Oil & Natural Gas Technology

DOE Award No.: DE-FE0010180

Quarterly Progress Report
(Period ending March 31st , 2017)

Gas Hydrate Dynamics on the Alaskan Beaufort Continental Slope: Modeling and Field Characterization
Project Period: October 1, 2012 –March 31st, 2017

Submitted by:

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

May 1st, 2017

Office of Fossil Energy

ABSTRACT
The final quarter of this project (Jan – March, 2017) was spent writing up results in peer-reviewer journal format. SMU and OSU researchers (Hornbach and Phrampus) also met in Dallas Texas to discuss final adjustments/changes to two manuscripts in preparation and one in review. Hornbach Also presented findings from the fall 2016 Beaufort Sea Cruise at The University of California Berkeley. At least one of the two manuscripts in preparation will be submitted this spring (likely within the next few weeks) to a high-impact scientific journal. This study demonstrates that intermediate ocean temperatures in the arctic ocean are warming at rates comparable to earth surface warming, with clear implications for methane hydrate stability in the arctic.

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EXECUTIVE SUMMARY

In October 2012, Southern Methodist University in 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. In late 2014, the project was further expanded to include analysis of methane hydrates and slope stability off the US east coast. This research is now at the conclusion of 4.5 year study funded by the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) that analyzes methane hydrate stability on both the Atlantic and Beaufort Margin. 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 and similar environments. 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 continental margins. To accomplish these goals, researchers use geophysical (seismic, heat flow, CTD/XBT) data combined with numerical models to assess methane hydrate stability in space and time. Researchers also integrate regional coring and biological data with methane hydrate stability models to place further constraints on hydrate dynamics.

PROGRESS AND RESULTS

The final quarter of the this project has been spent writing manuscripts for peer review that assess methane hydrate stability and ocean temperature change in the US Beaufort Sea. During this final quarter, researcher discussed via phone and at a meeting (Phrampus and Hornbach at SMU for a NSF-funded workshop) one manuscript currently in review, and two other manuscripts currently in preparation. Below I provide updates on these manuscripts.

Atlantic Margin Heat Flow and Methane Hydrate Stability (Phrampus et al., in review): This manuscript focuses on understanding both current Atlantic Margin heat flow and methane hydrate stability as well as the evolution of hydrate stability on the margin since rifting began 200 Ma. The manuscript received positive reviews with a revise and resubmit requested. A key request of the reviewers is that the study include additional 1D/2D basin evolution/compaction models. With model runs now complete, a revised version of the manuscript has been resubmitted.

Significant Intermediate ocean water warming in the Arctic Ocean destabilizing Methane Hydrate (manuscript 2, in preparation): we have completed our analysis of heat flow and thermal conductivity measurements made on the upper US Beaufort Margin. Our results indicate highly erratic ocean temperature swings occur along the margin edge not only on an annual basis, but perhaps more importantly, over decadal timescales, with significant and detectable ocean warming occurring at depths as great as 800 mbsl. Perhaps more importantly, rates of warming are significant, and will likely have a major impact on methane hydrate stability in the next few dec-

ades, with warming rates as high as 0.2 deg. C/decade--rates comparable to surface air temperature warming on earth). We intend to submit this work to a high impact journal in the next month.

Heat Flow below the US Beaufort Margin (focus of manuscript 3, in preparation): We have merged measured heat flow values along the entire margin to generate a more complete, basin-wide picture of heat flow for the US Beaufort Margin. The analysis indicates that systematically higher heat flow values exist in the western third of the margin. The cause of these high heat flow values (which are more than three times higher than background values at some locations) remains unclear, however, our draft manuscript provides three hypotheses for why these heat flow anomalous exist. The study will be very valuable in assessing hydrocarbon maturation and evolution along the Beaufort Margin and will likely lead to further study of the margin. We anticipate that this manuscript will besubmitted by this summer.

Meetings/Presentations this Quarter:

--Phrampus and Hornbach Met at SMU in Dallas, Texas this spring at an NSF-funded conference to discuss ongoing DOE results and manuscript preparation.

--Hornbach presented preliminary results from the fall 2016 Beaufort Sea heat flow cruise at an invited talk at the University of California, Berkeley. Talk title, "*New heat flow and seismic imaging results from the US Beaufort Sea: implications for ocean temperature change and methane hydrate stability*"

COST STATUS

Below we outline the current cost status for the project as we near project completion. Based on conversations I have had with all parties, my understanding is that we have spent out all DOE funds with appropriate cost-shares supplied by all parties, however, this is not yet fully represented in the current budget as not all parties (OSU and Bremen) have fully updated data (up to March 31st.

Importantly, the following should be note regarding cost share:

1. We received a certification from UCLA confirming their cost share.

2. We have not yet received the certification of cost share back from University of Bremen. We hope to have an update regarding this soon.

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Addtionally, Nearly all of the apparent $85,384.99 remaining Federal Funds balance is committed to the OSU sub-award, and is expected to be fully allocated in the coming weeks for expenses incurred during the project period (10/01/2012-03/31/2017).

Note that SMU *has* received the cost share certification from UCLA, though it may or may not appear on this quarter's SF-425, so remaining balances and amounts expended for the quarter are shown both with and without the UCLA cost sharing included. Over 93% of the $65,355.31 remaining Recipient Funds balance is expected to be satisfied by the University of Bremen cost share commitment of $61,200. Final certification from University of Bremen has been requested but, again, has not yet been received.

	Federal Funds	Recipient Funds*	Total Project Funds
Total Award Authorized 10/01/2012 - 03/31/2017	$ 1,330,615.00	$ 387,716.00	$ 1,718,331.00
Cumulative Expended* 10/01/2012 - 03/31/2017	$ (1,245,230.01)	$ (249,779.69)	$ (1,495,009.70)
Remaining Balance* As of 03/31/2017	$ 85,384.99	$ 137,936.31	$ 223,321.30
Expended* 01/01/2017 - 3/31/2017	$ (349,433.17)	$ (118,413.33)	$ (467,846.50)
Cumulative Expended* 10/01/2012 - 03/31/2017 With UCLA	$ (1,245,230.01)	$ (322,360.69)	$ (1,567,590.70)
Remaining Balance* As of 03/31/2017 With UCLA Included	$ 85,384.99	$ 65,355.31	$ 150,740.30
Expended* 01/01/2017 - 3/31/2017 With UCLA Included	$ (349,433.17)	$ (190,994.33)	$ (540,427.50)
Cumulative Expended* 10/01/2012 - 03/31/2017 With UCLA	-93.58%	-83.14%	-91.23%
Remaining Balance* As of 03/31/2017 With UCLA Included	6.42%	16.86%	8.77%

* "Expended" refers to when charges were booked, rather than when incurred. Similarly, recipient cost share allocations may not be reported in the month in which they are incurred. Remaining funds will be allocated to expenses incurred prior to the contract expiration date of 03/31/2017.

PROBLEMS OR DELAYS

Despite a short time window (our Beaufort Sea cruise was completed just over six months ago), we have made significant progress, and I have been very pleased with speed at which we have been able to (1) process/analyze thermal conductivities, (2) develop initial heat flow estimates, (3) generate initial 1D/2D model results, and, from this, (4) produce preliminary manuscripts. As noted above, I anticipate two more manuscripts either accepted or at least in review by the end of June and a third, overview manuscript assessing regional heat flow submitted by the end of the summer.

CONCLUSIONS AND FUTURE DIRECTIONS

We remain on schedule with research and reporting requirements and look forward to presenting our results in our final report. We remain confident that two manuscripts will be submitted within the next few months related to this work.

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