

Oil & Natural Gas Technology

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Quarterly Report

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Gas Hydrate Characterization in the GoM using Marine EM Methods

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EXECUTIVE SUMMARY

Work continued on laboratory electrical conductivity measurements of several hydrate-sediment mixtures. A *Geophysical Research Letters* paper was published this June on the activation energy and Arrhenius relationship of polycrystalline methane hydrate conductivity. A *Geophysical Journal International* paper is in press about the geological interpretation of the Hydrate Ridge CSEM survey. This quarter our work was presented at the MARELEC meeting in San Diego, at the ICGH7 meeting in Edinburgh, Scotland, and at the University of Southampton, UK. The total field navigation OCCAM code has been sped up and now includes a half-space resistivity for the transmitter.

PROGRESS, RESULTS, AND DISCUSSION

Phase 1.

Task 1.0: Project Management Plan.

Completed November 5, 2008.

Task 2.0: Technology Status Assessment.

This is embodied in the original proposal.

Task 3.0: Collect Marine CSEM Field Data.

Completed October 26, 2008.

Task 4.0: Preliminary Field Data Interpretation.

Completed October 2009.

Task 5.0: Design and Build Conductivity Cell.

Completed July 2010, results presented in Year 2, Quarterly Report 3.

Phase 2.

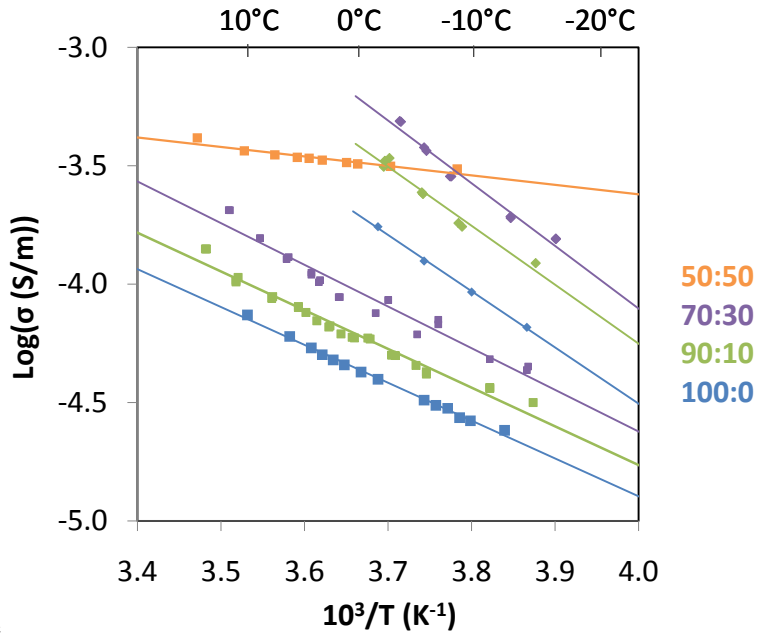
Task 6.0: Make Hydrate and Hydrate/Sediment Conductivity Measurement.

During this quarter we measured the electrical conductivity impedance spectra for four different hydrate-sediment mixtures: Run 4, a 50:50 OK#1 sand and hydrate mixture; Run 5, a 10:90 OK#1 sand and hydrate mixture; Run 6, a 30:70 OK#1 sand and hydrate mixture; Run 7, a 50:50 glass bead to hydrate mixture. Figure 1 shows a summary of the Arrhenius relationship for run 3,4,5, and 6. Figure 2 shows the cryo SEM image of a 50:50 OK#1 sand and hydrate mixture.

Task 7.0: Modeling and Inversion of Field Data.

The OCCAM total field navigation program has been sped up by David Myer, allowing us to also solve for the half-space resistivity below the seafloor ρ_a , as well as the X, Y , and θ of the transmitter. Letting the resistivity vary was an important factor for WR 313, AC 818, and GC 955, as an assumed 1 Ω m half-space did not capture the average resistivity at these locations. A paper about this technique is in preparation. At this point the navigation for all surveys is as good as is possible, allowing us to move on to make geologic interpretations. 2D forward modeling of the data has begun.

Figure

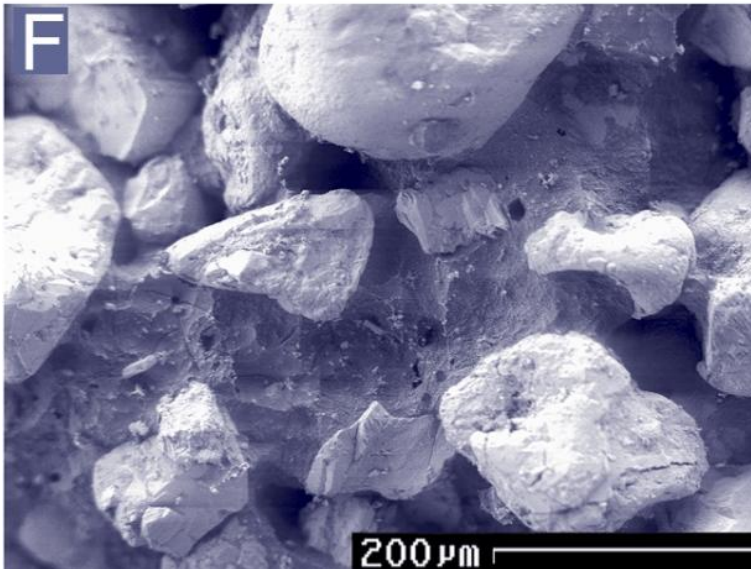


Figure

1: Summary of Arrhenius plots for sediment hydrate mixtures. Orange is run 4: 50vol% OK#1: 50vol% hydrate; green is run 5: 10vol% OK#1: 90vol% hydrate; blue is run 3: 0vol% OK#1: 100vol% hydrate;

1: Summary of Arrhenius plots for

Figure



Figure

2: This is a cryo SEM image of the run 4 sample, 50vol% OK#1: 50vol% hydrate, in which CH₄ hydrate (appears as the darker-colored connecting material between the sand grains) and OK#1 quartz sand grains (appear light in color and stand high in relief due to partial sublimation of the CH₄ hydrate) each occupy about 50 vol. % of the solid material here.

Task 8.0: Estimate Quantitative Hydrate Volumes from Field Models and Laboratory Studies.

Part of this task was completed in the Year 2 Final Report.

Task 9.0: Technology Transfer.

The data have been distributed to the sponsors (February, 2009) and preliminary results have been presented at the Seafloor Electromagnetics Consortium annual meetings in 2009, 2010 and 2011. Version 1.0 of the transmitter navigation was distributed to sponsors in early December 2009. Processed data were distributed to sponsors at the end of March 2010. We have undertaken a project to further develop the Vulcan technique with an industry partner. We have also started a collaboration with Carolyn Ruppel to develop a similar system to be used to map permafrost in the Beaufort sea.

Phase 3.

Task 10.0: Final Publication.

Several manuscripts are in preparation. A paper on the laboratory work was published this June in *Geophysical Research Letters*.

CONCLUSION.

We have made several laboratory electrical conductivity measurements on gas hydrate sediment mixtures. The OCCAM total field navigation for all surveys have been improved to include a half-space resistivity for all transmitter positions. Publication of the work is on track. We presented our results at MARELEC and at the ICGH7. We submitted a 2011 Fall AGU abstract.

MILESTONE STATUS

Milestone log for Budget Period 3.

Milestone 22 Fall AGU abstracts submitted. Task 9.0,10.0 Submitted a 2011 Fall AGU abstract, August 2011.

Milestone 23 Papers submitted for publication Task 10.0, in progress.

Milestone 24 Industry workshop to be held Task 9.0, to be completed later this budget period.

Milestone 25 Papers revised in final form Task 10.0, scheduled for later this year. One paper has been published.

Milestone 26 Web page updated Task 9.0, scheduled for later this budget period.

Milestone 27 Produced Phase 3 report Task 9,10 to be completed later this budget period.

ACCOMPLISHMENTS

- Collection of the Marine CSEM Field Data
- Conductivity cell completed.
- Processing of the data is completed.

- Raw data and processed data have been distributed to sponsors (2009, 2010).
- Generated merged transmitter navigation with the CSEM data using the Total field navigation program and distributed this version to the sponsors in early December 2009 and March 2010.
- Generated pseudosections for the 0.5 Hz and 6.5 Hz CSEM data transmissions for all 14 tows of the 4 surveyed areas in the Gulf of Mexico 2010.
- Generated pseudosections for Vulcan at MC 118, GC 955, AC 818, and WR 313 and preliminary interpretations of the data, 2010.
- Completed calibration tests of cell using water standard.
- Installed the cell in Menlo Park, formed hydrate in the cell and produced SEM images of this sample.
- Made three hydrate samples in the cell and have measured activation energies and produced Arrhenius plots.
- Made several hydrate sediment mixtures and measured activation energies and produced Arrhenius plots.

PROBLEMS OR DELAYS

Determining the navigational parameters for the transmitter have taken longer than anticipated and at this stage the navigational parameters are as good as is possible.

PRODUCTS

- Revised Project Management Plan.
- A project website was set up:
 - <http://marineemlab.ucsd.edu/Projects/GoMHydrate/index.html>
 - Cruise Report is available for download.
- Project Summary:
 - project summary outlining project goals and objectives on the NETL project Web site.
- Collection of Marine CSEM data in the Gulf of Mexico:
 - Data distributed to sponsors early February.
- NETL kick off meeting, Morgantown, WV - January 6, 2009
 - The PI delivered a project overview presentation.
- Fire in the Ice article published in 2009.
- Participated in a "Spot Light on Research" article for Fire in the Ice in 2009.
- Talk given at the 2009 MARELEC Meeting - Stockholm, Sweden - July 7-9 2009

Steve Constable presented *Applying marine EM methods to gas hydrate mapping*

- Steve Constable gave an invited talk at LLNL mid march 2009 called:

Marine Electromagnetic Methods for Mapping Gas Hydrate

- SIO Seafloor Electromagnetics Consortium annual meeting, La Jolla, CA - March 18-19, 2009

Karen Weitemeyer delivered two presentations:

Marine EM for gas hydrate studies, with first results from the Gulf of Mexico

Using Near field data to navigate controlled source electromagnetic data

- Karen Weitemeyer gave two invited talks in Australia

Marine EM for gas hydrate studies, with first results from the Gulf of Mexico

Steven Constable delivered a presentation in Japan:

Marine Electromagnetic Methods for Mapping Gas Hydrate

- Submitted the Phase 1 report October 2009.

- AGU Poster presentation December 2009 by Karen Weitemeyer and Steven Constable

Marine EM for gas hydrate studies, with first results from the Gulf of Mexico

- DoE Atlanta Hydrate Meeting January 25-29, 2010. A talk and Poster presented by KW and SC

Applying Marine EM Methods the Gas Hydrate Mapping

- Fire in the Ice article published March 2010.

Test of a new marine EM survey method at Mississippi Canyon 118, Gulf of Mexico

- SIO Seafloor Electromagnetics Consortium annual meeting, La Jolla, CA - March 17-18, 2010

Karen Weitemeyer and Steven Constable delivered a presentation:

Results from the GoM gas hydrate studies

- Processed data distributed to sponsors late March, 2010 and early April, 2010.

- First Break Article published this June (2010).

Mapping shallow geology and gas hydrate with marine CSEM surveys

- Attended the 20th Electromagnetic Induction Workshop in Giza, Egypt September 18-25, 2010, and presented a poster.

Mapping gas hydrates and shallow sedimentary structure in the Gulf of Mexico using

marine CSEM

- Geophysics paper published this Fall (2010).
- SIO Seafloor Electromagnetics Consortium annual meeting, La Jolla, CA - March 9-10, 2011

Karen Weitemeyer delivered a presentation:

Updates on marine CSEM for hydrate mapping

- *submitted Phase 2 Report May 1 2011.*
- *Oral presentation at the 2011 MARELEC Meeting - San Diego, USA - June 20-23 2011*
- Geophysical Research Letters paper published this June (2011). Electrical Properties of Pure, Polycrystalline Methane Hydrate Wyatt L. Du Frane, Laura A. Stern, Karen A. Weitemeyer, Steven C. Constable, John C. Pinkston, Jeffrey J. Roberts
- Two abstracts to the 7th International Conference on Gas Hydrates (ICGH7), were presented in July 2011.
a poster by Du Frane, Stern, Weitemeyer, Constable, Pinkston, Roberts, on
Electrical resistivity of laboratory-synthesized methane hydrate
The second by Weitemeyer and Constable on
The development of marine electromagnetic methods for gas hydrate mapping
- *Geophysics Journal International paper in press (2011): 'A marine electromagnetic survey to detect gas hydrate at Hydrate Ridge, Oregon.' by Weitemeyer, Constable and Tréhu*
- 2011 Fall AGU abstract submitted: 'Electrical properties of methane hydrate + sediment mixtures'.by Du Frane, Stern, Weitemeyer, Constable, Roberts

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