Oil & Natural Gas Technology

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Quarterly Progress Report
(Period ending March 31st, 2015)

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

Submitted by:

Digitally signed by Matthew J. Hornbach on 6/25/2015
Matthew J. Hornbach
Associate Professor of Geophysics
Southern Methodist University
DUNS #:001981133.
P.O. Box 750302
Dallas, Texas 75275
e-mail: mhornbach@smu.edu
Phone number: (214) 768-2389

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United States Department of Energy
National Energy Technology Laboratory

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ABSTRACT

The 2nd quarter of FY2015 research focused on (1) expanding the program and obtain funds so that both an Atlantic research cruise could occur in the summer 2015 by adjusting the statement of work and (2) the continued development of a comprehensive basin-scale heat-flow model for hydrate stability and heat flow evolution along the western Atlantic margin. The Atlantic cruise is tentatively scheduled on the *R/V Sharp* for fall of 2015, while the Beaufort Sea cruise is tentatively scheduled on the *M/V Norseman II* for summer 2016. During the 2nd quarter, Hornbach and Phrampus completed their preliminary modeling of a 2D/3D Basin-wide heat flow model that defines both methane hydrate stability and basin temperature evolution along the western Atlantic Margin. This new model integrates currently available offshore measurements combined with newly acquired high-resolution multi-channel seismic data collected on the US East Coast during the ENAM cruise. These data are publically available, contain high-resolution images of several newly discovered BSRs, and, therefore, are ideally suited for improved heat-flow analysis, evolution and hydrate stability along the US eastern margin. Results demonstrate that heat-flow progressively increases seaward, as expected for slow-spreading oceanic sediment, and that heat flow is low across most of the margin. The analysis, which accounts for sediment compaction, fluid advection, radiogenic heat production, and rifting also indicates that hydrocarbon maturation occurs along the margin at depths of approximately 2km. Phrampus and Hornbach are writing up these results for the *Journal of Marine and Petroleum Geology*.

TABLE OF CONTENTS

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) that is currently being expanded into a 4 year study that include additional heat flow analysis in the Atlantic. Key goals of this study include integrating and processing marine seismic data collected at the USGS as well as other publically available data 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 major 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. To accomplish these goals, we will use geophysical (seismic, heat flow, CTD/XBT) data combined with numerical models to assess methane hydrate stability in space and time. We will also integrate regional coring and biological data with methane hydrate stability models to place further constraints on hydrate dynamics.

PROGRESS AND RESULTS

SMU Progress on heat flow modeling in the Atlantic:

As noted in the previous quarterly report, Hornbach and Phrampus have been integrating recently collected MCS seismic data off the US east coast as part of the ENAM NSF-funded study with legacy 1977 USGS data to develop the first true 3D heat flow map for the Western North Atlantic Continental Margin. To model heat flow, we incorporate sedimentation rates, sediment compaction, fluid advection, initial rifting temperature, and radiogenic heat production. Results show that heat flow increases seaward of the margin in a manner consistent with seafloor spreading. The results also indicate that the heat flow is currently relatively low across most of the margin. Using these results, we forward model the temperature of the margin with time and demonstrate that hydrocarbon formation occurs along the margin at depths of approximately 2 km below the seafloor. Consistent with model predictions, we observe several hydrocarbon indicators in the newly collected ENAM seismic data at these depths. These results, which provide the first broad heat flow analysis of the margin, are currently being written up in manuscript form and will be submitted to the *Journal of Marine and Petroleum Geology* this summer.

SMU Progress on hydrate stability modeling in the Atlantic:

Hornbach and Phrampus have also begun a detailed study of methane hydrate stability modeling along the upper margin where we observe several unusual BSR features along the margin edge between the Cape Fear and Cape Lookout slides. To complete this analysis, Hornbach and Phrampus have been working with Colleagues at Lamont-Doherety Earth Observatory at Columbia University to develop the highest resolution possible pre-stack depth migrated images of the margin edge. Using these data and recent ocean temperature data obtained from the 2014 ENAM cruise, Hornbach and Phrampus have started modeling the hydrate stability zone in detail along the margin edge where we see BSRs at anomalous depths. Although results are preliminary, the analysis indicates that the hydrate stability zone appears to be unstable over a very broad region (tens to hundreds of kilometers), and that a double BSR exists between a zone of concentrated hydrate at depths of approximate 200 mbsf. The analysis, if correct, has important implications for hydrate stability, slope stability, and resource potential. We are only at the very beginning stage of this analysis, but we hope to have more definitive results by the fall that we can submit for peer review.

USGS progress on Atlantic ship scheduling:
During the past quarter, the USGS and SMU have worked with ship contractors at the University of Delaware to line up the timing, equipment, and personnel for the fall 2015 cruise on the R/V Sharp. This is on-going.

SMU/USGS progress on SOW revisions:
Revisions continued for the revised statement of work between DOE, the USGS, and SMU.

COST STATUS

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

--Total spent/encumbered for OSU subcontracting for research/personel to date: ~$124,000

--Total funds spend/encumbered by SMU on research time/support to date:$121,000
(SMU is currently in a no-cost extension)

--We anticipate a large expenditure next quarter related to subcontracting cost of the R/V Sharp

PROBLEMS OR DELAYS

CONCLUSIONS AND FUTURE DIRECTIONS

SMU will continue to write up the basin scale heat flow model for the Atlantic with the goal of having a new publication ready for submission by this summer. Hornbach and Phrampus will be presenting their initial results on Atlantic Margin heat flow evolution at an energy industry conference held next quarter at SMU. The USGS will be finalizing all logistics for the upcoming cruise on the *R/V Sharp*. Hornbach and Phrampus will continue to analyze and model hydrate stability using the newly acquired ENAM MCS data.

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

13131 Dairy Ashford, Suite 225
Sugarland, TX 77478

1450 Queen Avenue SW
Albany, OR 97321-2198

Arctic Energy Office
420 L Street, Suite 305
Anchorage, AK 99501

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