Oil & Natural Gas Technology

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Quarterly Progress Report
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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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ABSTRACT

The 1st quarter of FY2016 research focused on (1) AVO analysis of methane hydrate deposits on the US Western Atlantic Margin, (2) continued circulation/editing of a draft manuscript assessing Atlantic Margin heat flow and hydrate stability based on recently collected ENAM seismic lines, (3) preparation and planning for the 2016 Arctic cruise, and (4) analysis of data collected on the R/V Sharp this past fall. SMU researchers have been analyzing AVO data collected on the US east coast to develop a more quantitative approach for assessing subsurface pore pressures along the margin, and from this, better understand how ocean warming contributes to changes in pore fluid pressure and slope stability on the margin. After initial reviews, we have also re-revised a manuscript assessing heat flow, hydrates, and hydrocarbon maturity on the US East Coast. In addition, SMU researchers held a meeting with Rob Harris from OSU in Dallas to finalize shipping plans to the M/V Norseman, and also had several conversations with contractors firming up ship operations, timing, and procedures.

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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. 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 part of a now 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

SMU Atlantic Margin Research progress:

With access to ENAM data publically available, SMU researchers have been analyzing pore fluid pressures on the Atlantic Margin using AVO techniques. The goal of this approach is to decipher how changes in AVO response indicate changes in sediment strength, and in particular, changes in pore-fluid pressure. We have completed a preliminary analysis looking at data near Blake Ridge where high quality well control from ODP Leg 164 exists, and are now analyzing data near the Cape Fear Slide. Multiple recent studies indicate methane hydrate destabilization may lead to slope failure, sliding, and perhaps in some instances, tsunami generation. Our analysis based on last year's work on this project (and our recent publication in *JGR*) already demonstrates that hydrates are currently destabilizing both along the North Slope of Alaska and off the US eastern seaboard. Assessing slope stability requires a detailed assessment of in situ pore pressure. Higher pore pressures result in lower effective stress, with near lithostatic pressures implying very small changes in the subsurface stress regime will trigger failure. Thus, if we see evidence for locations with anomalously high subsurface pressures, we can effectively pin-point areas that are at highest risk for future slope failure in a region. Detecting subsurface pore pressure without in-situ measurements (via drilling or monitoring) however is difficult. A key tool for remotely detecting zones of elevated pore pressures in the subsurface is the integration of high resolution seismic velocity/amplitude data with rock physics models (e.g. Dvorkin et al., 1999; Mavko et al., 2011). Although the approach is limited in that it typically can only detect pore fluid pressures in excess of 60% lithostatic-hydrostatic pore pressure ratio (e.g. Hornbach & Manga, 2014), it is a proven tool for pin-pointing with meter-scale accuracy zones where near lithostatic fluid pressures may exist. For the past quarter, researchers at SMU have been using amplitude versus offset (AVO) analysis on high resolution seismic data to detect zones where anomalously high pore pressures likely exist in the subsurface. The current analysis conducted at SMU compares near offset versus far-offset seismic line stacks in sediments where clear BSRs exist in the subsurface. Comparison of these lines indicates surprising AVO anomalies that we have link directly to variations in Vp and Vs and Poisson's Ratio using rock physics models. Specifically, using forward models for amplitude versus offset (e.g. Shuey approximation), we reconstruct observed AVO anomalies using a best-fit approach for Vp and Vs and sediment matrix parameters derived from regional well logs. We then estimate in situ pore fluid pressure by integrating our best fit solution into a first-principles rock physics model. We are currently conducting this analysis to determine the location of where the highest pore fluid pressures exist above methane hydrate provinces along the US east coast. Initial results will be presented at the upcoming Gordon Research Conference in February-March 2016.

SMU Preparations for the Fall 2016 heat flow cruise in the Beaufort Sea: During the past quarter, SMU has also been preparing for the upcoming 2016 cruise in Alaska. We held a meeting with Rob Harris at OSU in Dallas in mid-november to discuss timing, logistics, including shipping, costs, and ship scheduling. We have also continued our discussion with contractors for the M/V Norseman II to ensure that the heat flow equipment we will use for the cruise is capable of being deployed easily from the ship. It appears we should be able to deploy the equipment at all water depths shallower than 2000 m, which is well within the target range of our study.

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COST STATUS

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

--Total spent/encumbered for OSU subcontracting for research/personnel to date: ~$214,039

--Total funds spent by SMU on research time/support to date:~$82,692
(SMU is currently in a no-cost extension)

--Total funds spent for subcontract for the R/V Sharp and associated ship costs: ~$227,000

PROBLEMS OR DELAYS

--None

CONCLUSIONS AND FUTURE DIRECTIONS

We remain on course with research, ship scheduling, and data analysis. All of this will continue in the next quarter and will include a presentation at the GRC during Q2 FY16 discussing preliminary results associated with AVO/pressure analysis.

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