Oil & Natural Gas Technology

DOE Award No.: DE-FE0010406

Quarterly Research Performance Progress Report (Period ending 12/31/2012)

CONTROLS ON METHANE EXPULSION URING MELTING OF NATURAL GAS HYDRATE SYSTEMS: TOPIC AREA 2

Project Period (10/1/2012 to 12/31/2012)

Submitted by:
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Signature

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ACCOMPLISHMENTS:

What are the major goals of the project?

The project goal is to predict, given characteristic climate-induced temperature change scenarios, the conditions under which gas will be expelled from existing accumulations of gas hydrate into the shallow ocean or directly to the atmosphere. When those conditions are met, the fraction of the gas accumulation that escapes and the rate of escape shall be quantified. The predictions shall be applicable in Arctic regions and in gas hydrate systems at the up dip limit of the stability zone on continental margins. The behavior shall be explored in response to two warming scenarios: longer term change due to sea level rise (e.g. 20 thousand years) and shorter term due to atmospheric warming by anthropogenic forcing (decadal time scale).

Milestone Description	Planned Completion	Actual Completion	Verification Method	Comments (progress toward achieving milestone, explanation of deviation from plan, etc.)
1.A 1-D simulation of gas hydrate dissociation in natural systems.	9/30/2013		Report	
1.B 1-D Simulation of gas hydrate dissociation in laboratory controlled conditions.	3/31/2014		Report	
1.C Model-based determination of conditions required for gas not to reach seafloor/atmosphere from dissociating hydrate accumulation.	3/31/2014		Quarterly Report	
1.D Determination of what hydrate reservoirs are at three-phase equilibrium.	12/33/2013		Report	Evaluating petrophysical basis for large saturation exponents for resistivity in sediments with large hydrate saturation. Applying approach to known reservoirs.
1.E Demonstrate ability to create and dissociate methane hydrate within sediment columns under conditions analogous to natural systems.	9/30/2013		Report	Currently developing/refining remote sensing technologies.
2.A 1-D simulation of gas expulsion into hydrate stability zone.	9/29/2014		Report	Preliminary simulations produced
2.B Determination of conditions for which gas expulsion into hydrate-stability zone is self-limiting.	12/29/2014		Report	
2.C Demonstration of reaction transport experiment where gas invades hydrate stability zone and creates three phase stability.	9/30/2014		Quarterly Report	Currently developing/refining remote sensing technologies.
2.D Demonstrate a 2D simulation of hydrate dissociation and gas expulsion.	3/31/2015		Report	

What was accomplished under these goals?

Task 1: Project Management and Planning: An initial web-based kick off meeting was held. We have spent a great deal of time recruiting post-docs and students for the project.

Task 4: Laboratory Evaluation of Hydrate Dissociation: the focus has been on developing the temperature and resistivity string necessary to monitor the chemical/thermodynamic signal that will be present as the methane hydrate forms.
Task 3: Categorize stability of known hydrate reservoirs: A graduate student has developed a methodology to calculate in-situ salinity and hydrate saturation based on resistivity logs and core measurements of salinity after hydrate melting. The model has been applied to two field locations (ODP Sites 1249 and 1250, and IODP Site U1328.

Task 2: Conceptual and Numerical Model Development -1D: We have begun developing and applying a one dimensional model of hydrate solidification coupling heat and salinity. Initial results simulate gas flux toward the seafloor and solidification due to cooling near the seafloor.

What opportunities for training and professional development has the project provided?

There have been several conversations between several researchers working on this grant, including a site visit by a UT research scientist associate and LBNL research scientist. Through these one-on-one interactions, the LBNL scientist was able to share their knowledge and experience related to CT scanning and image analyses, as well as the process of running hydrate formation experiments with the UT research scientist associate. A graduate student has been trained in interpretation of log and core data to determine hydrate saturation.

How have the results been disseminated to communities of interest?

At this time, no results have been disseminated.

What do you plan to do during the next reporting period to accomplish the goals?

Task 1: Project Management and Planning: Complete hiring of one post-doc and recruiting one student.

Task 2: Conceptual and Numerical Model Development -1D: Continue model development.

Task 3: Categorize stability of known hydrate reservoirs: apply approach to several more marine systems. We will review the applicability of geometrically realistic models of the growth of electrically insulating phase on the overall electrical conductivity of a sediment containing brine and the insulating phase. Previous work on diagenetic alteration of sediment pore space, e.g. growth of isopachous cement on grains surfaces, preferential growth of cement on grain surfaces near pore throats, growth of blocky pore filling cement, can be readily adapted for this purpose. In that work, the formation factor can be computed or measured and plotted as a function of porosity, and the cementation exponent *m* can be determined from that plot. For the present application, the logic is as follows: if the growth habit of hydrate corresponds to layers accreting on grain surfaces, then the resistivity index of a sand containing brine and hydrate will exhibit a saturation exponent that has the same numerical value as the cementation exponent observed for rocks in which porosity varies due to extent of isopachous cement. On the other hand if hydrate grows as blocky, pore-filling lumps within pore bodies, then the saturation exponent should have same numerical value as the cementation exponent in rocks in which blocky pore filling cement grows.

The importance of the saturation exponent is that the inference of in situ hydrate saturations in naturally occurring sediments depends critically on that value. The hydrate saturation in turn critically affects the expected brine salinity if the hydrate accumulation is in three phase equilibrium. Data obtained to date from the literature indicate that larger than customary values of saturation exponent are needed to make the three-phase equilibrium model consistent with observed brine salinities. Hence our desire to re-assess the basis for the choice of saturation exponent. There are no reliable laboratory measurements nor are there any models which correctly represent even the most basic aspects of connected pore space in sediments. Thus we are pursuing the approach outlined in the previous paragraph.

Task 4: Laboratory Evaluation of Hydrate Dissociation: We will complete the manufacturing of the thermistor and resistivity strings and data acquisition system. We will run these systems through a series of diagnostic tests, calibration exercises, and deliver them to LBNL for use in the laboratory portion of this project.

PRODUCTS:

What has the project produced?

Nothing to report

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS:

What individuals have worked on the project?

Provide the following information for: (1) principal investigator(s)/project director(s) (PIs/PDs); and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort).

Name	Peter Flemings	Steve Bryant	Tim Kneafsey	Dylan Meyer
Project Role	Principal Investigator	Co-Principal Investigator	Co-Principal Investigator	Graduate Student
Nearest person month worked	.25	.25	.25	1
Contribution	Advised graduate student Meyer, managed project, and recruited students. Worked with technicians for thermistor development.	Advised graduate student Meyer on analysis of models of pore space alteration due to hydrate growth and its effect on saturation exponent.	Participated in conference calls on experimental design.	Performed analysis of thermodynamic state of 3 locations.
Funding Support	The University of Texas	The University of Texas	Lawrence Berkeley National Lab	UTIG Fellowship
Collaborated with individual in foreign country	No	No	No	No

What other organizations have been involved as partners?

Organization Name: Lawrence Berkeley National Lab
Location of Organization: Berkeley, CA
Partner's contribution to the project (identify one or more)

- In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);
- Facilities (e.g., project staff use the partner's facilities for project activities);
- Collaborative research (e.g., partner's staff work with project staff on the project); and

Have other collaborators or contacts been involved?

No

IMPACT:

What is the impact on the development of the principal discipline(s) of the project?

Geological models of gas transport and hydrate melting and solidification have suggested that free gas cannot migrate through the hydrate stability zone during melting. In contrast, we suggest that free gas can migrate through the hydrate stability zone by altering the conditions of hydrate stability to a state of three-phase equilibrium through the elevation of salinity and possibly temperature. This results in fundamentally different macro-scale behavior during melting and may result in greater gas venting than has been previously demonstrated. If this hypothesis is correct, it may engender a new generation of field and laboratory investigations to document this behavior in both the field of geosciences and petroleum engineering. Second, the project links theoretical development with laboratory modeling because the concepts can be applied at the laboratory scale as well as the field scale. The laboratory experiments to be conducted will enable validation of the mechanisms incorporated in the models. These laboratory experiments will play a key role in demonstrating the processes.

What is the impact on other disciplines?

A likely outcome of our work is a more quantitative prediction of the magnitude of methane flux from the earth to the atmosphere over human (decadal) timescales and geological timescales (10,000 years). These will serve as boundary conditions for atmospheric climate models. In turn, these results may guide policy decisions.

What is the impact on the development of human resources?

We are working at the interface of geosciences and engineering. We are coupling theory and laboratory experiments to address macro-scale geologic problems. This is training a new generation of geoscientists and engineers to think with a systems-based approach that links observation with theory.

The results are being applied in the classroom and the support is training several graduate students.

What is the impact on physical, institutional, and information resources that form infrastructure?

The project is strengthening the experimental efforts and capability at UT as it is our drop to develop sensor equipment. The project is strengthening development at LBNL where primary experimental work is occurring.

What is the impact on technology transfer?

We are presenting our research to approximately 100 industry members at our GeoFluids consortium and we will be presenting at a range of national and international meetings.

What is the impact on society beyond science and technology?

A likely outcome of our work is a more quantitative prediction of the magnitude of methane flux from the earth to the atmosphere over human (decadal) timescales and geological timescales (10,000 years). These will serve as boundary conditions for atmospheric climate models. In turn, these results may guide policy decisions.

What dollar amount of the award's budget is being spent in foreign country(ies)?

Zero percent of the award's budget is being spent in foreign countries.

CHANGES/PROBLEMS:

Changes in approach and reasons for change

No changes in approach to report for this reporting period.

Actual or anticipated problems or delays and actions or plans to resolve them

We are having unanticipated difficulty identifying a suitable graduate student in petroleum engineering for this project. We are considering the possibility of devoting more of the post-doc's time to modeling to address this problem. A good candidate for this work has been identified and an interview has been scheduled for 15 Feb 2013.

Changes that have a significant impact on expenditures

There has been a delay in the hiring of the graduate student and post-doctoral positions for this project. The funds allocated for these positions are on hold till these positions have been filled.

Significant changes in use or care of human subjects, vertebrate animals, and/or Biohazards

Nothing to report

Change of primary performance site location from that originally proposed

Nothing to report

BUDGETARY INFORMATION:

Baseline Reporting (10/1/12 - 12/31/12)	Budget Period 1							
	Q1		Q2		Q3		Q4	
	10/1/12 - 2/15/13		2/16/13-6/30/2013		7/1/2013-11/15/2013		11/16/2013-3/31/2014	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 136,111.50	$ 136,111.50	$ 175,000.50	$ 311,112.00	$ 175,000.50	$ 486,112.50	$ 175,000.50	$ 661,113.00
Non-Federal Share	$ 43,568.75	$ 43,568.75	$ 43,568.75	$ 87,137.50	$ 43,568.75	$ 130,706.25	$ 43,568.75	$ 174,275.00
Total Planned	$ 179,680.25	$ 179,680.25	$ 218,569.25	$ 398,249.50	$ 218,569.25	$ 616,818.75	$ 218,569.25	$ 835,388.00
Actual Incurred Cost								
Federal Share	$ 44,330.00	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00
Non-Federal Share	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Incurred Cost	$ 44,330.00	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00
Variance								
Federal Share	$ (91,781.50)	$ (91,781.50)	$ (175,000.50)	$ (266,782.00)	$ (175,000.50)	$ (441,782.50)	$ (175,000.50)	$ (616,783.00)
Non-Federal Share	$ (43,568.75)	$ (43,568.75)	$ (43,568.75)	$ (87,137.50)	$ (43,568.75)	$ (130,706.25)	$ (43,568.75)	$ (174,275.00)
Total Variances	$ (135,350.25)	$ (135,350.25)	$ (218,569.25)	$ (353,919.50)	$ (218,569.25)	$ (572,488.75)	$ (218,569.25)	$ (791,058.00)

	Budget Period 2							
	Q1		Q2		Q3		Q4	
	4/1/2014-8/15/2014		8/16/2014-12/31/2014		1/1/2015-5/15/2015		5/16/2015-9/30/2015	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 127,422.00	$ 661,113.00	$ 127,422.00	$ 788,535.00	$ 127,422.00	$ 915,957.00	$ 127,422.00	$ 1,043,379.00
Non-Federal Share	$ 34,048.50	$ 174,275.00	$ 34,048.50	$ 208,323.50	$ 34,048.50	$ 242,372.00	$ 34,048.50	$ 276,420.50
Total Planned	$ 161,470.50	$ 835,388.00	$ 161,470.50	$ 996,858.50	$ 161,470.50	$ 1,158,329.00	$ 161,470.50	$ 1,319,799.50
Actual Incurred Cost								
Federal Share	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00
Non-Federal Share	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Incurred Cost	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00	$ -	$ 44,330.00
Variance								
Federal Share	$ (127,422.00)	$ (616,783.00)	$ (127,422.00)	$ (744,205.00)	$ (127,422.00)	$ (871,627.00)	$ (127,422.00)	$ (999,049.00)
Non-Federal Share	$ (34,048.50)	$ (174,275.00)	$ (34,048.50)	$ (208,323.50)	$ (34,048.50)	$ (242,372.00)	$ (34,048.50)	$ (276,420.50)
Total Variances	$ (161,470.50)	$ (791,058.00)	$ (161,470.50)	$ (952,528.50)	$ (161,470.50)	$ (1,113,999.00)	$ (161,470.50)	$ (1,275,469.50)

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