Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report

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Temporal Characterization of Hydrates System Dynamics beneath Seafloor Mounds: Integrating Time-Lapse Electrical Resistivity Methods and In Situ Observations of Multiple Oceanographic Parameters

Project Period: October 1, 2012 – June 30, 2015

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Temporal Characterization of Hydrates System Dynamics beneath Seafloor Mounds: Integrating Time-Lapse Electrical Resistivity Methods and In Situ Observations of Multiple Oceanographic Parameters

ACCOMPLISHMENTS:

Major objectives of the project are to:
1) characterize, geophysically, the sub-bottom distribution of hydrate and its temporal variability and,
2) contemporaneously record relevant environmental parameters (temperature, pressure, salinity, turbidity, bottom currents and seafloor microseismicity) to investigate possible links of the variability to climate. In order to achieve these overall objectives, we have identified the following goals:

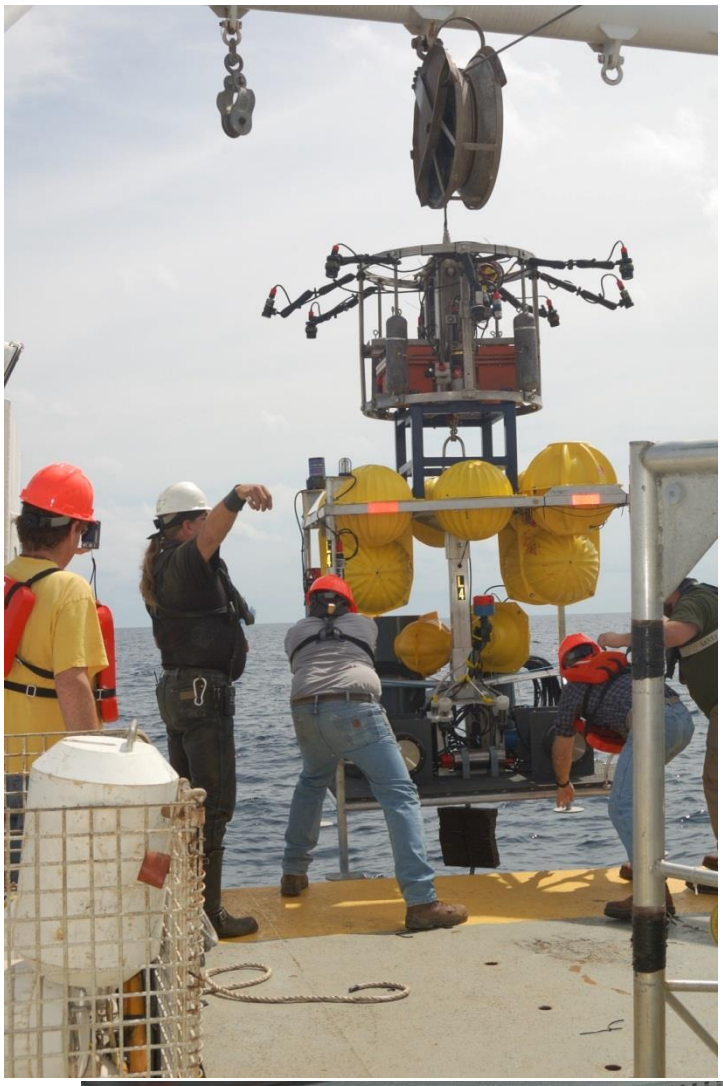
a) employ the Direct Current Resistivity (DCR) method as a geophysical indicator of hydrates,
b) identify hydrate formation mechanisms in seafloor mounds,
c) detect short-term changes within the hydrates system,
d) illuminate relationships/impacts of local oceanographic and microseismic parameters on the hydrates system and, indirectly, the benthic fauna,
e) monitor fluid/hydrate motion and seafloor instability that these changes might produce.

Accomplishments achieved in relation to these goals include the following:

- Completion and acceptance of the Project Management Plan,
- Successful completion and testing (at sea) of the SEA SPIDER, a new deployment and surveying system,
- Beginning of the assembly and evaluation of existing data from the research site at MC118,
- Renovation of the Direct Current Resistivity (DCR) cable in preparation for the September survey.

Completion and acceptance of the Project Management Plan
The completion of the PMP solidified the project sequencing and scheduling. Following the acceptance of this plan, the team participated in the kick-off web event. During this time and immediately following it, significant concerns were addressed (depth of hydrate stability at the site, ability of the project to provide estimates of volume of hydrate) that provide guidance of the project into the future.

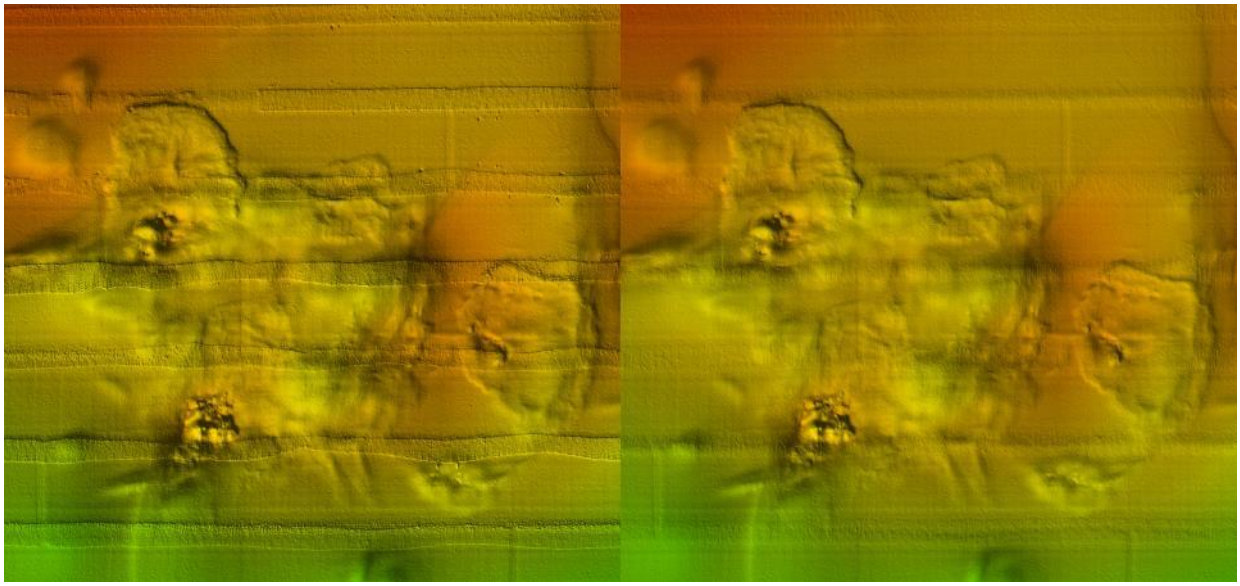
Successful completion and testing (at sea) of the SEA SPIDER, a new deployment and surveying system
We (MMRI) have developed and tested a site reconnaissance camera system and adapted it with a framework that enables it to serve as a survey/deployment platform. This device, built and tested with Bureau of Ocean Management (BOEM) funds and called the SEA SPIDER (Special Evolving Advanced Scientific Platform for Instrument Deployment and Emergency Recovery), includes 4 adjustable cameras and 4 adjustable lights, a sonar unit, an altimeter and two fixed camera and light units. This platform has several advantages over the Station Service Device ROV as far as array surveying, the primary one being that the researcher in the support vessel can see the survey or deployment site and can make on-the-spot decisions concerning direction, continuing, deploying, etc. The Sea SPIDER enables us to see where we are, has 360^{o} field of view, laterally as well as downward. It also has downward facing sonar and an altimeter, so we always know where we are and the whereabouts of everything else in the vicinity. Another of its attributes is its ability to carry instruments to locations that the researcher sees and likes rather than dropping them "blind," as is traditionally the case. The SEA SPIDER can function from the seafloor or above it without touching down. The SEA SPIDER enables us to avoid hazards during surveying and deployment, to find appropriate deployment sites, and to KNOW what's down there before we core.



The Sea SPIDER, left, atop a lander, rides down to near seafloor “watching” for an ideal deployment site and steering clear of hazards. When the site is reached, the lander – or other instrument such as a camera, probe, collector, etc. – is released, acoustically. The large screen TV (below) shows what the 6 cameras see including the one that has tracked the lander as it fell through the final 2-3m of the water-column and onto the seafloor (main view, upper left on the screen).

The SEA SPIDER will be the survey and deployment vehicle for the Direct Current Resistivity array when it is deployed during the September cruise. This vehicle has a wide array of potential applications and will undergo a series of test applications during the upcoming quarter. One of its many applications that we will test in July, is its utility providing a view of the seafloor prior to and following sampling activities. This will enable us to link seafloor types and cover with hydrate presence/absence and to detect short-term changes within these environments through repeat visits to the same sites.

Beginning of the assembly and evaluation of existing data from the research site at MC118
The MMRI has in its archives many datasets from MC118. Autonomous Underwater Vehicle (AUV) data, acquired in 2012, have not yet been post-processed or evaluated. This process was begun recently and an example of the improvement in data quality reached through very preliminary data treatment appears in the figure below. This figure is one that is being submitted as part of a paper for the GCAGS (see the ***Products*** section of this report).



Preprocessing (left) vs. b) Postprocessing (right) (MC118 AUV Eagle Ray 50m altitude survey)

This processing will provide the team with an excellent map of the bathymetry and the hardgrounds (from backscatter) at the research site as well as morphologic features that may translate to hazards, to seep sites or to benthic communities. This effort will be part of the student's responsibilities when he/she arrives and will continue into the next quarter.

Renovation of the DCR cable in preparation for the September survey
In this last quarter Dunbar and Higley made two trips to AGI in Austin to work with them to get the seafloor resistivity system back in working order after the damage it sustained in the summer of 2012. Four electronic cards have been replaced in the instrument and a new transmitter card and two new switch cards purchased. They discovered a short in the old electrode array that will require molding on new connectors. This work is underway. There was another short found in one of the connectors that penetrate the instrument housing, probably resulting from water being forced from inside the housing back into the connectors during the July 2012 flooding event. There is a good chance that this short can be fixed without replacing the connector, but it has not been accomplished yet. This will cover most of the cost and effort of getting the instrument back in action. We also checked the O-ring groove dimensions and verified that they are appropriate and should seal properly, if the assembly process is performed successfully, without the O-rings slipping out of place.

The next steps are building a jig to hold the instrument during assembly and pressure testing it in San Antonio.

Progress was made towards achieving Milestones A and B. Please see Milestone chart, below.

Milestone	Planned Completion Date	Actual Completion Date	Verification Method	Progress/Deviation from Plan
Milestone A: Target sites selection for IPSO deployment at MC118	9/15/2013		4 targets identified	
Milestone B: Successful testing of a new Integrated Portable Seafloor Observatory (IPSO).	9/15/2013		Successful onshore test of IPSO	
Milestone C: Successful deployment of Integrated Portable Seafloor Observatory (IPSO).	9/30/2013		Proper orientation and functioning of IPSO	
Milestone D: Recover data from MC118 with the IPSO	6/2014		IPSO recovered with data	
Milestone E: Complete analysis of temporal characterization of hydrates system dynamics at MC118	3/31/2015		Resistivity and temporal data produce reasonable temporal analysis	
Milestone F: Complete final report and submit to DOE	6/30/2015		Report accepted by COR	

PRODUCTS:

Although this project is in the very early stages, it is building on existing work. A major component of data that the MMRI/CMRET holds is multibeam and chirp data from the research reserve at MC118. MMRI/CMRET scientists have, since 2005, studied, reprocessed, and analyzed geophysical datasets from this area. An abstract was submitted and accepted for development into a full paper for the 2013 Transactions of the Gulf Coast Association of Geological Societies (GCAGS). This paper, now nearing completion, will be presented at the Annual Meeting of the GCAGS in New Orleans in October. Part of the paper includes innovative treatment of multibeam data from acquisition through post-processing and analyses. This constitutes another product, or cluster of products, in the form of maps of the research site. These will be used in all stages of the project from the planning of the cruises and selection of target sites for data-collection and potential deployment sites for the resistivity array. Products include:

- Lutken, C. B., D'Emidio, M., Macelloni, L., Ingrassia, M., Pierdomenico, M., Asper, V., Woolsey, M., Jarnagan, R., Diercks, A., 2013, *Challenges in imaging the deep seabed: examples from Gulf of Mexico cold seeps,* Transactions of the Gulf Coast Association of Geological Societies, New Orleans, October 6-8.
- Post-processing of multibeam data acquired in 2012 from Woolsey Mound (MC118) begun. This dataset will be used along with previously acquired multibeam data to select target sites for the resistivity active study as well as for sites at which to deploy the resistivity array.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

During this quarter, personnel from the University of Mississippi and from both subcontracting organizations, participated in the initial stages of the project. Their contributions are as follows:

Name: Carol Lutken
Project Role: PI, University of Mississippi
Nearest person month worked: 1 (4 weeks)
Contribution to Project: Lutken renegotiated the contract, wrote the Project Management Plan and organized and led the Kick-off meeting (web meeting with DOE).

Name: Marco D'Emidio
Project Role: Scientist, University of Mississippi
Nearest person month worked: 1 (three weeks)
Contribution to Project: D'Emidio has led the effort to assemble existing geophysical data from the project site. He has begun the post-processing efforts of the two new (2012) multibeam surveys from the Woolsey Mound area of MC118.

Name: Matt Lowe
Project Role: Marine Systems Specialist, University of Mississippi
Nearest person month worked: 1 (three weeks)
Contribution to Project: Lowe is the Chief of shop operations at MMRI/CMRET. During this quarter, he has assembled existing lander components and begun the redesign of an existing lander to accommodate the resistivity array. He has also directed the shop's completion of a deployment vehicle, the SEA SPIDER, the primary means by which the DCR survey will take place.

Name: John Dunbar
Project Role: Co-I, Baylor University
Nearest person month worked: 1 (3 weeks)
Contribution to Project: Dunbar has acquired additional communications cards, repaired shorts in the array and connectors and travelled twice to AGI to arrange for software modifications to their control software.

Name: Paul Higley
Project Role: Co-I, Specialty Devices, Inc.
Nearest person month worked: 0 (1 week)
Contribution to Project: Travelled to AGI to arrange for software modifications to existing control software.

IMPACT:

A significant contribution to marine research and particularly to at-sea data-recovery methods has been realized in the success achieved with the SEA SPIDER. Although not funded under this award, the SEA SPIDER is a result of the ongoing at-sea activities of the MMRI and the need to have better visuals and seafloor information prior to making instrument deployments, recovering samples and executing surveys. The use of this system is intended to reduce risk to equipment in a hazardous environment and to improve a researcher's chances of recovering data and to recovering data from the precise location or environment targeted. It will be used in this project to emplace instruments/arrays in premier locations and to conduct surveys that include visual data matched precisely to location and to other datasets.

The survey and deployment efforts of the SEA SPIDER and other instrumentation used in this project will be guided by the seafloor imagery in-hand. The better definition we are able to get of the seafloor, the better we will be able to guide these efforts. A beginning has been made to produce a new generation of imagery that will serve the goals of this project better than existing quality products.

The quality of seafloor imagery is not a trivial consideration. Hydrocarbon companies and their support industries rely upon seafloor imagery to site, survey, build, operate and decommission seafloor structures. With more detailed information from the seafloor and shallow subseafloor, including the hydrate stability zone (HSZ), these operators can achieve their goals in a safer and more efficient manner. They can also use the improved definition to focus on preferred sites, eliminate sites without characteristics that recommend others, saving needless expense and reducing risk. Although it has not happened yet, we anticipate conversations (at least) with industry participants interested in incorporating this or similar innovations into their seafloor reconnaissance activities.

The methods that we have developed and that we are developing are used, in fact some have been developed by, students and interns. We encourage these students to participate at all levels and expect at least one student to go to sea with us in September as part of the scientific crew. We also hope to have a student/intern as part of our shop team at that time.

The collaboration of our shop with another shop at the University of Mississippi in the electrical components of the SEA SPIDER has made that project and system available to this project ahead of schedule. Because of this collaboration, we have gained access to their expertise in electronics and underwater systems and they have gained access to our expertise in mechanical design, machining and deployment and recovery techniques.

CHANGES/PROBLEMS:

Changes to this project were made prior to the execution of the contract. Since that time, there have not been major changes in approach, anticipated timing, or budget. Some changes that are currently being addressed are:

- The development, by the University of Mississippi, of the SEA SPIDER as a survey and deployment tool makes it an option for this project in both modes. The Station Service Device ROV will also be available as an option for both surveying and for deployment of the DCR array. However, particularly for survey mode, we hope to accomplish the projects goals using the SEA SPIDER, primarily because we will be able to monitor the survey, visually, as it is happening, thus avoiding hazards while acquiring the ability to match seafloor environment with resistivity anomalies.
- Dunbar's time budget includes hiring a student at the beginning of Year 2 of the project. This addition of personnel will need to happen sooner in order for the Baylor team to be ready for the September cruise. Dunbar has identified a student and will need to rebudget his funds differently in order to get the student onboard sooner than January, 2014. The total funding for the student will remain the same but the period of funding will begin sooner.
- The University of Mississippi has lost personnel originally budgeted to participate in the project. Ken Sleeper has taken another position at the University and Larry Overstreet has retired. While Larry may return as a part-time employee, his participation will, likely, be diminished. Ken's will probably be eliminated. The tasks originally proposed for these individuals will fall to other MMRI employees. While we do not anticipate any change is costs, expenditures may look somewhat different.

SPECIAL REPORTING REQUIREMENTS:

None noted.

BUDGETARY INFORMATION:

The expenses incurred during this quarter have been charged to cost-sharing. Simply put, a portion of our state salary, allocated for cost-share for this project, must be spent within the current state fiscal year which ends June 30. So we want to be sure that that effort is properly credited.

Subcontractor Dunbar has spent some of his funds but they have not been charged to UM yet so do not appear in the budget sheet. Please see the budget report spread sheet, below.

DOE Hydrates FY12 DE-FE0010141 Baseline Reporting by Quarter	Budget Period 1								Budget Period 2								Budget Period 3			
	Quarter 1		Quarter 2		Quarter 3		Quarter 4		Quarter 1		Quarter 2		Quarter 3		Quarter 4		Quarter 1		Quarter 2	
	1/1/13 - 3/31/13		4/1/13 - 6/30/13		7/1/13 - 9/30/13		10/1/13 - 12/31/13		1/1/14 - 3/31/14		4/1/14 - 6/30/14		7/1/14 - 9/30/14		10/1/14 - 12/31/14		1/1/15 - 3/31/15		4/1/15 - 6/30/15	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total
Baseline Cost Plan																				
Federal Share	127,121	127,121	127,120	254,241	209,200	463,441	127,120	590,561												
Non-federal Share	36,912	36,912	36,912	73,824	36,912	110,736	36,912	147,648												
Total Planned	164,033	164,033	164,032	328,065	246,112	574,177	164,032	738,209												
Actual Incurred Cost																				
Federal Share	-	-																		
Non-federal Share	15,694	15,694																		
Total Planned	-	-																		
Variance																				
Federal Share	127,121	127,121																		
Non-federal Share	21,218	21,218																		
Total Planned	164,033	164,033																		