Oil & Natural Gas Technology

DOE Award No.: DE- FE0013961

Quarterly Research Performance Progress Report
(Period ending 6/31/2014)

Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

Project Period (10/1/2013 to 9/30/2016)

Submitted by:
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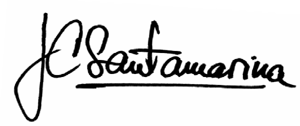

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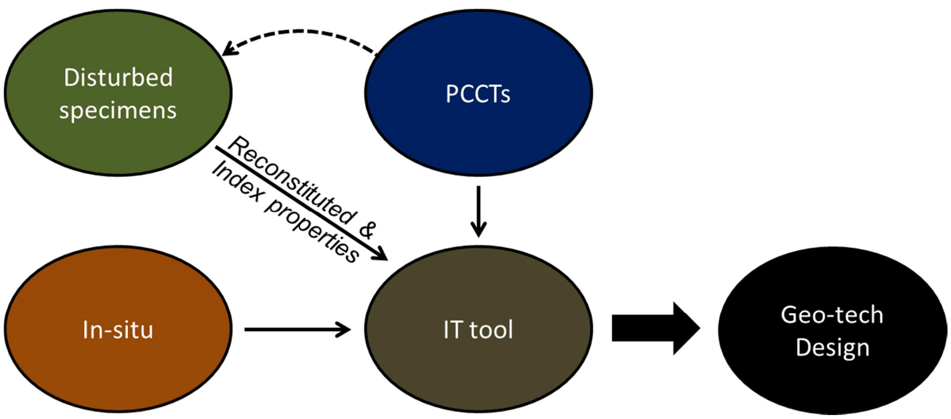
Office of Fossil Energy

ACCOMPLISHMENTS

Context – Goals. *The determination of physical properties for hydrate bearing sediments relies on correlations with geophysical measurements, and experimental data gathered on conventional and pressure cores; however, there are intrinsic uncertainty in correlations and inherent sampling disturbance and testing difficulties when hydrate bearing sediments are involved. This research focuses on the development of a robust borehole tool for the comprehensive characterization of hydrate bearing sediments in-situ, complemented with an IT tool for the selection of appropriate material parameters.*



Accomplished

The main accomplishments for this period include:

- IT tool (sub-task 2.1: Update database of hydrate-bearing sediment properties)
    - Compilation database of hydrate-bearing sediments
- Borehole tool (sub-task 3.1: Evaluation and design of alternatives)
    - Various modules
- Borehole tool (sub-task 4.1: Development of penetrometer)
    - Penetration resistance module construction
    - Standard testing module construction
    - Temperature calibration

Plan - Next reporting period

Calibrate the tool for longitudinal forces. Build the soil sampler and test it. Improve the interface and complete formulations of the IT tool. Add probabilistic framework in the IT tool.

Research in Progress

Borehole Tool Design: Sensor module

The proposed tool is a stackable-type system, made of a train of modules. It was built out of stainless steel 316 in order to meet stress and chemical resistance. The top body has the ability to be adapted to most of the operators' fishing systems. Figure 1 shows the general schematics of the tool and details of the tip and connections to the standard testing module. The penetration module consists of three parts: the penetration body, tip and sleeve. The sleeve acts as housing for the instrumentation.

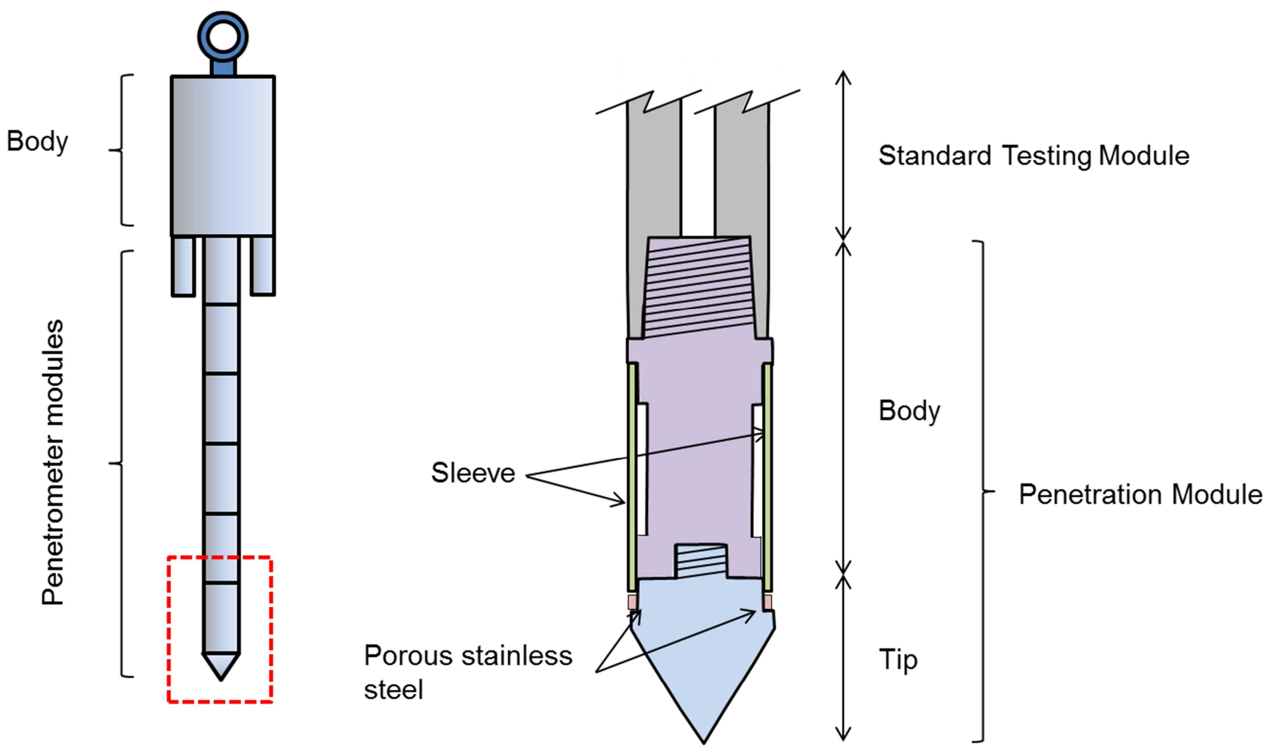


Figure 1. Borehole tool. a) Tool; b) Penetration module.

Figure 2 summarizes the characteristics of the tool measurement procedures. Above the cone, a porous stainless steel ring works as a filter for water pore pressure measurement, fluid sampling and gas production (50 ml/min).

Material	SS316
Diameter	1 7/16”
Max. force capacity	90 kN + 10 MPa water pressure
Press transducer	up to 35MPa
Standard module tests (SM)	Electrical resistivity, thermal conductivity
Tip tests (TIP)	Penetration force, temperature and pore water pressure
TIP or SM with Body	Pore fluid sampler, hydraulic conductivity, mini-production test, soil sampler and soil stiffness

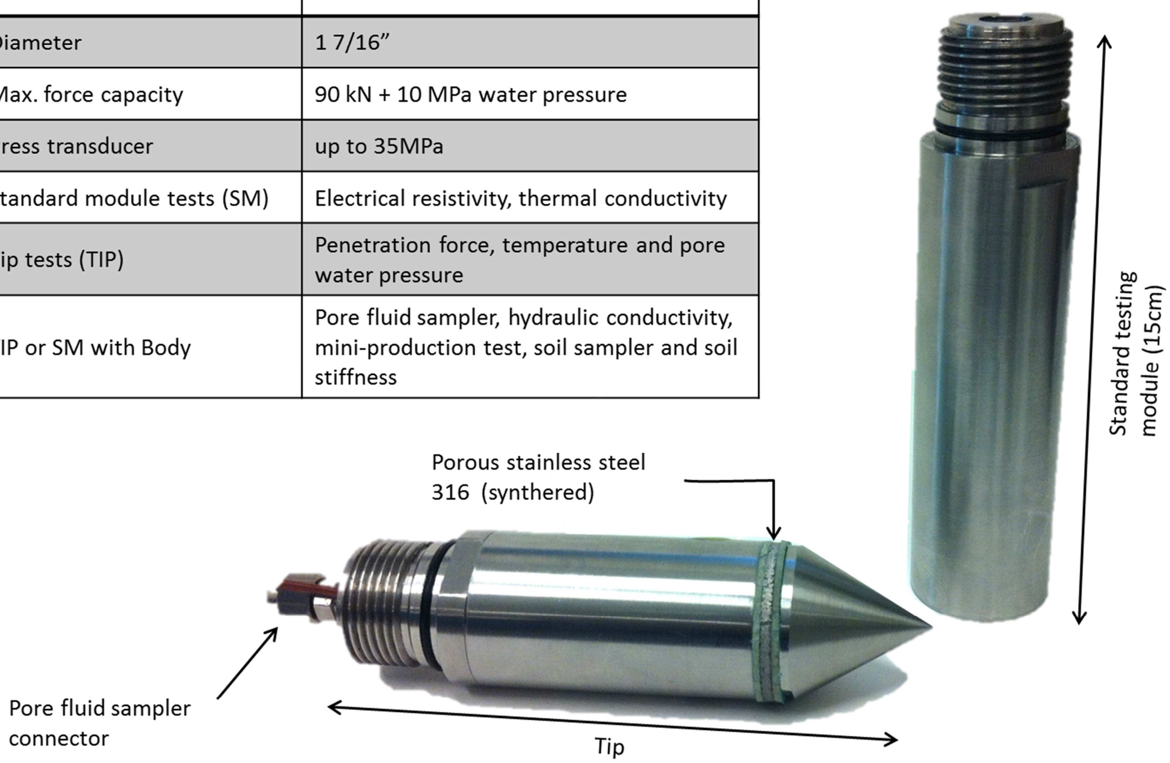


Figure 2: Measurements, tool characteristics and prototype.

The first prototype force module and standard testing module are built (Figure 3). The system is tested and calibrated with water within a pressure chamber (figure 4).

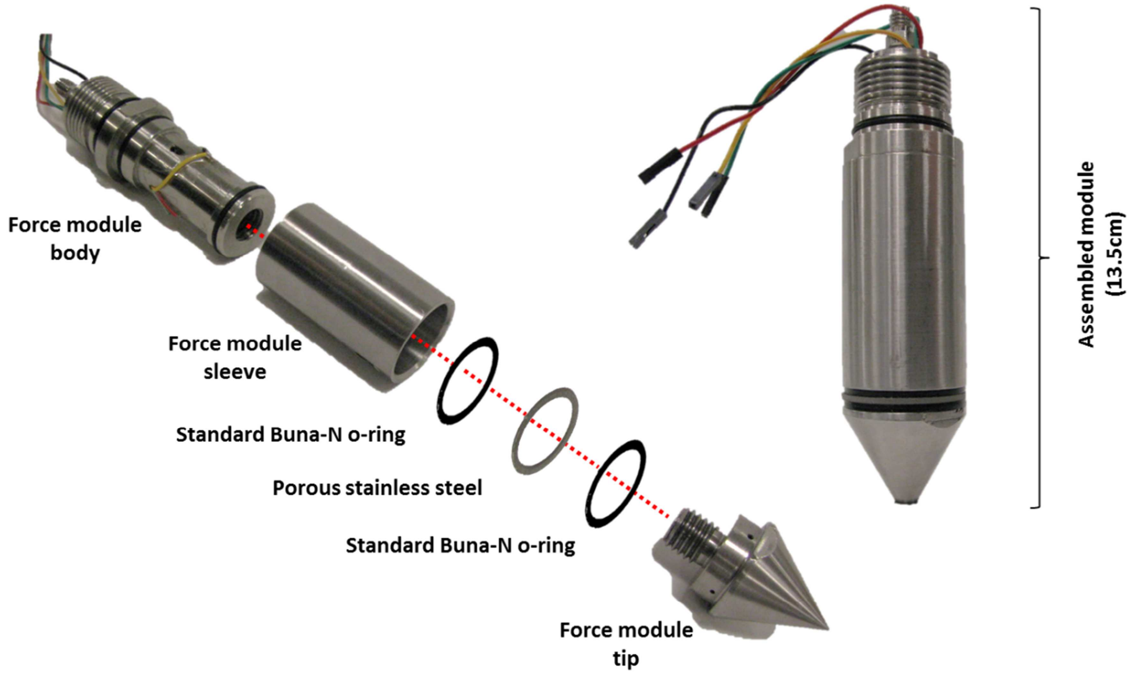


Figure 3: Force module assembly

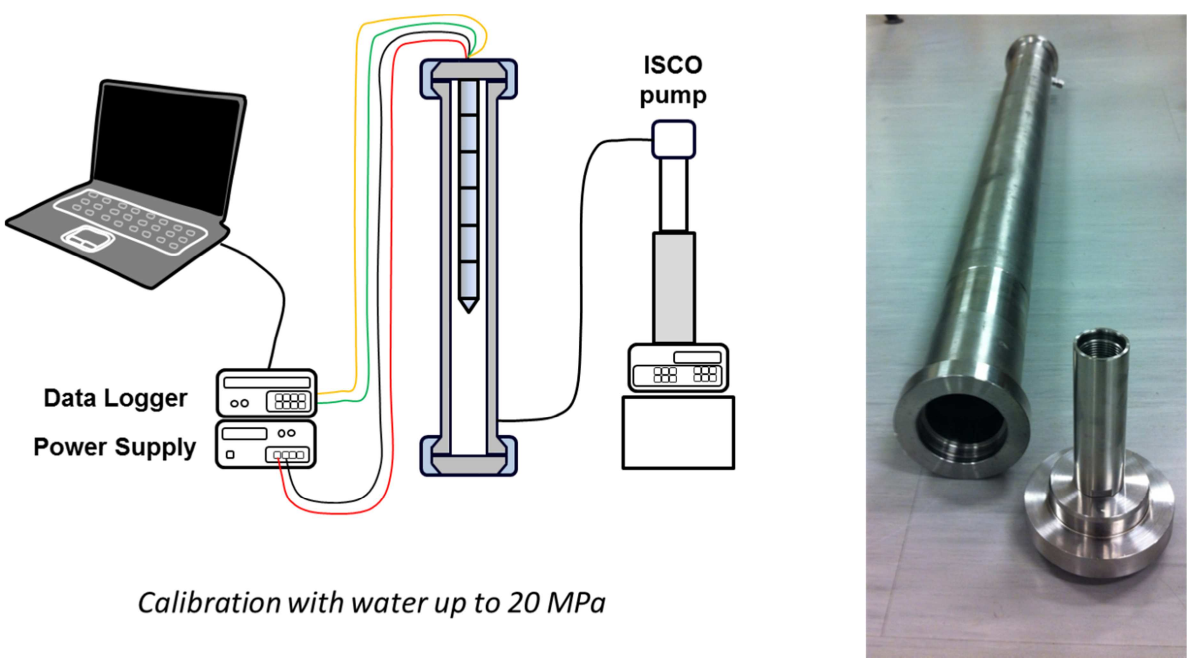


Figure 4: Set-up and calibration chamber

Strain gauges are installed on the shaft inside the force module (two tee rosettes reduce temperature and bending effects - Figure 5).

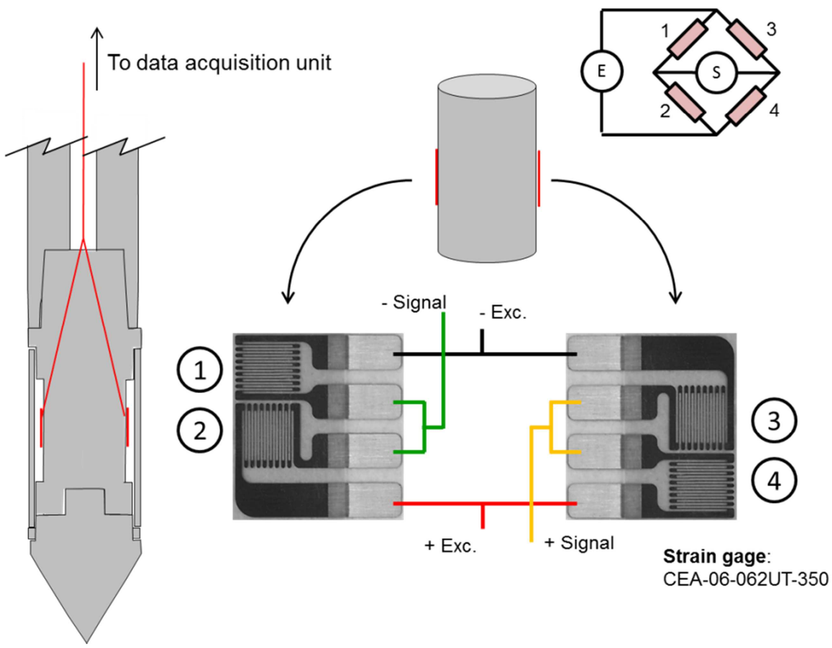


Figure 5: Strain gage installation and configuration

Preliminary calibration results are shown in figure 6 and 7 for different configurations.

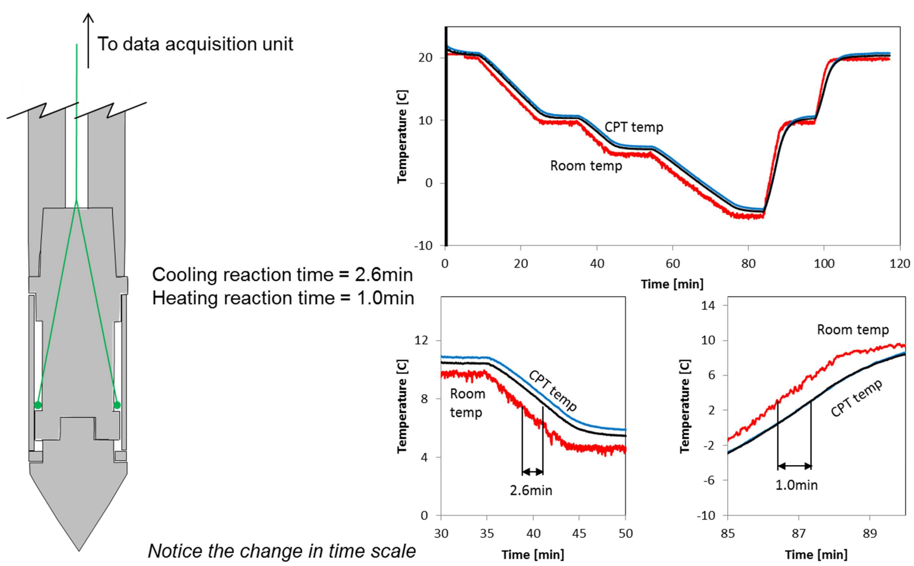


Figure 6: Thermocouples configuration and response

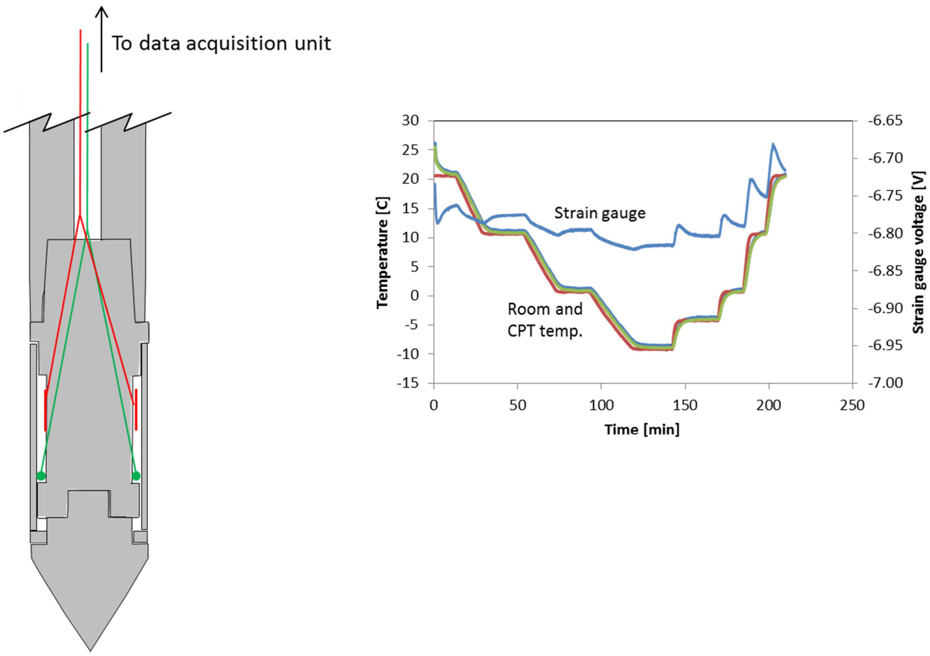


Figure 7: Alternative configuration

The sampler is shown in Figure 8

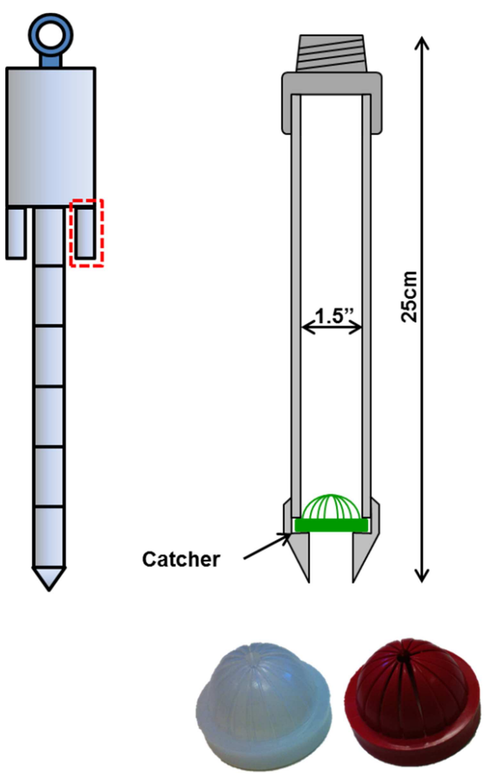


Figure 8: Soil sampler design, configuration and standard plastic catchers.

IT tool

More data for methane hydrate and hydrate-bearing sediments were compiled and new constitutive relations were added to the IT tool. Specific surface area of hydrate in sediments is a significant parameter in the estimation of hydrate decomposition rate. Here we provide the analytical solution for pore-filling condition (Upper bound) and patchy-hydrate condition (Lower bound) schematized in figure 9. Figure 10 shows an example of the upper and lower bound of specific surface area of hydrate for the case of 0.6 of hydrate saturation. It can be seen the specific surface area of hydrate for pore-filling condition is about 2 orders of magnitude larger than that of patchy condition.

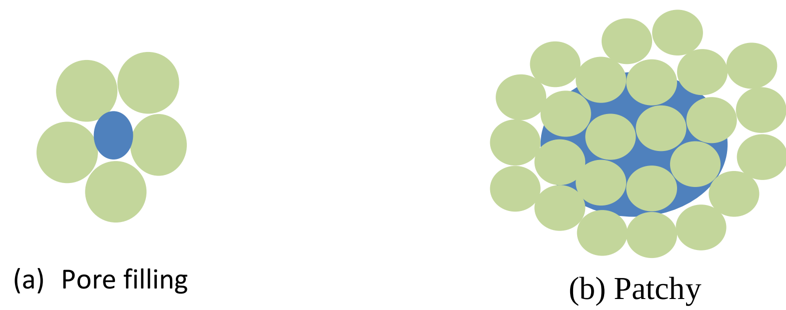


Figure 9. Different pore habits of hydrate in sediments.

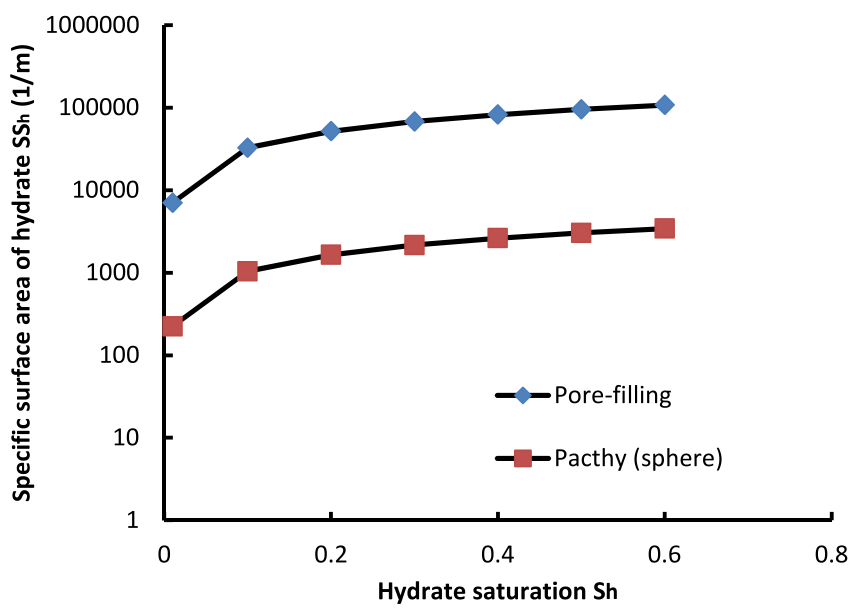


Figure 10. Specific surface area of hydrate. For pore-filling condition, porosity is 0.3, pore size is 10^{-5} m; for patchy condition, it is assumed the number of patchy is 10^{9} $1/m^{3}$.

MILESTONE LOG

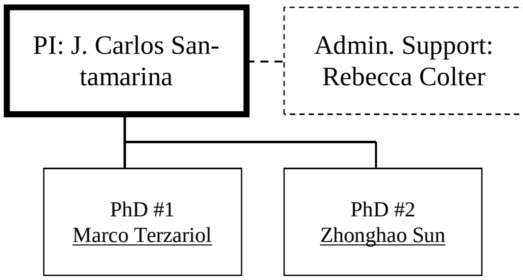
	Milestone	Completion Date	Comments
Title Planned Date Verification method	Completion PMP November 2013 Report	11/2013	
Title Planned Date Verification method	Insertion – Tool design September 2014 Report	In progress	
Title Planned Date Verification method	Database and IT tool September 2014 Report	In progress	
Title Planned Date Verification method	Electronics in operation January 2015 Report	In progress	
Title Planned Date Verification method	Lab testing of prototype September 2015 Report	In progress	
Title Planned Date Verification method	Tool deployment Before September 2016 Report		

PRODUCTS

- **Publications – Presentations:** None at this point
- **Website:** Publications and key presentations are included in http://pmrl.ce.gatech.edu/. (for academic purposes only)
- **Technologies or techniques:** None at this point.
- **Inventions, patent applications, and/or licenses:** None at this point.
- **Other products:** None at this point.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Research Team: The current team is shown next. We anticipate including external collaborators as the project advances



IMPACT

None at this point.

CHANGES/PROBLEMS:

None at this point.

SPECIAL REPORTING REQUIREMENTS:

We are progressing towards all goals for this project.

BUDGETARY INFORMATION:

As of the end of this research period, expenditures are summarized in the following table (Note: in our academic cycle, higher expenditures typically take place during the summer quarter):

Baseline Reporting Quarter DE-FE0013961	Budget Period 1							
	Q1		Q2		Q3		Q4	
	10/1/13 - 12/31/13		1/1/14 - 3/31/14		4/1/14 - 6/30/14		7/1/14 - 9/30/14	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	34,736	34,736	34,736	69,472	34,736	104,208	34,736	138,944
Non-Federal Share	13,326	13,326	13,327	26,653	13,327	39,980	-	39,980
Total Planned	48,062	48,062	48,063	96,125	48,063	144,188	34,736	178,924
Actual Incurred Cost								
Federal Share	-	-	20,865	20,865	45,109	69,650		
Non-Federal Share	-	-	-	-	39,980	39,980		
Total Incurred Costs	-	-	20,865	20,865	85,089	109,630		
Variance								
Federal Share	-34,736	-34,736	-13,871	-48,607	10,373	-34,558		
Non-Federal Share	-13,326	-13,326	-13,327	-26,653	26,653	0		
Total Variance	-48,062	-48,062	-27,198	-75,260	37,026	-34,558		

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