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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 – October 31, 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 I-SPIDER (patent pending), 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 2013 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 determined what caused the resistivity instrument to flood in the summer of 2012;
- We have made repairs to the damaged resistivity system resulting from the flooding event;
- 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 proposed 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 through-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.

Accomplishments achieved in relation to project goals include the following (Quarter 4):

- We have inventoried data from MC118 that has and will continue to inform our survey and deployment strategies;
- We have established a processing protocol for the polarity-preserving chirp data from MC118;
- We have designed and begun acquiring components for the replacement battery system for the IPSO;
- We have completed a paper describing the new resistivity data processing method that will be used to process the targeting data as a 3D data set;
- We have developed a data acquisition and communication and control system to allow long term deployment of a DC resistivity array on the sea floor;
- We have submitted a no-cost extension request to complete Year 1 work that has been approved.

Accomplishments achieved in relation to project goals include the following (Quarter 5):

- We have completed the electronics integration for command and control throughout survey and deployment/monitoring modes;
- We have tested the joint operation of the IDP, the control computer, and the resistivity instrument in the remote-control and autonomous monitoring mode of operation;
- We have built/modified a deployment system for the 1000m long DCR array;
- We have a plan for processing initial reconnaissance DCR data;
- We have a plan in place for the cruise to collect survey data and to place the DCR array and lander for a 6-month data-collecting period.

Accomplishments achieved in relation to project goals include the following (Quarter 6):

- We completed the construction and assembly and installation of sensors for the IPSO;
- We planned and conducted a successful cruise to MC118, April 9-12;
- We have made an experimental and successful use of a new/modified deployment system for the 1000m long DCR array;
- We collected four ~1km-long resistivity profiles in survey mode;
- We completed initial analyses of the survey lines;
- We selected the monitoring site, adapted the lander for monitoring mode, and deployed the IPSO-DCR assembly at the monitoring target;
- We successfully executed the continuation presentation;
- We have a No-Cost Extension in place;
- We have reprocessed initial survey data with a variety of filters.

Accomplishments achieved in relation to project goals include the following (Quarter 7):

- We planned and executed a cruise to MC118 to recover the DCR array and IPSO lander;
- We successfully recovered all systems ahead of schedule, by partnering with another agency's late-scheduled cruise;
- The long term data acquisition and communication and control system for the DC resistivity array on the sea floor successfully recorded the data from the DCR;
- We recovered 2 time-lapse DCR data files (images/profiles of the subbottom);
- Two DCR profiles have been processed in time-lapse mode showing changes in high resistivity anomalies changed from one week to the next;
- The IPSO electronics successfully collected and stored data from the oceanographic sensors;
- We managed to have the failure of the DCR array isolated;
- We completed a cruise report for the April cruise detailing the deployment of the DCR/IPSO system (http://mmri.olemiss.edu/Home/Publications/Cruise.aspx);
- We completed a cruise report for the August-September cruise detailing the recovery of the DCR/IPSO system (http://mmri.olemiss.edu/Home/Publications/Cruise.aspx).

We planned and executed a cruise to MC118 to recover the DCR array and IPSO lander

Since the repairs required to make the Station Service Device (SSD) Remotely Operated Vehicle (ROV) functional had not yet been completed – and we did not have the parts required to make it operable by in time for this cruise – we decided to make some minor modifications to the I-SPIDER (Integrated Scientific Platform for Instrument Deployment and Emergency Recovery) to enable it to perform the recovery. We reserved 6 days in late October on the R/V Pelican to perform the recovery and determine whether to recover the DCR array and IPSO lander or to redeploy them. If the batteries and instruments were all functioning properly, our plan was to redeploy.

We successfully recovered all systems ahead of schedule, by partnering with another agency's late-scheduled cruise

MMRI was required to run a NIUST (National Institute for Undersea Science and Research) cruise in August-September. With the probability of deteriorating weather in the Gulf of Mexico later in the year, we took the opportunity to combine these trips. We have also suffered a loss of personnel and were able to get the needed crew together for the earlier dates, while for the later dates this was doubtful. This plan saved the project considerable funds as NIUST covered transit days for the cruise. It also provided the possibility of using saved ship-time to fund an additional cruise should we have to recover the DCR array and lander on this trip and redeploy them at a later date.

The recovery of the IPSO lander and DCR array was a difficult task, made possible with deft maneuvering of the ship and coordination of the crews onboard. The I-SPIDER was key to the recovery as illustrated in Figures 1, 2 and 3.

Figure 1. Cruise participants Dunbar (Baylor), Stoekel (SDI), and Tidwell(MMRI) make final adjustments to the I-SPIDER before sending it on its mission to retrieve the DCR array and instrumented IPSO lander.

Figure 2. The grapnel lands and hooks - with two prongs - the east-facing top horizontal bar of the IPSO lander. Note oceanographic instruments on north and south-facing bars.

Figure 3. After the I-SPIDER was recovered to the Pelican's deck, the IPSO lander was hooked to the Pelican

The long term data acquisition and communication and control system for the DC resistivity array on the seafloor successfully recorded the data from the DCR

Specialty Devices has worked with Dr. Dunbar and AGI to develop and deploy a long term data acquisition and communication and control system for a DC resistivity array on the sea floor. This system utilizes a new Atom based processor along with previously developed equipment to create a system which can take periodic DCR measurements over a deployment of 6 months.

During this cruise the DCR system with seafloor controller and data logger was recovered from the seafloor. The system was removed from the deployment cage and opened in the lab of the ship. The DCR system, the IDP controller and the Atom based data logger were all recovered and in good physical condition with very little if any corrosion or damage to the housings or cabling. The battery power was determined to be in good condition with ample stored energy remaining. Upon opening the housings all three housing were in good condition with no signed of leakage. Powering up the Atom based data logger we found it had stored data but not as much as anticipated for the length of the cruise. Although all functions of the Atom based computer appeared to remain functional, the instrument contained only 2 time-lapse data files. From the system log files, we determined that what had happened was that the system had worked as expected through two recording cycles, meaning that the system woke up, transferred data from the instrument to the controlling computer, transferred instructions from the controlling computer to the DCR instrument, collected a profile, and then went back to sleep. However, at the being of the third recording cycle, 21 days after its deployment, the controlling computer woke up and tried to connect to the DCR instrument, but got no response from the instrument. This process was repeated every week for the remaining four months of the deployment. When the instrument was recovered from the seafloor and opened in the ship's lab, dry inside and the electronics operating, we tried to power-up the instrument but a "Low-Battery" message was displayed on the instrument's internal screen, with the instruction for the user to "press any key to continue". During the time-lapse deployment, there was clearly no operator. Hence, this message caused the instrument to hang and not respond to the connection request from the external controlling computer. The seafloor power-supply battery was still near full charge, with plenty of power and voltage to run the instrument. The "Low-Battery" message is a feature built into the DCR instrument to prevent damage to the instrument when an attempt is made to run the instrument with an insufficiently charge battery. The message had not been received during weeks of testing in the lab, prior to deployment and yet it appeared in the ship's lab after the cruise. The fact that the instrument failed to run at room temperature in the ship's lab rules out temperature as the cause. Instead, it appears that something in the power-handling hardware associated with the instrument failed. This could be the DC-to-DC converter that drops the 48 volts input from the power supply battery to the 12 volts required by the instrument. It could also be one or both of the capacitors inline with the DC-to-DC converter used to filter the startup voltage fluctuations. A third possibility is that the feature within the instrument that tests for low voltage failed. Further forensic analysis will be needed to determine the source of problem.

To address the programming hang-up, we believe the command request asking if the battery status is acceptable to continue operations should either be deleted from the operational code or a delay start up relay should be installed in the resistivity system to remove the resistivity system's capability to test this battery status until the system DC-DC converters are up and running a sufficient time to prevent this request from being issued. Short of this software issue the system electronics functioned as designed throughout the deployment period, surviving the challenges of a 4.5 month residence on the seafloor.

We recovered 2 time-lapse DCR data files (images/profiles of the subbottom)

The location of the monitoring line for the project was determined, in part, from anomalies mapped during a 2009 resistivity survey of Woolsey Mound (Figure 4). During the April 2014 deployments cruise, several test profiles were collected and the location for the DCR/IPSO determined (Figure 5). In spite of the failure of the command request function three weeks into the deployment, the recovery of the DCR array and electronics proved that the system worked and that the overall design is sound.

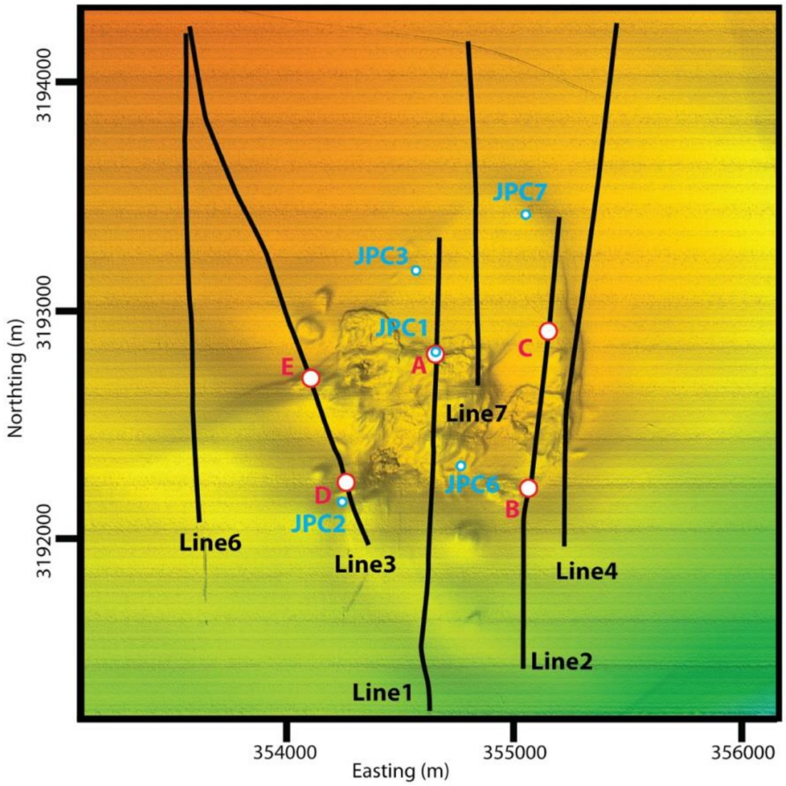

Figure 4. A 2009 DCR survey (black lines) run to test the system's capability to determine the presence of gas\hydrates established anomalies A-E. Blue circles indicate Jumbo Piston Core locations. JPC1 and JPC6 contained solid hydrate and gas, respectively.

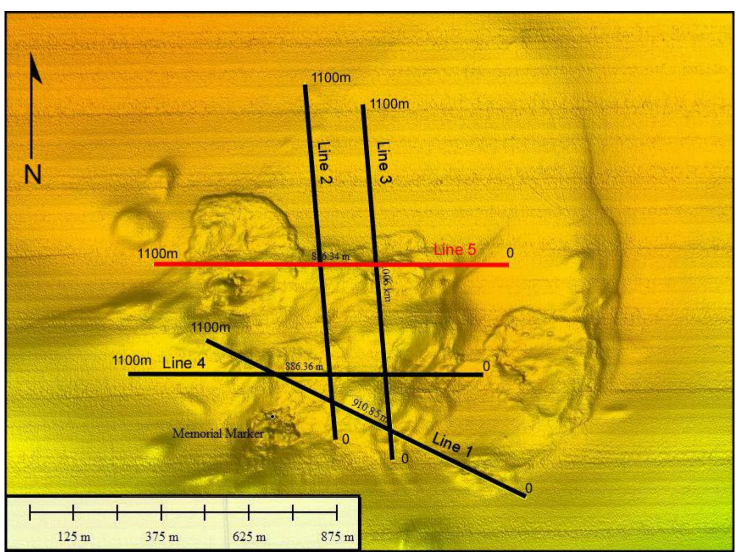

Figure 5. During an April, 2014 DCR cruise, four survey/reconnaissance profiles were collected along the traces shown in black. The IPSO lander and attached DCR array were deployed at the location shown in red. This deployment line coincides with a fault along which three anomalies had been identified (Figure 4, above), bubble plumes observed at the seafloor, and hydrates recovered (via gravity cores) from the shallow subsurface.

Two DCR profiles have been processed in time-lapse mode showing changes in high resistivity anomalies changed from one week to the next
Following the cruise and recovery of resistivity data, the two profiles that were recorded were processed in time-lapse mode (Figure 6). These images show that even within the short span of two weeks, significant changes in the distribution of high resistivity anomalies associated with hydrate concentration changed, with new anomalies appearing within 40m of the seafloor and other anomalies decreasing in amplitude. However, given that the current design of electrode array has proven to be unsuitable for long-term deployment, redeployment for further time-lapse monitoring as originally planned was not an option.

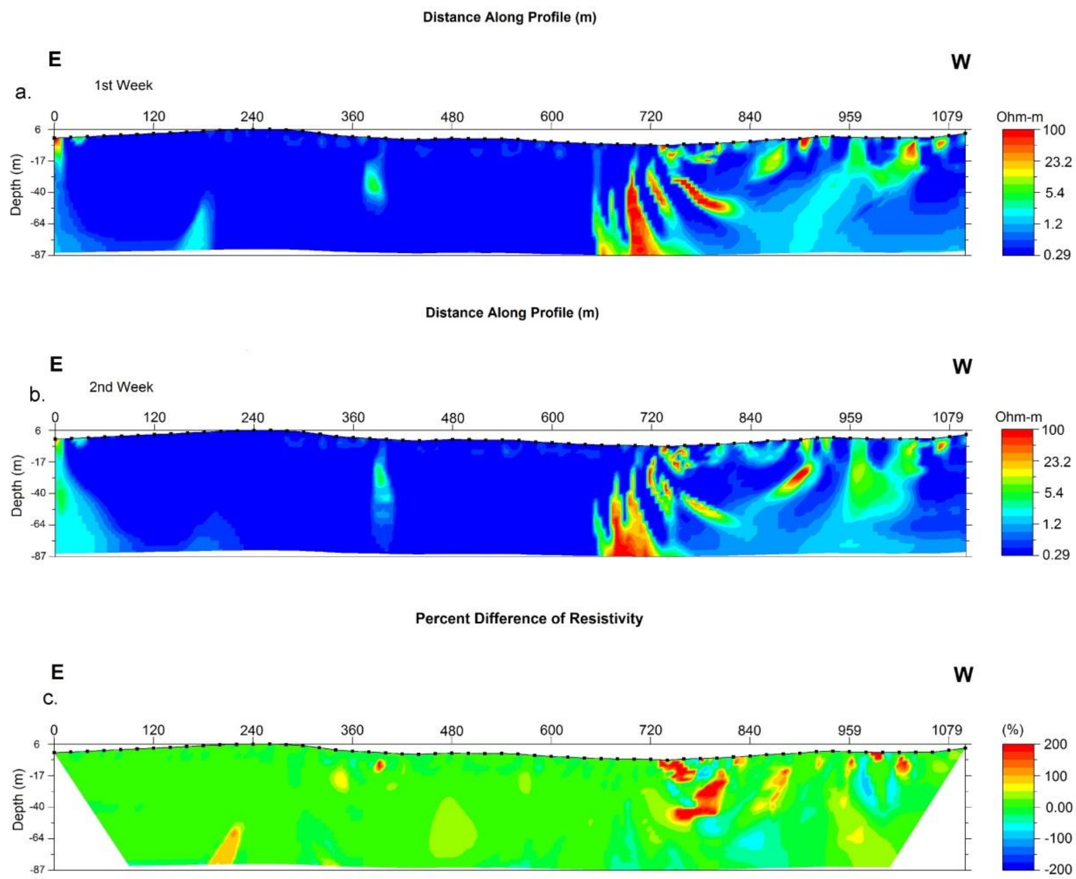

Figure 6. Inverted DCR time-lapse profiles. (a) Initial DCR profile collected along monitored line. High resistivity anomalies associated with shallow hydrate are concentrated in the western half of the profile, where the profile passes just north of the most active gas vent at the site. (b) Second profile collected along monitored line one week later, with the array in the same position. (c) Percentage change in resistivity from one week to the next. Positive resistivity change indicates increasing resistivity over time, which is associated with hydrate formation, whereas negative resistivity change over time indicates hydrate dissociation.

The IPSO electronics successfully collected and stored data from the oceanographic sensors
Sensors on the IPSO lander collected oceanographic data. This was somewhat in doubt as the lander was deployed at a severe angle from vertical. Upon our return we found that the instruments were all appropriately located within the water column with the lander much closer to vertical.

We managed to have the failure of the DCR array isolated
After the cruise was complete, we tested the array for electrical isolation between electrodes and electrical continuity between the connector pins and the electrodes. The array passed the isolation test, but failed the continuity test. All 56 electrodes were no longer electrically connected to the connector pins. Apparently the graphite electrodes are sufficiently permeable such that during the long deployment at high pressure, seawater penetrated the electrodes and corroded the connection between the copper conductors and the copper pins in the graphite electrodes. Further forensic analysis will be needed to determine if this is the source of the problem.

We completed a cruise report for the April cruise detailing the deployment of the DCR/IPSO system
This report of cruise operations is posted to the MMRI website and can be found at http://mmri.olemiss.edu/Home/Publications/Cruise.aspx.

We completed a cruise report for the August-September cruise detailing the recovery of the DCR/IPSO system
This report of cruise operations is posted to the MMRI website and can be found at http://mmri.olemiss.edu/Home/Publications/Cruise.aspx.

MILESTONE CHART:

Milestones A, B, C, D and E are complete.

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 the DCR cable in a pressure-testing facility – SW Research Institute or comparable.	9/15/2013	9/11/2013	Successful test of the DCR system at 1000m water depth equivalent	
Milestone C: Successful testing of a new Integrated Portable Seafloor Observatory (IPSO).	9/15/2013	9/25/2013	Successful onshore test of IPSO	10 days
Milestone D: Successful deployment of Integrated Portable Seafloor Observatory (IPSO).	4/30/2014	4/12/2014	Proper orientation and functioning of IPSO	
Milestone E: Recover data from MC118 with the IPSO	10/31/2014	9/3-4/2014	IPSO recovered with data	8 weeks early
Milestone F: Recover data from MC118 with the IPSO	4/30/2015		IPSO recovered with data	
Milestone G: Complete analysis of temporal characterization of hydrates system dynamics at MC118	10/31/2015		Resistivity and temporal data produce reasonable temporal analysis	
Milestone H: Complete final report and submit to DOE	1/31/2016		Report accepted by COR	

PRODUCTS:

A new lander, the Integrated Portable Seafloor Observatory, or IPSO;
oceanographic instruments for the IPSO;
A new cable-deployment system for the DCR;
Command and control hardware and software;
A 1100m long DCR cable-array;
Cruise report of April's activities, http://mmri.olemiss.edu/Home/Publications/Cruise.aspx;
Raw and processed resistivity data from a hydrates mound.
Cruise report of August-September activities, http://mmri.olemiss.edu/Home/Publications/Cruise.aspx;
Initial time-lapse resistivity data with areas and percentage change over time.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

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

Name: Carol Lutken
Project Role: PI, University of Mississippi
Nearest person month worked: 2
Contribution to Project: Lutken executed all communications between participants and with DOE and LUMCON and made arrangements for the August-September, 2014 cruise. She worked with the MMRI shop to assure everyone's readiness for the recoveries cruise, filed the Request to conduct research with the Bureau of Ocean Energy Management, and the pre- and post-cruise reports with LUMCON. She served as Chief Scientist on the cruise making her responsible for the successes and failures of the mission. She was responsible for the coordination of the lander/array recovery plan. She is responsible for and has completed the cruise reports for both cruises during this quarter. She continues to work with D'Emidio to analyze subsurface data available from MC118. She compiled information for and wrote the quarterly progress report. She has communicated with both the Project Manager and the Contracts Officer regarding the end of the project, rebudgeting and task justifications.

Name: Marco D'Emidio: 1
Project Role: Scientist, University of Mississippi
Nearest person month worked: 1
Contribution to Project: D'Emidio worked to assure all electronics and computing components were functional, up-to-date and ready to go on the cruise. This included making backup copies of all data relevant to the cruise and data-collecting efforts and assuring that the maps used for navigation and target location were complete. He continues to work with the polarity-preserved chirp processing, focusing on the MC118 data. D'Emidio is in charge of cruise navigation, tracking all components during survey mode and logging locations and dispositions of equipment on the seafloor. He also generates visuals for cruise navigation, reports, proposals, etc.

Name: Steven Tidwell
Project Role: Research Associate, University of Mississippi
Nearest person month worked: 1
Contribution to Project: Tidwell is the MMRI/CMRET shop research associate with a degree in geological engineering and expertise in machining and electronics as well as computer software. With the departure of Lowe from MMRI in August, Tidwell became chief engineer on this project, directing both shop activities and deck activities at sea. He was responsible for adaptations to the I-SPIDER and for

integration of the instrumentation. During the cruise, Steven is also able to operate TrakLink. He is training in cable maintenance – terminations and storage.

Name: Jeremy Dew
Project Role: Research Associate, University of Mississippi
Nearest person month worked: 0
Contribution to Project: Jeremy is a geologist with extensive shop experience. He assisted in I-SPIDER adaptations and went on the cruise.

Name: Larry Overstreet
Project Role: Electronic Technician, University of Mississippi
Nearest person month worked: 1
Contribution to Project: Larry is experienced in fiber-optics work including cable terminations and systems integration. He is also an accomplished machinist who designed and built the grapnel used in the successful recovery of the DCR/IPSO system as well as a back-up. He built in acoustic releases to the recovery system in case of an unwanted recovery (the grapnel snagged something we did not want to recover, such as an instrument).

Name: John Dunbar
Project Role: Co-I, Baylor University
Nearest person month worked: 1 (5 weeks)
Contribution to Project: Dunbar participated in the cruise and in the evaluation of the DCR instrument onboard the Pelican and following the cruise. He is responsible for the evaluation of the cable, post-cruise. Dunbar and Xu have completed initial processing of the data recovered during the cruise.

Name: Tian Xu
Project Role: Graduate student, Baylor University
Nearest person month worked: 2
Contribution to Project: Xu works with Dunbar to define the processing of resistivity data collected during survey and monitoring modes. Xu participated in the cruise and processed data onboard as well as post-cruise. Xu will be the primary author on a paper resulting from this work and has already completed one accepted, peer-reviewed article on these methods.

Name: Paul Higley
Project Role: Co-I, Specialty Devices, Inc.
Nearest person month worked: 1
Contribution to Project: Higley, an ocean engineer, works in all aspects of pre-cruise and cruise activity. He participated in the cable design and spooling and in the terminations and adaptation of the DCR system from survey to monitoring mode. He participated in both deployment and recovery cruises and is responsible for the evaluation of the Atom computer and IDP performances.

Name: Scott Sharpe
Project Role: Electronics specialist, Specialty Devices, Inc.
Nearest person month worked: 0
Contribution to Project: Sharpe heads the electronics and programming staff at SDI. He redesigned the IDP for this project, programmed and reprogrammed the components for the cruise and for monitoring mode. He developed the data acquisition and communication and control system to allow long term deployment of a DC resistivity array on the sea floor. Although he did not participate in the cruise itself

this quarter, he designed the electronics tests and communications capabilities executed by Higley upon systems recovery.

Name: SDI Technical staff
Project Role: Electronics and technical support, Specialty Devices, Inc.
Nearest person month worked: 0
Contribution to Project: Worked with Higley and Sharpe to evaluate the data acquisition and communication and control system to allow long term deployment of a DC resistivity array on the sea floor. One technician participated in the cruise both in the tech room and on the back deck.

IMPACT:

Since the SSD was not available for this cruise, we again adapted the I-SPIDER to perform its functions, expanding the capabilities of this vital vehicle. The MMRI shop designed and constructed a 4-pronged grapnel for the purpose of snagging the top bar of the IPSO lander from the underside of the I-SPIDER. The DCR array was always expected to be recovered along with the array, following it onboard. This is what happened though it took quite awhile for the crews of the Pelican and the MMRI to coordinate this precise operation successfully.

The coordination and interactions of the hardware and software performed to near-perfection and all systems were recovered undamaged. The failure of the array, although not determined definitively, appears to have resulted from the failure of graphite to perform as an insulator over time and at 900m water depth. Even this failure does not negate the success of the overall project design. Should a more robust (and expensive, in all cases so far investigated) insulator be built into the array, and the computer software hang overcome – something that should not be difficult in terms of time, effort or expense – this monitoring system should perform successfully at this depth and over the 6-month period. ***The results of the time-lapse data analyses accomplish the primary objective of the project: to image shallow hydrate and to illustrate its temporal variability.***

The collaboration of the MMRI shop with the NIUST lab has continued to be productive. Their expertise in electronics enabled us to adapt some of the functions of the I-SPIDER and to operate efficiently on the recovery of the DCR array-IPSO lander system.

In spite of the successes of this first effort to recover data using the DCR array and instrument in monitoring mode, the failure of the array to withstand the extreme conditions of the long-term seafloor deployment have resulted in the DOE's decision to terminate the project early, rather than to have us attempt to rebuild the array using more robust insulating material. We are doing our best to make the most of the acquired data – both resistivity and oceanographic parameters – by early 2015. We anticipate that the shallow chirp profiles we have in hand will help determine possible geological/geophysical explanations for the profound changes observed in the shallow hydrate distribution over the brief period of investigation in monitoring mode. It is clear that this system holds great promise as a prospecting tool for shallow hydrates.

Students and interns have long been a vital part of our projects. The early termination of the project will truncate student efforts/projects related to this study. We added a student/intern as part of our shop team for this project and had hoped to add another for data analyses. The latter appears an unlikely possibility unless we manage to employ one already experienced in data analyses. In either case, we will likely have to redouble our analyses efforts before December. Tian Xu, a graduate student in geophysics at Baylor University, participated in the cruise and through this project has become skilled in analyses of the DCR data.

CHANGES/PROBLEMS:

The computer command glitch encountered during the deployment resulted in the diminished volume of data collected during the deployment time. Because this difficulty was not discovered during months of laboratory testing yet appeared in the ship's lab following recovery, it appears not to be temperature –related. We believe it can be corrected or bypassed with relative ease. The failure of the cable, we believe is owing to the failure of the graphite to function as an insulator of the nodes in the DCR array over extended time. Salt water was able to penetrate the nodes causing them all to corrode. The array could be rebuilt with copper or other insulator in place of the graphite. This could involve no additional funds but would require additional time – approximately one year – beyond the current schedule. We realize that DOE does not support this delay and we are making every effort to make the most scientifically productive use of the time between now and the new end-date of January 31 to evaluate the oceanographic data, the resistivity data and to integrate the two. Interpretation will involve the use of subbottom data already in-hand.

Since the system was not in shape to redeploy, we recovered it on the early cruise. Because we were able to combine the DOE work with that of another scheduled cruise, we saved money in ship-time.

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. 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 5		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		7/1/15 - 9/30/15	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q5	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	-	590,561	105,994	696,555	82,926	779,481								
Non-federal Share	36,912	36,912	36,912	73,824	36,912	110,736	36,912	147,648	-	147,648	28,973	176,621	26,747	203,368								
Total Planned	164,033	164,033	164,032	328,065	246,112	574,177	164,032	738,209	-	738,209	134,967	873,176	109,673	982,849								
Actual Incurred Cost																						
Federal Share	-	-	8,592	8,592	86,331	94,923	201,745	296,668	42,214	338,882	74,615	413,497	146,404	559,901								
Non-federal Share	22,599	22,599	5,770	28,369	12,584	40,953	-	40,953	55,488	96,441	10,843	107,284	41,363	148,647								
Total Planned	22,599	22,599	14,362	36,961	98,915	135,876	201,745	337,621	97,702	435,323	85,458	520,781	187,767	708,548								
Variance																						
Federal Share	127,121	127,121	118,528	245,649	122,869	368,518	(74,625)	293,893	(42,214)	251,679	31,379	283,058	(63,478)	219,580								
Non-federal Share	14,313	14,313	31,142	45,455	24,328	69,783	36,912	106,695	(55,488)	51,207	18,130	69,337	(14,616)	54,721								
Total Planned	141,434	141,434	149,670	291,104	147,197	438,301	(37,713)	400,588	(97,702)	302,886	49,509	352,395	(78,094)	274,301								