Oil & Natural Gas Technology

DOE Award No.: DE- FE0013961

Quarterly Research Performance Progress Report
(Period ending 12/31/2013)

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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Prepared for:
United States Department of Energy
National Energy Technology Laboratory

Submission date: 1/31/2014

Office of Fossil Energy

DISCLAIMER:

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):
    - Compilation of a database for hydrate-bearing sediment properties
    - Prototyping the IT tool in Mathcad
- Borehole tool (sub-task 3.1):
    - alternative designs of the tool
    - sensor technology
- Micro-electronics (sub-task 4.1):
    - Preliminary tests with an Arduino UNO based system

Plan - Next reporting period

Advance the mechanical design of the body and sensors (following interaction with operators and our mechanical shop). Advance microelectronics to include various sensors, data collection and storage in stand-alone operation.

Research in Progress

IT tool

The IT tool being prototyped synthesizes experimental data gathered from the literature (phase boundaries, mechanical, thermal, and hydraulic properties). As part of this development, we have developed correlations among properties and with index properties. The tool is being prototyped in Mathcad in order to produce a rich interface that can benefit from text, equations and graphical displays.

Borehole Tool Design

Two borehole tool concepts are considered: a wall characterization tool and bottom-hole tool. In both cases, the design addresses the "tool body" and the "sensor scheme". The body will be machined out of stainless steel and will have an API connector to couple the tool with standard components used by operators.

Figure 1 shows the body of the bottom-hole tool. Two designs are being developed. The first one includes a double penetrometer in an OD=30cm (12in) body in order to house two sets of sensors to run “cross hole” measurements. The second tool, OD=15cm (6in) has a single multi-sensor penetrometer. In both cases, the flexibility of the tools relies on the sensors and assembly design.

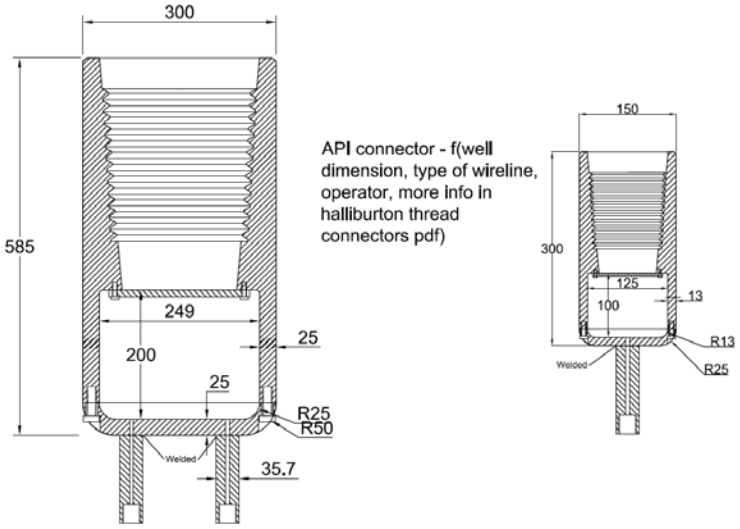


Figure 1. Body of the bottom hole tool

Sensor housing is anticipated in 13cm long and 3.5cm diameter segments (Figure 2). Penetrometers are analyzed for buckling: Figure 3 shows the maximum allowable insertion length.

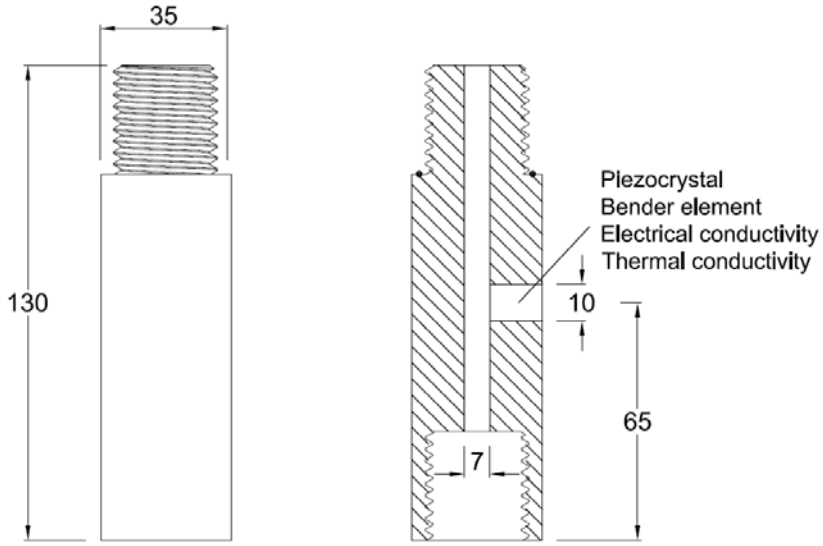


Figure 2. Standard sensor housing

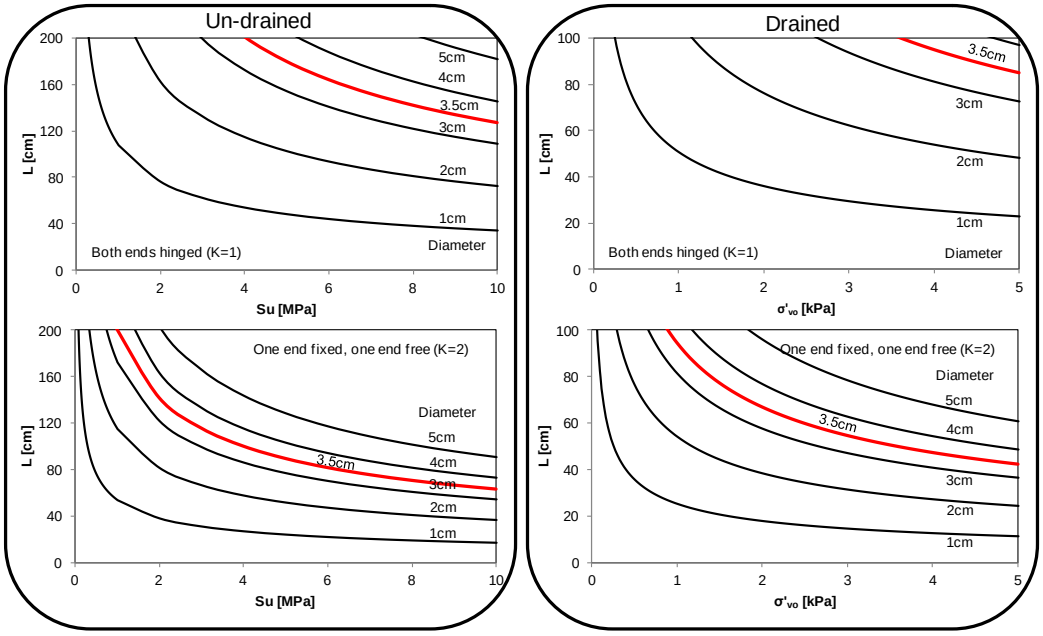


Figure 3. Maximum tool length

The tip will be instrumented to measure pressure and insertion force (Figure 4). We are also exploring the measurement of hydraulic conductivity (Figure 5-a) and soil sampling (Figure 5-b).

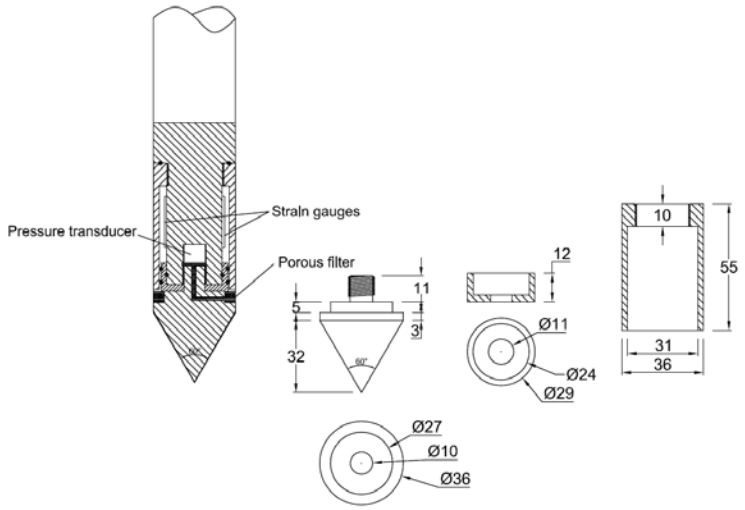


Figure 4. Force measurement sensor (insertion force)

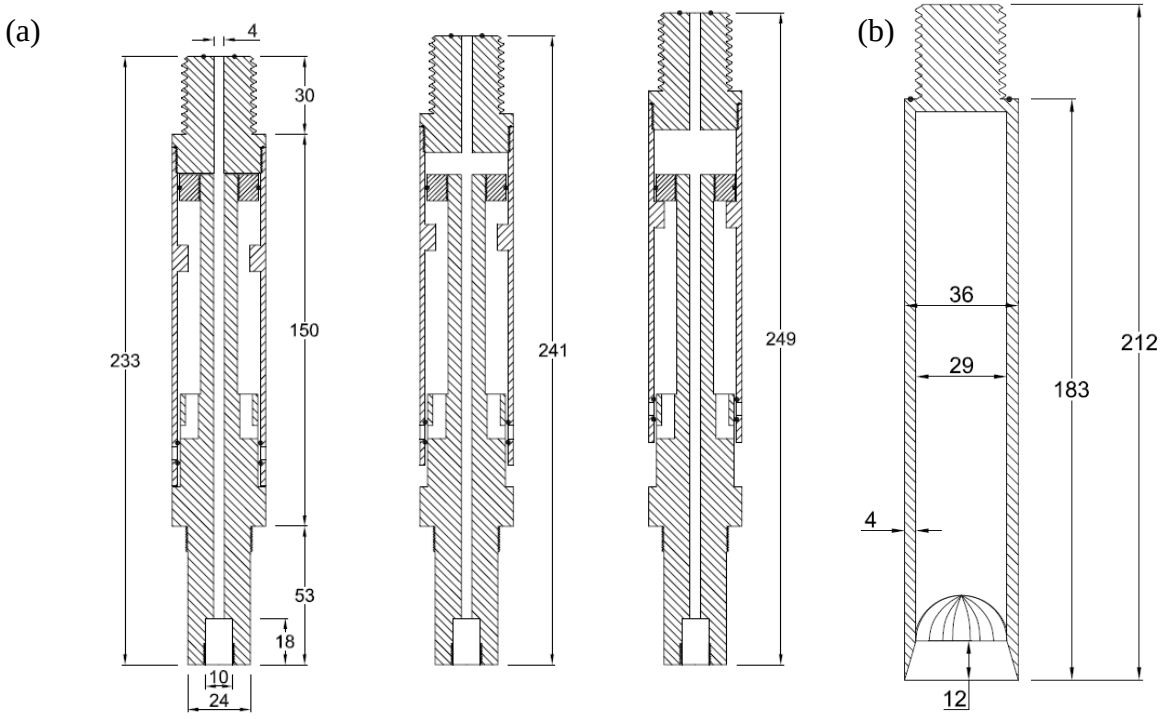


Figure 5. Hydraulic and sampling moduli.

Micro-electronics

An Arduino UNO microcontroller is currently being considered and tested to operate sensors (Figure 6 and Table 1). Figure 7 shows data gathered with a low resolution thermal sensor (ε_T=0.5°C).

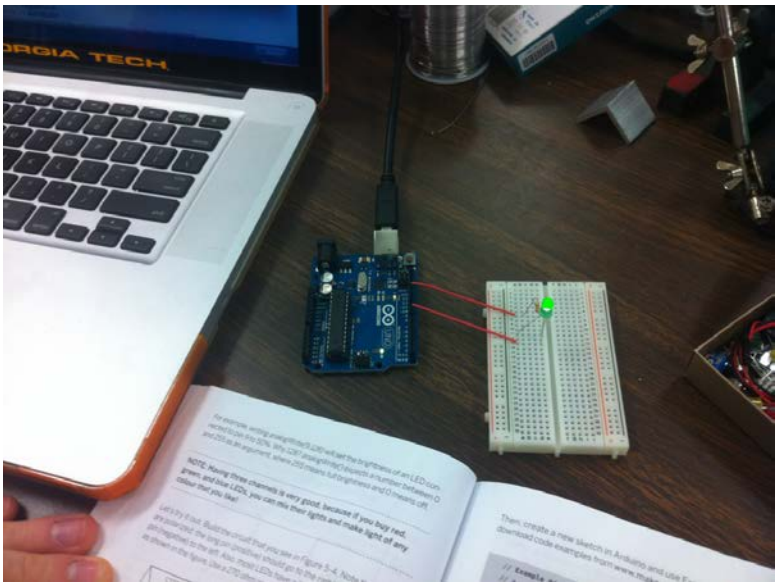


Figure 6. Arduino UNO

Table 1: Arduino UNO capabilities

CPU	16 MHz ATmega328
Pins In/Out	14 I/O
Memory flash	32 K
Size	2.7in x 2.1in
Software	Arduino IDE (Java based)
Power	Batteries / USB / AC-to-DC adapter
PC connection	USB port
Voltage (limits)	6-20 V
Voltage (recommended)	7-12 V
Memory storage	Peripheral / SD card

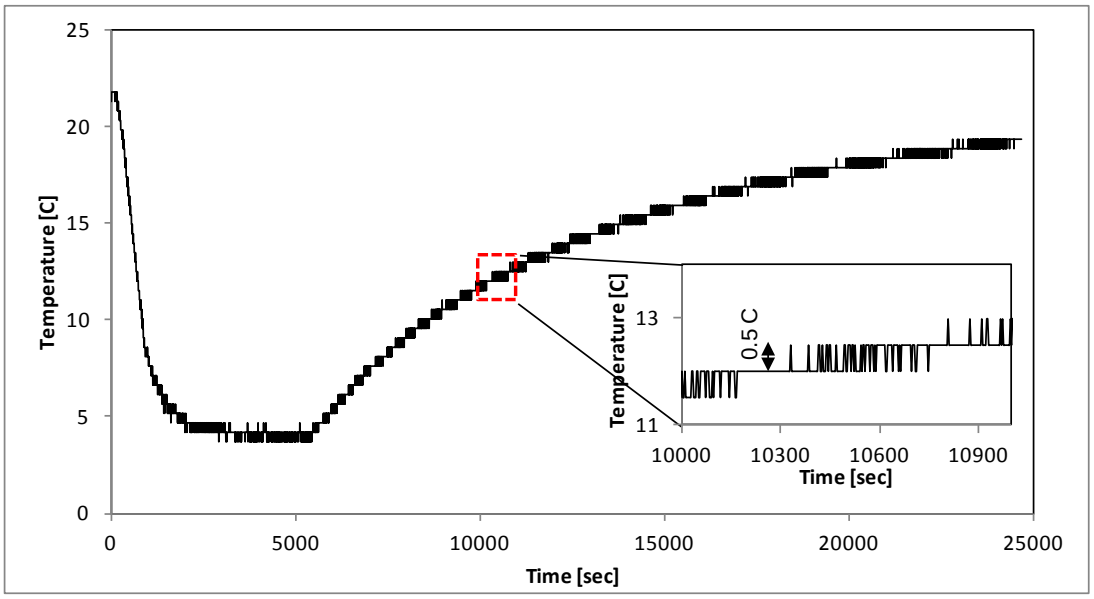


Figure 7. Thermal test on Arduino - Low resolution sensor.

MILESTONE LOG

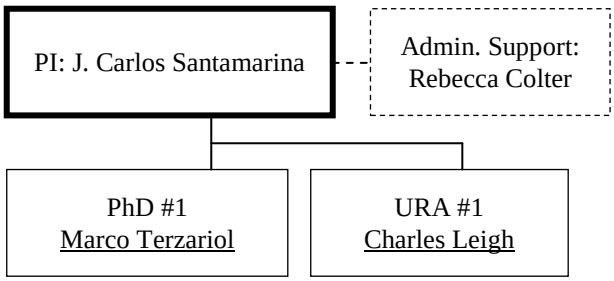
	Milestone	Completion Date	Comments
Title Planned Date Verification method	Completion PMP November 2013 Report	11/2013	
Title Planned Date Verification method	Insertion – Tool design September 2014 Report	In progress	
Title Planned Date Verification method	Database and IT tool September 2014 Report	In 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		
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	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	18,000	18,000	18,000	36,000	18,000	54,000	84,945	138,945
Non-Federal Share	13,326	13,326	13,327	26,653	13,327	39,980	-	39,980
Total Planned	31,326	31,326	31,327	62,653	31,327	93,980	84,945	178,925
Actual Incurred Cost								
Federal Share	18,242	18,242						
Non-Federal Share	13,326	13,326						
Total Incurred Costs	31,568	31,568						
Variance								
Federal Share	242	242						
Non-Federal Share	-	-						
Total Variance	242	242						

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