, researchers at OSU continue to develop more advanced synthetic seep models for constraining methane emission on the Beaufort margin. For the final milestone, the USGS continues to explore ship options and will soon file Ship Time Requests for a UNOLS vessel as well as request bids for potential contract vessels. Additional updates include the resubmission of a revised manuscript to JGR outlining 1977 numerical modeling results and the integration of fluid advection in the numerical model. SMU and the USGS also both presented preliminary finding for this work at the Gordon Research Conference, in Gaveston, Texas, during March of this quarter.

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EXECUTIVE SUMMARY

In October 2012, Southern Methodist University in close partnership with The United State Geological Survey at Woods Hole and Oregon State University, began investigating methane hydrate stability in deep water (>100 mbsf) environments below Alaskan Beaufort Sea. This research is part of a three-year study funded by the Department of Energy's (DOE) National Energy Technology Laboratory (NETL). Key goals of this study include integrating and processing marine seismic data collected at the USGS with dynamic 2D/3D/4D heat flow models developed at SMU to determining the depth, location, and dynamics of methane hydrate stability along the Alaskan Beaufort Margin. A key component of this study is to constrain how the methane hydrate stability zone is changing with time. Additional goals of this study include determining areas where concentrated methane hydrate might exist in the subsurface and to understand the role methane hydrate plays in slope stability along the Alaskan Margin.

FY2014 second quarter research associated with the DE-FE0010180 grant required progress on three fronts based on a revised set of milestones for FY2014. Specifically, the second quarter of FY2014 was dedicated to (1) integrating numerical modeling with 2012 USGS data and revising 1977 model results, (2) continuing pre-cruise artificial methane seep experiments at OSU, and (3) moving towards securing a ship contract for 2015. Scientifically, significant progress was made on several fronts, with further model advancement at SMU and continued experimental advancement of an artificial methane seep site at OSU that we will use to ground truth results for the upcoming cruise. Additionally, during the past quarter, SMU and USGS researchers presented preliminary results from the DOE study at the Gordon Research Conference.

PROGRESS AND RESULTS

Due to a 1 year delay in the cruise, both researchers and DOE managers agreed a revised set of milestones and deliverables for FY2014 was needed to move the project forward. Below, we outline the revised milestones and deliverables for FY2014, as agreed upon by both the PIs and DOE. Each of these milestones represents a component of the original milestones listed in our statement of purpose for the project, and therefore these milestones represent no changes to the scientific goals or objectives. However, the timing involved in achieving them has changed slightly. For example, milestone 2 was originally supposed to be conducted in year 2 but not fully completed until year 3 of the study. Given the progress made by OSU researchers, we have moved a component of milestone 2 into year 2. Following discussion of the revised milestones and deliverables, we note progress towards each of these milestones during the 2nd quarter of FY2014 (SMU, OSU, and the USGS).

REVISED MILESTONES FOR FY2014

Milestone 1 (SMU-lead): Completion of numerical modeling of hydrate stability based on comparisons between 1977-2012 USGS datasets.

Deliverables: an initial manuscript in draft form by 9/1/2014.

Milestone 2 (OSU-lead): Complete analyses and synthesize molecular biology data and water chemistry data for artificial methane seeps as model systems where incipient gas flux in sediments causes changes to microbial community structure and recruitment of key microbes.

Deliverables: Abstract submitted for presentation at Fall AGU meeting by August 2014, and progress towards a draft manuscript by the end of the fiscal year.

Milestone 3 (USGS-lead): Identify a ship that we may use as a potential research platform for summer 2015 by 9/1/2014.

Milestone #1 Progress:

In March, SMU was provided a 2012 sparker seismic line from the USGS that is nearly coincident with a 1982 industry survey line. SMU researchers have since started loading and interpreting this data. Our goal is to use the 2012 data to develop dynamic numerical models extending from 1982 to the present. Currently, we are reconfiguring the numerical heat flow model used for 1977 seismic data heat flow modeling so that it applies to the 1982 and 2012 dataset. This reconfiguration requires developing a model with potentially higher grid spacing to account for higher resolution sparker data collected by the USGS in 2012. scaling differences between the two different seismic datasets have made model development a challenge, however, we anticipate we will have a preliminary model results by the completion of the next quarter.

In addition to developing a dynamic numerical model, we have been integrating advective fluid flow into our model parameters to better understand the role of fluid flow in hydrate stability along the margin. Preliminary results from advection models demonstrate that the anomalously deep BSRs we observe in 1977 data along the Beaufort Margin cannot easily be explained via fluid advection from the shelf. This result is also now included in the Appendix of our revised manuscript for JGR-Solid Earth that will be resubmitted this quarter.

Milestone #2 Progress:

OSU continues to make significant progress with its artificial methane seep experiments. UC Santa Cruz undergraduate Daisy Castillo will return during summer 2014 to continue re-

search that she started in 2013 on the artificial methane seeps that were developed in Yaquina Bay. Castillo will repeat some of the 2013 experiments, and conduct molecular analyses to identify methanotroph communities in the methane-stimulated sediments. She will complete the project at the end of the summer by drafting a manuscript that will be submitted for peer review publication on the design and characterization of artificial methane seeps.

In order to capitalize on the DOE-FE's support for this research and to take advantage of DOE Office of Science research capabilities, Colwell and Graw submitted a Letter of Intent to the Joint Genome Institute (JGI) - Environmental Molecular Sciences Laboratory (EMSL) Collaborative Science Initiative in early April. By late April, we received word that the LOI has been approved and a full proposal is requested (due May 27). The proposal (entitled: ***Integrated biogeochemical modeling of microbial consortia mediating anaerobic oxidation of methane in dynamic methane hydrate-bearing sediments***) will allow us to perform whole-genome shotgun sequencing on environmental isolates obtained from areas like the Beaufort Slope sediments, assemble the genomes for these organisms (using JGI resources) and utilize metatranscriptomic and metabolomic data from the same set of samples (using EMSL resources) to guide construction of the individual metabolic models for microorganisms involved in anaerobic methane oxidation. If this proposal is funded, it will dramatically increase the cost-sharing aspect of the research giving the team access to the instrumentation and computational resources of these DOE User Facilities.

To prepare for field sampling in the Beaufort Sea, during April and May, Michael Graw (OSU graduate student) is aboard the RV Tangaroa obtaining core samples from the Hikurangi Margin off New Zealand in a hydrate rich area. Core samples being collected will be used in preparation for sampling in the summer of 2015 in the Beaufort Sea. Geochemical and microbiological samples being acquired by Graw will be consistent with the studies to be performed as a part of this project and give Graw valuable seagoing experience prior to the 2015 field research.

Milestone #3 Progress:

Having thoroughly explored known ship options for the planned coring and heat flow cruise, we will be releasing a request for informational quotes to prospective commercial vessels along with a task order containing the required specifications. We will also be filing Ship Time Request(s) in the UNOLS system.

Additional Results

Results from this study were presented both by the USGS and SMU at the Gordon Research Conference in Galveston Texas this March. These presentations included a poster by Ben Phrampus (SMU) outlining our analysis of the 1977 seismic data showing direct evidence for hydrate destabilization along the margin, and an oral presentation by Carolyn Ruppel that synthesized multiple DOE-funded studies in the arctic that demonstrate hydrate instability along the shelf and margin, but no clear evidence for elevated methane concentrations in the atmosphere.

Additionally, we have received reviews back from our JGR-Solid Earth manuscript, which we have revised and will resubmit to JGR in the next few days. Both reviews suggested we look further at the potential role of fluid flow in hydrate instability along the margin. As a result, the revisions include a more detailed fluid flow analysis, including an advection component that we have now added to our model that provides valuable insight into the role of fluid flow in causing hydrate instability across the Beaufort Margin. There is some evidence for low (< 0.01-1 m/s) advection rates along the shelf. Our analysis demonstrates it is very unlikely that fluid flow plays a role in explaining the anomalously deep BSRs we observe on the margin, and this is primarily because it require very deep (~1000 m) and very cold fluids for low (~ 1 m/s) advection rates to explain observations. It is hard to explain why such deep, slow moving fluids would be cold enough to cause such an anomaly. We now include a more detailed analysis outlining the role fluid flow plays in hydrate stability in the Beaufort in an Appendix of our revised manuscript.

COST STATUS

Costs incurred on DOE Grant by SMU (not including SMU matching):

--RA support + fringe for Hornbach's graduate student, Ben Phrampus: $6,831

--Subcontract to OSU for research support and cruise preparation:$3,781

--Travel for SMU researchers to the Gordon Reasearch Conference: Not yet posted.

--Overhead: $2328.62

Total approximate expenditures charged to DOE on SMU Grant in Quarter #1: ~$12,941.

Total approximate matching support provided by SMU for Quarter #1: ~$3,674

PROBLEMS OR DELAYS

None, besides 1 year cruise delay noted during the last quarter.

CONCLUSIONS AND FUTURE DIRECTIONS

We continue to make progress assessing the dynamics of methane hydrate stability on the Beaufort Margin. The numerical models comparing past and present BSR depth that we are analyzing now will represent a key result of this study that constrain the timing and scale of methane hydrate destabilization in this region. We anticipate having initial results for presentation to DOE by August and a preliminary draft manuscript in september. The synthetic seep experiments at OSU continue to progress ahead of schedule, and we anticipate researchers will have an AGU abstract near completion by the time of the next quarterly report.

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