Oil & Natural Gas Technology

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Quarterly Report

October 2008 to December 2008

Gas Hydrate Characterization in the GoM using Marine EM Methods

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EXECUTIVE SUMMARY

In August, 2008, Scripps Institution of Oceanography was notified that the National Energy Technology (NETL) project *Gas Hydrate Characterization in the Gulf of Mexico using Marine Electromagnetic Methods* would be funded. The proposal was to carry out controlled source EM (CSEM) surveys to study gas hydrate at Alaminos Canyon 818, Green Canyon 955, and Mississippi Canyon 118, along with the design, construction, and use of a conductivity cell to study electrical properties of gas hydrate in the laboratory. Initial work after the funding announcement involved re-writing the budget so that LLNL and USGS sub-awards to Jeff Roberts and Laura Stern would be paid directly by DoE, and instrument purchases would be made with matching funds so that issues of ownership would not arise later. The environmental impact report was revised to include greywater, cooling water, and CO_2 emissions from the research vessel Roger Revelle during our experiments in the GoM. Funding arrived at the end of September, 2008, in time for our October field work, and on November 5th we submitted a revised Project Management Plan.

In August work had already begun instrument preparation for the cruise scheduled 7th–26th October 2008, consisting of extensive calibrations and test of all receivers, and the construction of a second EM transmitter. In September discussions with DOE indicated that there would be interest in doing an additional CSEM survey at Walker Ridge block 313, since WR313 was a target for a 2009 Joint Industry Program (JIP) drilling campaign. In order to coordinate our own CSEM site locations with the JIP proposed wells we had extensive discussions with Carolyn Ruppel, Emrys Jones, Dan MacConnell, and Hunter Danque. Due to uncertainty in weather conditions, the limited time for the cruise, and the expectation that there would be a drill rig at Green Canyon 955 during our survey, we developed approximately three survey plans per site to use depending on circumstances.

We carried out the 18-day cruise on the R.V. Roger Revelle in the Gulf of Mexico from 7th–26th October. During this experiment we deployed 30 ocean bottom electromagnetic (OBEM) recorders a total of 94 times at the four survey areas and towed the Scripps Undersea Electromagnetic Source Instrument (SUESI) a total of 103 hours. SUESI transmission was 200 A on a 50 m dipole antenna at heights of 70–100 m above the seafloor. We also towed a 3-axis electric field recorder behind the SUESI antenna at a constant offset of 300 m. Only two seafloor deployments failed to collect data, and data quality was excellent on all the rest. We also carried out a multibeam survey over a suspected landslide in the Green Canyon area for a student project, funded by BP America.

On December 14th, prior to the AGU meeting, we held a meeting in Menlo Park to discuss the design of the conductivity cell with Laura Stern, Jeff Roberts, John Pinkston, Steve Kirby, and Heather Watson. Bill Durham participated by phone. At that time the decision was made to construct a conductivity cell in which hydrate could be grown in situ, rather than transferring hydrate into the cell after synthesis, as proposed.

During the review period Karen Weitemeyer worked on this project as a graduate student, and defended her thesis shortly after the collection of the GoM data (on October 31, 2008). Because of the work involved in finishing the thesis and creating the final document, and the end-of-year holiday and meeting season (SEG and AGU), work on the data set, other than quality control during the actual cruise, did not commence until January 2009.

We generated a web site for the project, and provided real-time updates during the October cruise. This site generated a lot of traffic, with 1037 views during the month of October alone. We have now posted a cruise report on the site.

PROGRESS, RESULTS, AND DISCUSSION

Phase 1.

Task 1.0: Project Management Plan. On November 5th the Principal Investigator (PI) revised and resubmitted the Project Management Plan (PMP), incorporating comments from the DOE Project Officer. This plan outlines the research to be preformed during the entire three-year project.

Task 2.0: Technology Status Assessment. This is embodied in the original proposal.

Task 3.0: Collect Marine CSEM Field Data. We prepared the Scripps fleet of 30 seafloor EM recorders, two EM transmitters, and ancillary equipment for use in the field and used established methods and procedures to do so. The equipment was thoroughly tested in the laboratory prior to shipping. The Revelle mobilized from Port Everglades, Fort Lauderdale, Florida. EM laboratory engineers and technicians Jacques Lemire, Cambria Colt, Chris Armerding and Jake Perez of SIO EM Lab flew out to Port Everglades on the 3rd to carry out loading on the 4th and 5th. Scientists and engineers Arnold Orange, Karen Weitemeyer, John Souders, and Steven Constable flew on the 5th to assist in instrument setup on the 6th. The balance of the science party arrived on the afternoon and evening of the 6th for push-off at 16:00 on the 7th.

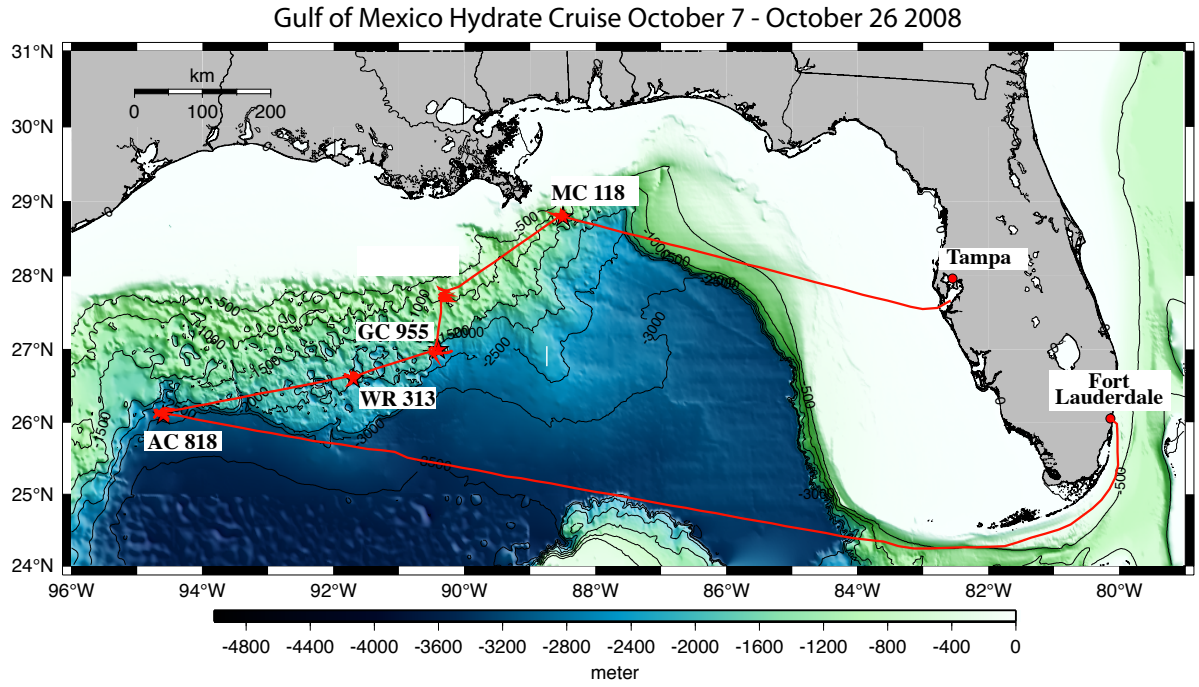

Figure 1. Map of CSEM hydrate survey areas, with ship trackplot in red.

We carried out marine CSEM surveys over blocks MC118, GC955, WR313, and AC818 in the Gulf of Mexico:

Alaminos Canyon 818. Chevron encountered a thick hydrate-bearing section (20 m) a few hundred meters below seafloor in an exploration well on this block, with high resistivities (30-40 Ohm.m) evident in the logs. Water depth is around 3,000 m, which is deep for exploration but easily within the 6,000 m operating depth of our equipment. Initially we were hoping to impact future Joint Industry Project (JIP) drilling plans, but shortly before the cruise we heard that AC 818 was dropped from the JIP program. However, as one of the few places in the Gulf where hydrate has been found in the sub-section (c.f. the seafloor), this area remained the highest priority for our own studies. We deployed 30 receivers and made four transmission tows, centered on the Chevron well. Two instruments failed to record data.

Mississippi Canyon 118. This block has been designated as a Minerals Management Services observatory. Large outcrops of hydrate occur on the seafloor in relatively shallow water depths of 800-900 m, but there is yet no direct evidence of hydrate at depth. This area provides the opportunity to coordinate and collaborate with many other ongoing scientific programs, including shallow resistivity surveying. We deployed 24 receivers in a 6 x 4 array and towed 10 transmitter lines in a grid pattern (avoiding the already installed seafloor equipment). All receivers recorded data.

Green Canyon 955. This prospect is in intermediate water depth (2200 m) and shows evidence of gas accumulation in a channel sand near the base of the hydrate stability field, based on examination of seismic data. It is targeted by the JIP program, but unfortunately current exploration drilling prevented us from carrying out our planned survey. We

deployed 20 seafloor instruments (all of which collected data) along two transmission lines as close as possible to the anchor patten of the drill rig.

Walker Ridge 313. This fourth prospect was added at the request of NETL to the 3 sites above selected in consultation with our industry sponsors. It is in intermediate water depths on the lower slope of the northern Gulf of Mexico, within a tabular salt minibasin province and having a very low geothermal gradient (hence a very thick gas hydrate stability zone). Evidence for hydrate comes from seismic data, gas mounds, and focused fluid expulsion sites. WR 313 is the third location chosen for the JIP (along with GC 955 and AC 818), and so clearly it is desirable to have marine EM data for comparison with the drilling results. We decided that if we had cooperative weather (we did) and scaled back the GC 955 survey by a few sites it would be possible to carry out a two-line survey similar to the one at Green Canyon. Again, we had 100% data recovery.

Several aspects of our work differentiate it from earlier studies. The deployment of large numbers of seafloor receivers results in an expanded set of transmitter–receiver offsets and extends the depth of investigation from the seafloor to the base of the hydrate stability field, and even deeper. Seafloor recorders collected every EM component except the vertical magnetic field (Ex, Ey, Ez, Bx, and By). We supplemented the deployed instruments with a receiver ("Vulcan") towed at a constant offset of 300 m behind the transmitter antenna, to provide short-offset data for all transmitter positions. Our transmitter and towed receiver operate at altitudes of 50–100 m above the seafloor, allowing us to operate in areas with seafloor infrastructure or rough terrain, rather than being dragged in contact with the sediments and rocks. The towed receiver records all three axes of electric field instead of just the inline Ey field, and because it is not in contact with the seafloor has much lower noise levels. Instead of transmitting a single fixed frequency, we transmitted a binary waveform with about two decades of frequency content, from 0.50 Hz to about 50 Hz.

Task 4.0: Design and Build Conductivity Cell. We held a pre-AGU meeting (Sunday December 14th 2008) at Menlo Park to introduce Constable, Weitemeyer, and Jeff Roberts to the facility and to Laura Stern's group. The USGS facility has a well established method to produced synthetic hydrate. Also in attendance at the meeting was Steve Kirby and John Pinkston of USGS, and Heather Watson of LLNL. This initiated discussions on the design of the conductivity cell:

Task 5.0: Preliminary Field Data Interpretation. The navigational parameters for the ship, transmitter, tail buoy, Vulcan have been processed. The receiver positions have been navigated and located with acoustic sounding and a Marquardt inversion program. The data for WR 313 are currently being worked up, having identified this prospect as being of highest priority for DoE/NETL.

Task 6.0: Make Hydrate and Hydrate/Sediment Conductivity Measurement. This task is scheduled for later this year and Budget Period 2.

Task 7.0: Modeling and Inversion of Field Data. This task is scheduled for Budget Period 2.

Task 8.0: Estimate Quantitative Hydrate Volumes from Field Models and Laboratory Studies. This task is scheduled for Budget Period 2.

Task 9.0: Technology Transfer. We have maintained a web page and a daily cruise log during the cruise. Initial results were presented to sponsors meeting during the SEG Annual Conference, November 2008. Cruise report is in progress (released January, 2009), and data are being prepared for distribution to sponsors (February, 2009).

Task 10.0: Final Publication. This task is scheduled for Budget Period 3.

CONCLUSION

The project was off to a great start with the successful Gulf of Mexico data collection cruise commencing within a week or two of funding. All the proposed objectives of the cruise were met, with the addition of a fourth survey area added at the request of NETL. The updated project management plan was provided in November, after the cruise but within

the time frame requested. However, the need to concentrate on the field project right from the beginning has resulted in some delays to the design and construction of the conductivity cell, although we had a fruitful design meeting with the whole team just prior to AGU in December.

COST STATUS

Table 1: Project costing profile for Budget Period 1, Quarter 1

Time period	Cost share	DoE Plan	DoE Actual
pre October 2008	$91,773	-	-
October 2008	$396,527	$475,690	$454,873
November 2008	-	$11,844	$14,958
December 2008	$39,841	$11,844	$11,292
Totals	$528,141	$499,378	$481,123

Pre-October cost share reflects material on hand already purchased for this project with non-federal funds, including anchors, MMS permits, batteries, and acoustic release components.

MILESTONE STATUS

Milestone log for Budget Period 1.

Milestone 1: Revised Project Management Plan. Task 1.0, completed 3 November, 2008.

Milestone 2: Submission of Technology Status Assessment. Task 2.0, embodied in the original proposal.

Milestone 3: Preparation of marine instrumentation for shipping. Task 3.0, completed 30 September, 2008. Equipment was tested in the laboratory and trucked to Fort Lauderdale. Critical milestone for tasks 5,7,8,9,10.

Milestone 4: Carry out field program in GoM. Task 3.0, completed 26 October, 2008. Field program was completed mare than successfully, with one extra survey area covered and 15 more stations than proposed. Critical milestone for tasks 5,7,8,9,10.

Milestone 5: Produce initial cruise report Task 3.0, completed 30 January, 2009.

Milestone 6: Design conductivity and pressure cell. Task 4.0, underway. Critical milestone for tasks 6, 8, 9, 10.

Milestone 7: Generate merged EM/navigated data set. Task 5.0, underway. Critical milestone for tasks 7, 8, 9, 10.

Milestone 8: Construct conductivity/pressure cell Task 4.0, work underway. Critical milestone for tasks 6, 8, 9, 10.

Milestone 9: Make calibration tests of cell using water standard Task 4.0, work not yet started. Critical milestone for tasks 6, 8, 9, 10.

Milestone 10: Install cell in Menlo Park and make initial hydrate measurements Task 4.0, work not yet started. Critical milestone for tasks 6, 8, 9, 10.

Milestone 11: Preliminary interpretation of field data Task 5.0, work underway.

Milestone 12: Webpage updated Task 9.0, January 30 2009.

Milestone 13: Produce Phase 1 Report Tasks 1-5, to be completed 31 July 2009.

ACCOMPLISHMENTS

• Collection of the Marine CSEM Field Data

• Conductivity cell design underway.

• Processing of the data is underway.

• A Fire in the Ice article was written and submitted.

PROBLEMS OR DELAYS

The design and construction of the conductivity cell is progressing more slowly than planned. The reasons are a combination of a later than proposed funding of the project, the large amount of work that went into the highly successful field work, the diversions of the year-end holiday and conference (AGU, SEG) season, and other ongoing projects competing for attention. However, the pre-AGU meeting went well and we have a plan for moving ahead with this part of the project.

PRODUCTS

• Revised Project Management Plan

• A project website was set up:

http://marineemlab.ucsd.edu/Projects/GoMHydrate/index.html

• 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:

preliminary cruise report is delivered. Data will be distributed soon.

• Fire in the Ice article submitted.

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