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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RESEARCH PERFORMANCE PROGRESS REPORT

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 (Quarter 1):

- Completion and acceptance of the Project Management Plan; successful "kick-off,"
- 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.

Accomplishments achieved in relation to these goals include the following (Quarter 2):

- We have used the I-SPIDER, the Integrated Scientific Platform for Instrument Deployment and Emergency Recovery, successfully on three successive cruises both surveying and deploying instruments;
- CMRET's shop and SDI's shop have coordinated effort to build the communications software that will enable us to have live communication with the DCR array while in survey mode;
- We have completed the consolidation of electronics into a single "topside system" that greatly increases our ability to control and monitor at-sea operations;
- We have installed Ultra-short Baseline (USBL) transponders in the hull of the R/V *Pelican* to maintain our exceptional navigation/locating capabilities while at sea;
- We have made significant progress in processing the 2012 multibeam data from MC118;
- We have established a processing protocol for the new polarity-preserving chirp data from MC118;
- We have begun to build the Integrated Portable Seafloor Observatory (IPSO) lander;
- We have made repairs to the damaged resistivity system resulting from the flooding event, summer 2012;
- We have determined what caused the instrument to flood;
- We have devised a solution to the flooding problem;
- We have begun work to devise a means whereby operation of the array can be accomplished autonomously while on the seafloor;
- We have scheduled two cruises for 2014 on the R/V Pelican: April 7-12 and October 3-6.

Accomplishments achieved in relation to project goals include the following (Quarter 3):

- We have completed the survey-mode communications electronics;
- We have upgraded the SSD and I-SPIDER individually and as a tandem system;
- We have selected primary and secondary target sites for the DCR survey and have plotted the survey;
- We have built the IPSO lander frame, researched and ordered instruments and installed them on the IPSO lander;
- We have begun processing the new polarity-preserved chirp data from MC118;
- We have completed repairs to the seafloor DCR system associated with the housing flooding that occurred in July 2012;
- SDI replaced the power and control though-housing connector to the DCR instrument with one that has higher current capacity;
- We have devised a system whereby the DCR system will be controlled remotely while on the seafloor;
- SDI built the Atom control computer and installed it in a pressure housing.
- We have developed/acquired new control software for autonomous operation of the DCR instrument;
- We have built a stand that will hold the DCR instrument electronics and housing end cap in an inverted position while assembling the DCR housing.

We have completed the survey-mode communications electronics such that during survey mode, communications from the ship directly to the DCR system will be through the payload communications line in the I-SPIDER's auxiliary/spare electronics bottle which was developed for use with the DCR survey as well as other user defined payloads;

We have upgraded the SSD and I-SPIDER individually and as a tandem system. Hydraulics and thrusters on the SSD have been upgraded, cameras added to the collective system and the electronics box rewired. Spare electronics cards have been built and an entire spare box for the I-SPIDER constructed so that when we go to sea, we will be much less likely to be shut-down by predictable failures.

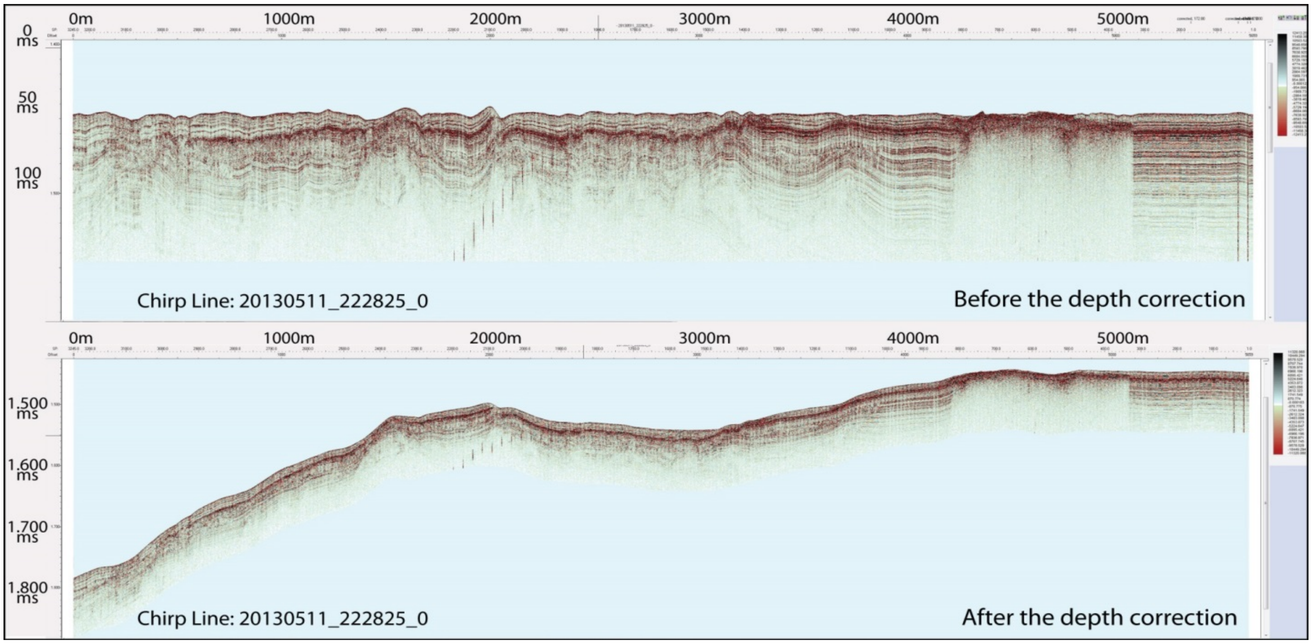
We have selected primary and secondary target sites for the DCR survey and have plotted the survey itself including contingencies for circumstances of the sea that we can predict: currents, current direction, counter-currents (see Appendix A). ***This marks achievement of Milestone A.***

We have built the IPSO lander frame, researched and ordered instruments and installed them on the IPSO lander. All instruments have now been tested and the lander is ready for deployment at MC118. ***This marks achievement of Milestone B.***

The lander appears in the photograph below, complete with Acoustic Doppler Current Profiler that will collect current data – direction and magnitude – over a 6-month period and the CTD (conductivity-temperature-depth) instrument. At the base is the power supply for the system.

We have begun processing the new polarity-preserved chirp data from MC118. Navigational and depth corrections must be completed before the data-set can be used with confidence. However, faults and slides and other seafloor hazards can already be identified.

The figure (below) displays depth-corrected ppchirp data under the non-depth-corrected line, illustrating the differences in visual aids. Since the data are acquired by an AUV that is programmed to fly a constant distance from the seafloor, the only variations in depth from that constant reflect areas where the vehicle was unable to maintain constant depth. The inertial navigation system records actual depth, used to build the depth-corrected file.



We have completed repairs to the seafloor DCR system associated with the housing flooding that occurred in July 2012. In prior quarters, Advanced Geosciences, Inc. of Austin, Texas (AGI) provided three new circuit cards for the DCR instrument itself and a replacement connector core for the housing penetrator for one-leg of the 56-electrode array, to fix a short to in the connector. In this quarter, AGI re-terminated the electrode array to fix a second short discovered during earlier repair sessions;

SDI replaced the power and control though-housing connector to the DCR instrument with one that has higher current capacity. This change was required to convey power into the instrument from the seafloor Lander at 48 Volts. The previous configuration was designed to work with the 240 Volt power supply from the Station Surface Device (SSD) ROV. Within the instrument housing the 240 Volt to 12 Volt DC-to-DC converter used in the 2009 survey of MC118 was replaced with a 48 Volt to 12 Volt converter.

We have devised a system whereby the DCR system will be controlled remotely while on the seafloor. For this project, the seafloor DCR system will be used in two ways. During the first phase cruise, the instrument will be used in a remote-control mode, similar to the way it was used during the 2009 reconnaissance survey of MC118. This mode will be used to collect a set of profiles near the site of the largest known high-resistivity anomaly, to locate the best profile for long-term monitoring. In this mode, a human operator onboard the surface ship will instruct the instrument which set of commands to execute, when to begin collecting data, and will download the resulting data files. Communication for these operations will be through an emulated RS232 connection between the surface ship and instrument over a fiber-optic cable to the electronics module temporally borrowed from the ROV. All the software and hardware need to operate the DCR instrument in this remote-control mode was developed before the 2009 survey and is still available for the first phase cruise for the current project.

SDI built the Atom control computer and installed it in a pressure housing. After the initial set of profiles has been collected and processed onboard the surface ship, we will reconfigure the DCR system for autonomous operation on the seafloor, and re-deploy the system along the most promising profile for long-term monitoring. Autonomous, operation will be achieved using the Integrated Data Processing (IDP) device, designed to serve as the main control module for the seafloor observatory at MC118. The IDP will keep time and periodically power-up the Atom computer in a second housing and the seafloor DCR instrument in a third housing. The Atom computer will perform the autonomous control of the DCR instrument.

We have developed/acquired new control software for autonomous operation of the DCR instrument. AGI provided a library of routines to communicate with the DCR instrument and to instruct the instrument to perform low-level operations. John Dunbar (Baylor University) used these routines to develop the autonomous control program, SSAutoRun. A link to the program was placed in the Startup folder of the Atom control computer, such that the program automatically runs each time the Atom computer is booted by the IDP. The program initially checks to see if there is an existing data file on the DCR instrument. If so, the program downloads the data file, stores it on the Atom's local storage, and deletes the file from the DCR memory. This makes the limited DCR storage available for a new data file. The program then transmits a file containing recording instructions to the DCR, initializes a new data file to store readings from a new profile, instructs the DCR instrument to begin data recording, and then shuts down the Atom computer. The DCR recording process continues asynchronously, without further commutation from the Atom computer. After a pre-set time interval, power to the DCR instrument and Atom computer is shut down and the system sleeps until it is time to begin the next recording cycle. The control program was initially tested in a standalone mode using an AGI land resistivity system at Baylor University, and then tested on the housed Atom computer connected to the IDP in SDI's shop in Wylie, Texas.

We have built a stand that will hold the DCR instrument electronics and housing end cap in an inverted position while assembling the DCR housing. The use of the stand to assemble the housing is part of the new closing procedure intended to prevent flooding events, such as the one that occurred in summer 2012. In the inverted position, gravity holds the housing O-rings in place during assembly, which otherwise have a tendency to slip. This appears to have been the cause of the 2012 flooding event. The modified housing assembly procedure was tested initially by closing the housing, drawing a vacuum on the housing, and allowing it to set for 12 hours. The housing was then transported to the high-pressure testing facilities at the Southwest Research Institute, in San Antonio, Texas, where it was assembled using the new procedure, and placed in water under 1,500 PSI (10,342.5 kPa) or a depth equivalent of approximately 3,410 ft (1,040 m) in sea water. This pressure was held for 4 hr, after which the instrument was brought back to room pressure and opened. It was found to be completely dry inside. Next, the instrument was re-closed using the same procedure, returned to 1,500 PSI pressure, and held at that pressure for another 30 minutes. These tests indicate that the new procedure makes it possible to seal the DCR housing effectively. ***Passing this test satisfied the go/no-go requirement imposed by DOE prior to execution of the first cruise***.

Milestone chart; Milestones A and B were completed; Progress was made towards achieving Milestones C.

Milestone	**Planned Completion**	**Actual Completion**	**Verification Method**	**Progress/Deviation from Plan**
Milestone A: Target sites selection for IPSO deployment at MC118	9/15/2013	9/17/2013	4 targets identified	2 days
Milestone B: Successful testing of a new Integrated Portable Seafloor Observatory (IPSO).	9/15/2013	9/25/2013	Successful onshore test of IPSO	10 days
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:

MMRI/CMRET scientists have, since 2005, studied, reprocessed, and analyzed geophysical datasets from the MC118 area. They have deployed instruments here since 2005 and have developed a variety of successful methods. These have formed the foundation of the new lander and instrument array to be deployed during the initial cruise for this project.

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 has been written, reviewed, revised and resubmitted (June). It is scheduled to 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 are being used in all stages of the project including the planning of the cruises and selection of target sites for data-collection and potential deployment sites for the resistivity array. Products include:

- Post-processing of polarity-preserved chirp data acquired in 2012 from Woolsey Mound (MC118) is underway. When processing is complete, this dataset will be used along with simultaneously-acquired multibeam data (already processed) to refine and reinforce selection of target sites for the resistivity active study as well as for sites at which to deploy the resistivity array.
- A working DCR cable is ready for surveying and deployment to collect resistivity data from the Hydrate Stability Zone.
- A lander, fully equipped with oceanographic instruments, is ready for deployment with the DCR array.
- A submission to G-3 has been made, reviewed and returned for revision, revised and resubmitted. A complete citation:
  Wilson, Rachel M., Leonardo Macelloni, Antonello Simonetti, Laura Lapham, Carol Lutken, Ken Sleeper, Marco D'Emidio, Marco Pizzi, James Knapp, and Jeff Chanton, *Subsurface methane sources and migration pathways within a gas hydrate mound system, Gulf of Mexico.*
- An article was prepared and a presentation made at the Annual Oceans meeting in San Diego that focused on efforts to develop the ppchirp system. A complete citation:
  Woolsey, M., R. Jarnagin, K. Sleeper, L. Macelloni, M. D'Emidio, A.-R. Diercks, V. L. Asper, 2013, *Integration of a Polarity-Preserving Chirp Subbottom Profiler into the NIUST AUV Eagle Ray.*
- An article was prepared and a presentation made at the Annual Oceans meeting in San Diego that focused on efforts to develop the I-SPIDER and to coordinate it with the SSD ROV. A complete citation:
  Lowe, P.M., M. Woolsey, R. Jarnagin, C. B. Lutken, B. Noakes, L. Overstreet, S. Tidwell, 2013, *Development of I-SPIDER: a towed platform for video survey and instrument placement*.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

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

Name: Carol Lutken
Project Role: PI, University of Mississippi
Nearest person month worked: 0 (2 weeks)
Contribution to Project: Lutken worked with D'Emidio to evaluate available data from MC118 and to select sites best suited to both DCR surveying and to DCR cable long-term deployment. She also compiled information for and wrote the quarterly progress report. She executed all communications between participants and with LUMCON and made arrangements to postpone the September cruise.

Name: Marco D'Emidio
Project Role: Scientist, University of Mississippi
Nearest person month worked: 0 (2 weeks)
Contribution to Project: D'Emidio worked with Lutken to evaluate available data from MC118 and to select sites best suited to both DCR surveying and to DCR cable long-term deployment. He has led the effort to assemble existing geophysical data from the project site. He has begun processing the ppchirp data from MC118 according to the newly established processing protocol.

Name: Matt Lowe
Project Role: Marine Systems Specialist, University of Mississippi
Nearest person month worked: 2 (8 weeks)
Contribution to Project: Lowe is the Chief of shop operations at MMRI/CMRET. During this quarter, he and the shop team completed the IPSO lander including researching, ordering and fitting instruments to the steel frame. An on-line test of the lander proved the functioning of all components (Milestone B). Considerable communications adaptations and tests were also done to assure communications with and through the I-SPIDER during operations at sea. He built a back-up electronics system for the I-SPIDER.

Name: Steven Tidwell
Project Role: Research Associate, University of Mississippi
Nearest person month worked: 1 (5 weeks)
Contribution to Project: Tidwell is the MMRI/CMRET shop technician with a degree in geological engineering and expertise in machining and electronics as well as computer software. During this quarter, he worked to complete the conversion of existing lander components to those needed for the IPSO lander and began the redesign of an existing lander to accommodate the resistivity array. He has machined pressure housings and an additional Box for a back-up electronics system for the I-SPIDER.

Name: John Dunbar
Project Role: Co-I, Baylor University
Nearest person month worked: 2 (7 weeks)
Contribution to Project: Dunbar has worked with AGI and SDI to repair the DCR instrument and electrode cable. Test it on land, under low pressure at SDI and at 1020m equivalent at SW Research Center, San Antonio. He designed and built a jig to hold the housing during assembly. He also wrote the computer program to control the DCR instrument during autonomous operation on the seafloor which included building an Atom computer to conduct land tests of the software, traveling to SDI and testing the operation with the DCR instrument and the computer and power supply that will actually reside on the seafloor during the 6-month deployment.

Name: Paul Higley
Project Role: Co-I, Specialty Devices, Inc.
Nearest person month worked: 1 (3 weeks)
Contribution to Project: Worked with AGI and with Dunbar to develop autonomous seafloor operation capability and to repair and test repairs of the DCR instrument and cable. Higley provided the Atom computer and power supply that will reside on the seafloor during the 6-month deployment and designed and executed tests of these components. He also participated in the tests at SW Research Facility and in addressing the concerns of DOE before and during the tests.

Name: Scott Sharpe
Project Role: Electronics specialist, Specialty Devices, Inc.
Nearest person month worked: 0 (6 weeks)
Contribution to Project: Worked with AGI and with Dunbar to develop autonomous seafloor operation as well as interfacing the control system to the DCR instrument. Sharpe was the lead building the Atom computer and in writing the survey software.

Name: SDI Technical staff
Project Role: Electronics and technical support, Specialty Devices, Inc.
Nearest person month worked: 0 (2 weeks)
Contribution to Project: Worked with Higley and Sharpe to produce the Atom computer, the power supply and the electronics to power and run the DCR system while on the seafloor.

IMPACT:

The I-SPIDER continues to be a valued resource to the Gulf of Mexico marine research community. It was instrumental in the successes of 2 ECOGIG cruises in June and August-September, with the second an unscheduled performance. The I-SPIDER and SSD were used together to rescue a $600,000 NIUST photo-AUV that had become unresponsive on the seafloor. Due to the Herculean effort put forth by the MMRI shop team, we were put behind in our other projects, including this DCR effort. A benefit of this is that the SSD has been upgraded in thrusters and will be upgraded in electronics prior to the next trip. So now in addition to its functions of reconnoitering seafloor deployment sites, providing visuals on bubble streams and benthic communities, carrying instruments and landers to the optimal/selected site and releasing the payload on command, it has added AUV/instrument emergency recovery. It has been used alone and in concert with other systems and is the ROV of choice for the DCR survey. This system is designed to reduce risk to equipment in a hazardous environment and to improve a researcher's chances of recovering data and to recover 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 I- SPIDER and other instrumentation used in this project will be guided by the seafloor imagery in-hand. This is constantly improving as we reprocess existing data and add datasets to our arsenal. This quarter has been one in which we have concentrated on making the ppchirp data available to this project. We anticipate that the shallow profiles will be able to be collated with hydrate sampled and detected via resistivity surveys and hope that will lead to its use as a prospecting tool for shallow hydrates.

We have recently entered into a contractual agreement with George Mason University-BOEM and the US Navy to work with them on seafloor projects that require very precise locating capabilities and multiple sets of "eyes on the seafloor," in this case, our ROVs. Government and 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 and eliminate sites without characteristics that recommend others, saving needless expense and reducing risk.

Students and interns have long been a vital part of our projects. The methods that we have developed and that we are developing and are using, have been tested and some of them developed by students. We encourage these students to participate at all levels and expect at least one student to go to sea with us on every cruise in this project, as part of the scientific crew. We hope to have at least one student as a participant in the geological effort of this project and to add a student/intern as part of our shop team.

The collaboration of our shop with the NIUST shop has continued to be productive. Their expertise in electronics has enabled us to duplicate the electronics box and to make spare cards for the I-SPIDER so that when we do go to sea next, we will not be shut down if one of these functions goes down. We are doing our best to predict and prepare for any and all problems that may arise when we are at sea.

CHANGES/PROBLEMS:

Changes to this project that have been made this quarter derive from the changes in our schedule related to the demands made on our ROVs. As the scheduling of time and tasks at sea has changed, so our work schedule, spending schedule and achievements schedule will change. Our first cruise has been shifted to the first week in April (previously scheduled for the second cruise). Our lander and DCR instrument are ready and the DCR housing has passed the pressure testing Go/No-Go requirement. There have not been changes in approach since the addition of the I-SPIDER to our "fleet" of ROVs available to the project Some changes that are currently being addressed are:

- The I-SPIDER has now been operated successfully on five cruises as a survey and deployment tool as well as a rescue vehicle, performing excellently in every case. The upgraded Station Service Device ROV will also be available as an option for use in concert with the I-SPIDER. Particularly for survey mode, we hope to accomplish the projects goals using the I- 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 has rebudgeted the time for which he will employ a student on this project. With a strong student "in-hand", he has altered his time-budget to allow the student to begin work in the third quarter of Year 1 of the project.
- Our cruise schedule has shifted. With no additional cost to the project, we will spread our time out to be sure to be prepared to go to sea while staying within the confines of the original budget.

SPECIAL REPORTING REQUIREMENTS:

None noted.

BUDGETARY INFORMATION:

The expenses incurred during this quarter have been charged to both direct charges and cost-sharing. Subcontractors Higley and Dunbar have also charged time to the project as noted in the expenditure of time report. However, Higley's subcontract has just been issued so no charges have yet been made to it. 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 - Corrected		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	-	-	8,592	8,592	86,331	94,923														
Non-federal Share	22,599	22,599	5,770	28,369	12,584	40,953														
Total Planned	22,599	22,599	14,362	36,961	98,915	135,876														
Variance																				
Federal Share	127,121	127,121	118,528	245,649	122,869	368,518														
Non-federal Share	14,313	14,313	31,142	45,455	24,328	69,783														
Total Planned	141,434	141,434	149,670	291,104	147,197	438,301														

Appendix A.

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

DOE Award No.: DE- FE0010141

Title: Milestone A: Target sites selected for IPSO deployment at MC118
Planned Date: 15 September, 2013 (Quarter 3, Budget Year 1)
Verification Method: Four (4) targets have been identified

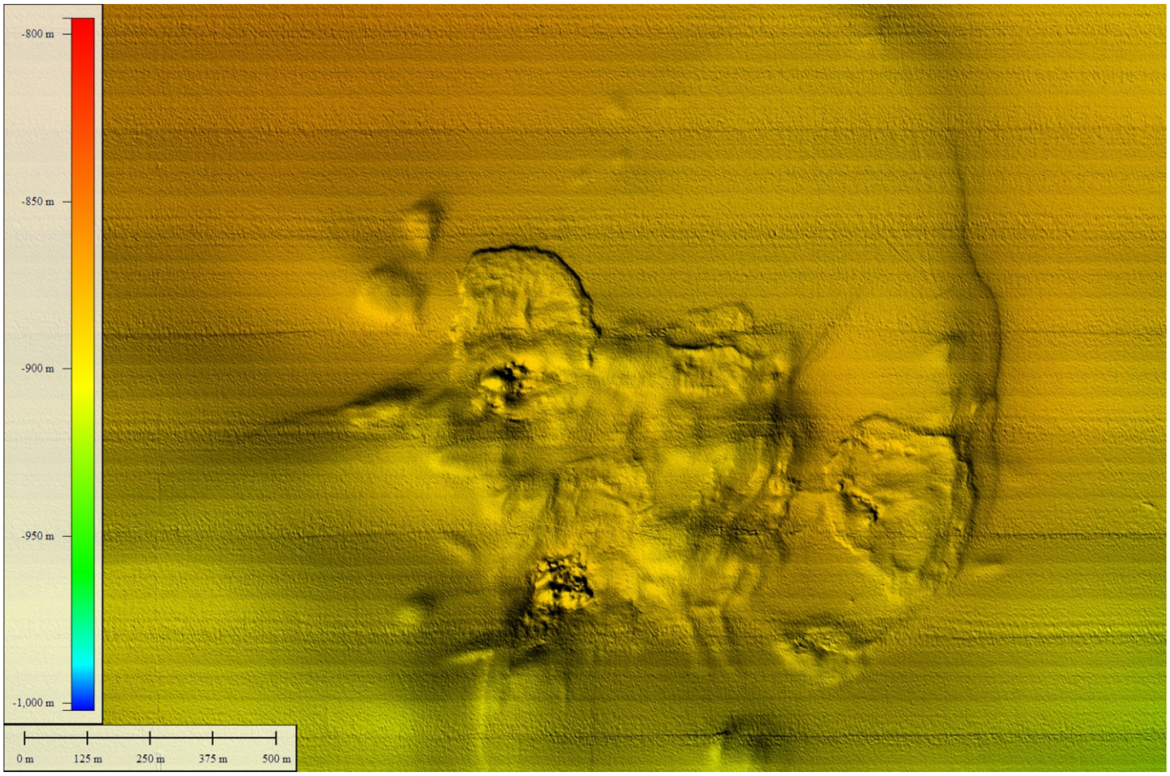
The MMRI/CMRET has a variety of data types available from MC118: gravity core, Jumbo piston core, push core, chirp, multibeam bathymetry, water-column multibeam, Shallow-source deep-receiver seismic, 3D industry seismic, heat-flow and many hours of video data. Analyses of these and comparisons between and across data types support the initial selection of the target deployment sites for the Direct Current Resistivity study. These are plotted in the accompanying figure. The 1000m long DCR cable that will be deployed and left on the seafloor to measure resistivity over a 6-month period will be centered (approximately) over a target site and oceanographic parameters measured from instruments on the Integrated Portable Seafloor Observatory (IPSO).

After arriving onsight at MC118, our plan is to conduct an initial survey that involves towing the cable near the seafloor. The purposes of the survey are to verify the selection of our targets and to inspect the data for possible new targets for this and future missions. When considering placement of the array and the IPSO, we will also have to consider the presence of known hazards. These include natural hazards such as coral colonies, irregular outcroppings of hydrate and calcium carbonate, hardgrounds at vent areas, and scarps as well as instruments presently residing on the seafloor, components of the seafloor observatory. These are also plotted in the accompanying figure.

The primary site (A), is supported by the recovery of hydrate in the 2011 Jumbo Piston coring effort, by the identification of a significant resistivity anomaly during the 2009 DCR survey of the mound at MC118 and by anomalously high heat flow values measured across the nearby surface trace of the fault identified in the subsurface chirp data (2005). In addition, analyses of multiple resolution seismic datasets support the direct communication of this fault with the crestal faults emanating from the salt structure some 600m beneath the mound. This site includes the seismic high frequency scatter signal we suspect may indicate the presence of hydrate. Site B marks the area of elevated hydrocarbon presence in a 2009 AUV survey and is the site of multiple small faults visible in chirp data as well as subsurface blanking. The heat-flow data from this area is much higher than background. Area C includes the highest heat-flow recorded in 2012 after the highest measurement in area A. Based upon the fauna observed there (video data), this is a suspected brine pool. SSDR data show a brightening 10s of meters beneath the seafloor. Area D is the area from which we first recovered hydrate in a gravity core in 2008. This site also showed heat-flow anomalies in the pockmarks in the 2012 study. The fault trace running approximately E-W through this area is the same one discussed for area A that communicates with the deep crestal fault.

The projected 1m lines in the figure represent the approximate orientations and locations we are considering for deployment of the DCR array. The black squares are located at the ends of the lines preferred for IPSO long-term deployment. As the figure shows, there are 6 possible locations under consideration. We hope to survey all six though current conditions and weather will, necessarily, play roles in our success at surveying. Current and wind directions will dictate our approach and survey direction(s). For this reason we have selected lines that represent a variety of directions of approach. In addition, the hazards (in red) will have to be avoided during survey mode so that we do not damage the cable. The number of instruments on the seafloor (small red dots) is the lowest in several years but the scarps and coral colonies make surveying near the crater complexes extremely dangerous so these areas must be avoided.

An additional figure, a map of the bathymetry of the mound area, cleared of the targets, hazards, hardware, etc. is included so that one can benefit from an unobstructed view of the seafloor bathymetry.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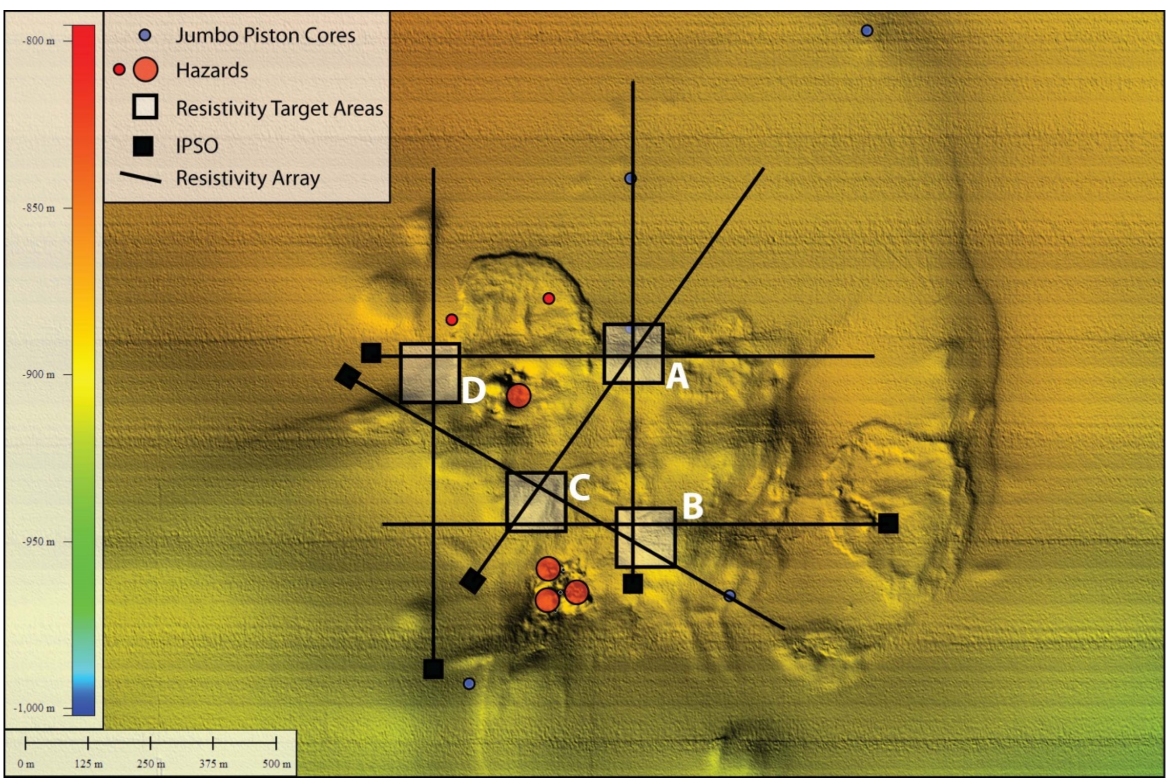
0 m
125 m
250 m
375 m
500 m


Jumbo Piston Cores
Hazards
Resistivity Target Areas
IPSO
Resistivity Array
A
B
C
D
-800 m
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0 m
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250 m
375 m
500 m