

Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report
(Period ending 09/30/2014)

Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

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

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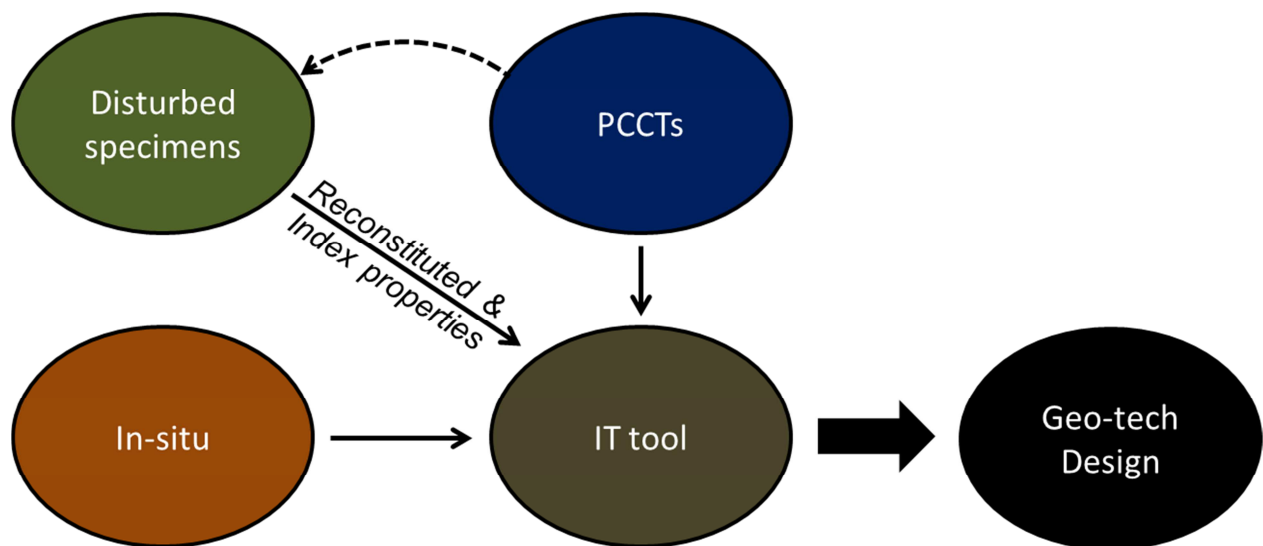
Office of Fossil Energy

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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.*



Accomplishments

The main accomplishments for this period include:

- IT tool (sub-task 2.1: Update database of hydrate-bearing sediment properties)
 - Added uncertainty analysis
 - Improved interface
- Borehole tool (sub-task 3.2 and 3.3: Preliminary mockups)
 - Module developments: Force module
 - Module developments: Permeability

- Construction: Sampler
- Borehole tool (sub-task 4.1: Electronics)
 - High resolution: temperature, strain gauges and force/pressure transducer
 - Stand-alone system
- Borehole tool (sub-task 4.2: Lab Testing)
 - Force module
 - Permeability tests
 - Sampler
 - Electrical resistivity module

Plan - Next reporting period

Improve the interface and the models for IT tool and finish user's manual. Stand-alone impedance analyzer for electrical resistivity measurements.

Research in Progress

Borehole Tool: Sensors

The borehole tool is a train of modules, machined in stainless steel 316 for its high corrosion and stress resistance. The tool couples to the drill string and bottom hole assembly BHA. Penetration is based on the weight of the drilling rods (either actively pushing or passive reaction). Various calibrations were performed during this quarter.

Force module

The penetration module consists of three parts: the penetration body, tip and sleeve. The sleeve houses strain gauges and sensors. Figure 1 shows the force calibration test conducted in a high pressure chamber. Water pressure and force resistance are measured during this calibration.

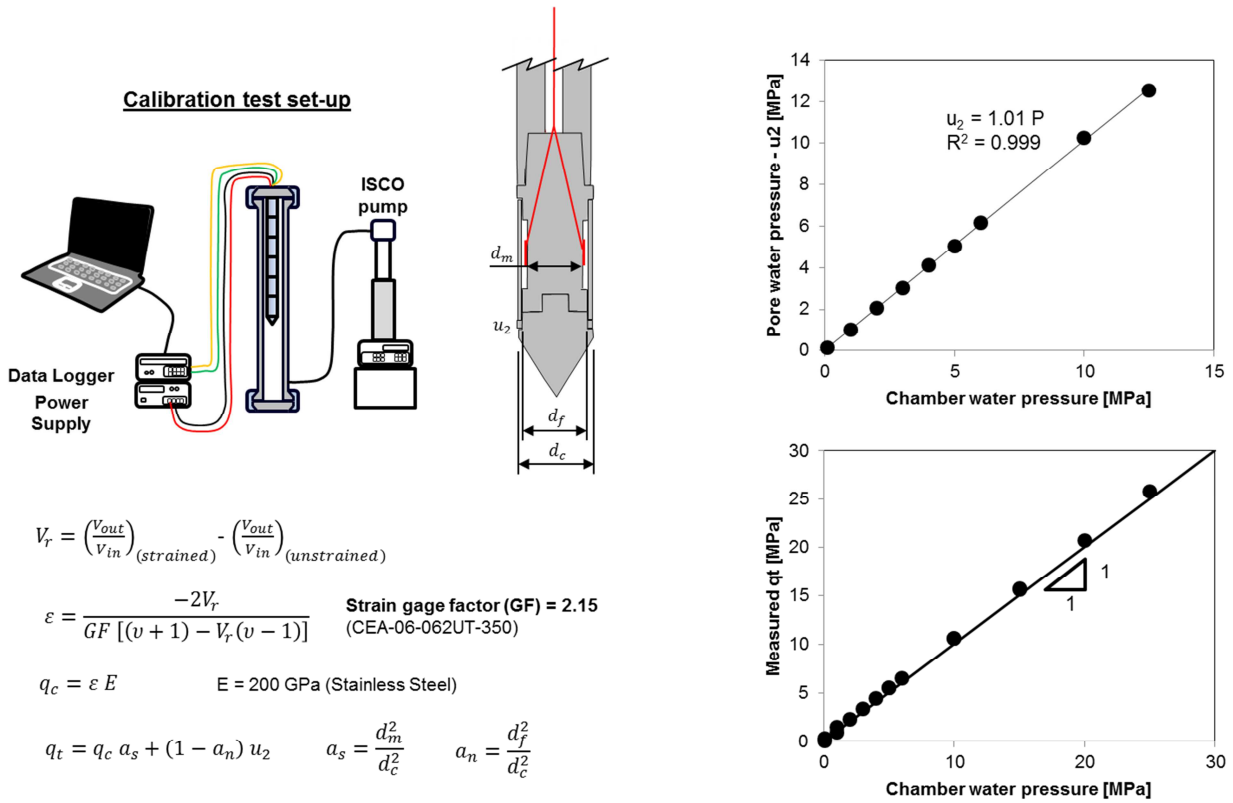


Figure 1. Force module calibration tests for water pressure and tip resistance.

A near surface field test was performed to check the performance of the tip resistance in sediments (beach sand in Lake Acworth, GA). The portable reaction frame includes three self-driven helicoidal anchors, an Enerpac hydraulic piston and a load cell.

The load cell resistance and the tip resistance measured with the force module are compared in Figure 2: results show excellent agreement.

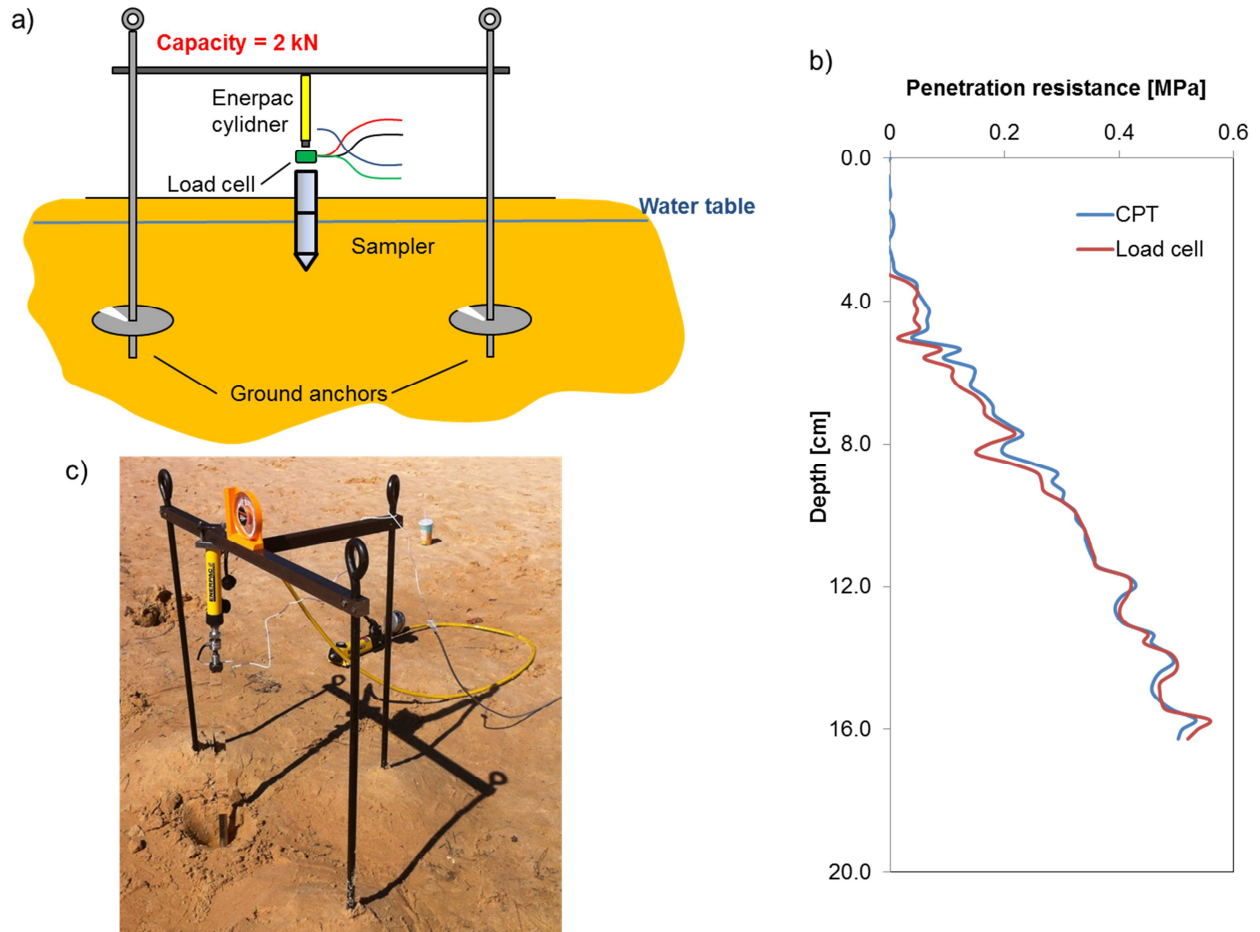


Figure 2: Field test. a) Reaction frame set-up; b) results comparison between the measured with the load cell and the force module; c) picture of the set-up on site.

Permeability / Production

Sub-components for permeability measurements, fluid sampling and in-situ production test were redesigned to attain a simpler and more robust configuration (Figure 3). The fluid sampler will be filled with an inert gas at a pressure slightly higher than the dissociation pressure for methane hydrate so that fluid sampling will not cause dissociation; the solenoid valve will be activated to allow water invasion into the sampler driven by the higher reservoir pressure. The pressure transducer will monitor the change of pressure in time to assess flow rate vs. time (see also design by Tortenson 1984). Permeability computations will follow.

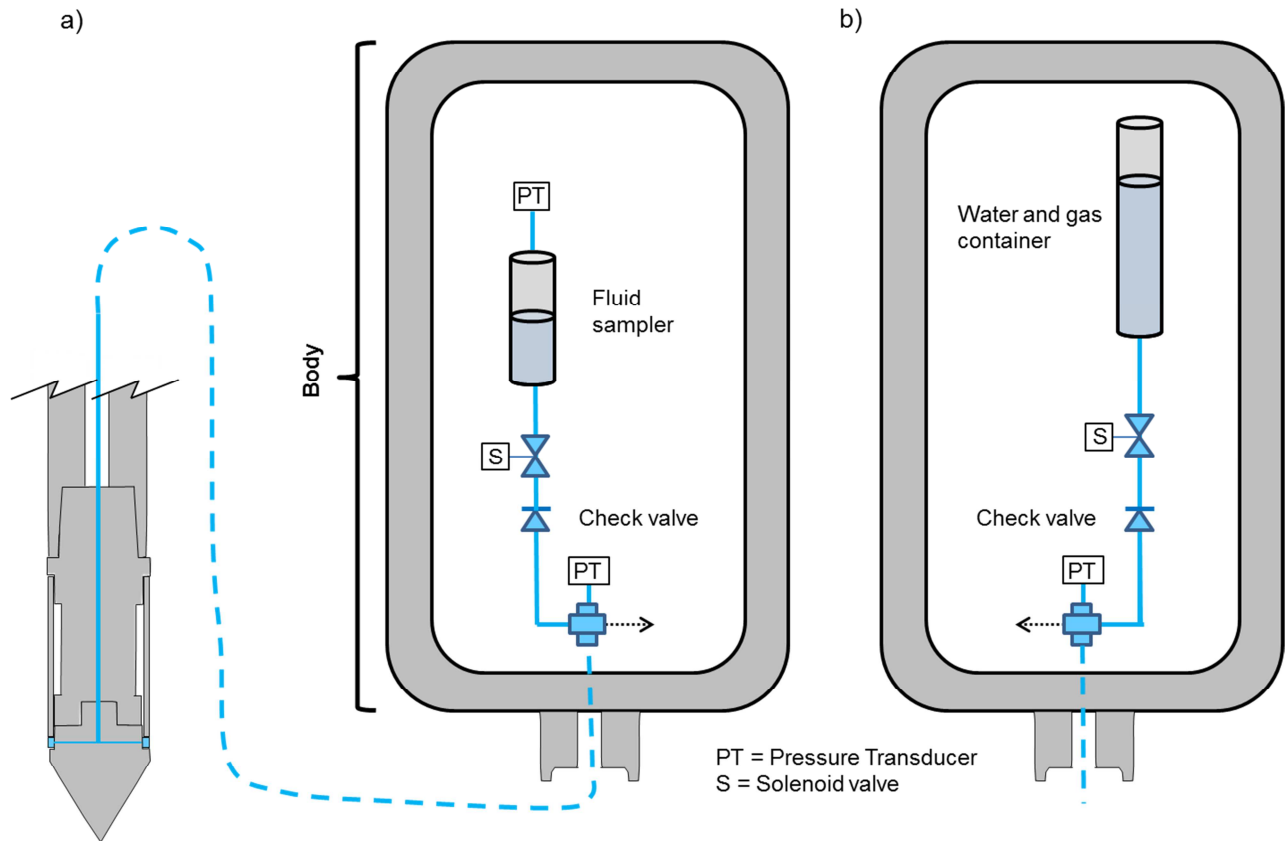


Figure 3: Hydraulic system. a) hydraulic measurement system and fluid sampler; b) mini production test.

The porous ring above the cone tip works as a filter and is used for water pore pressure measurements, fluid sampling and gas production. Several porous filters have been tested using pressure control and flow control protocols. Filter types include a standard plastic commonly used in geotechnical in-situ tests, and three grades of sintered stainless steel SSS beads (MOTT corporation - denominations: 100, 40 and 20). Test results were compared to numerical simulations. Figure 4 shows test results and corresponding numerical simulations. In all cases, the filters exhibit very high permeability ($> 10^{-3}$ cm/s).

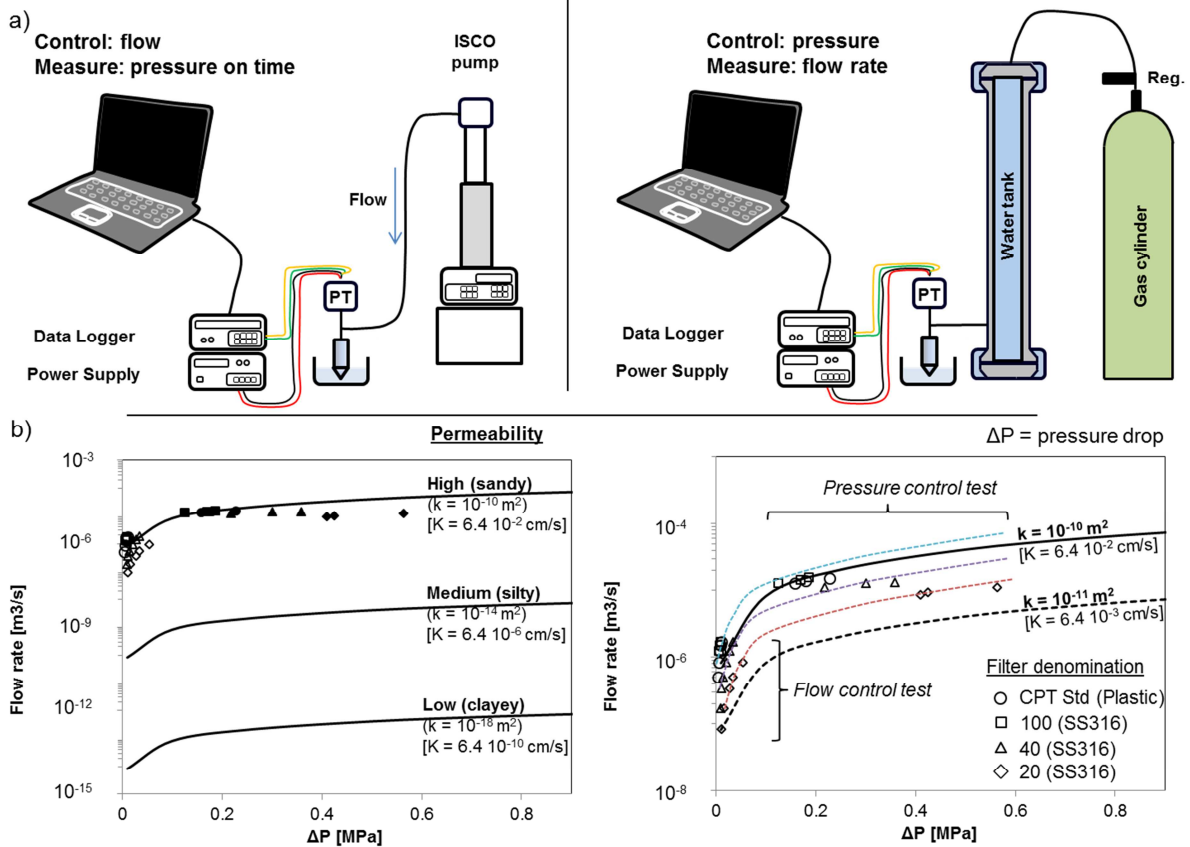


Figure 4: Porous filter calibration: a) setup of the two types of control tests: flow control and pressure control-based test, b) Results for different porous filter. Lines represent results from numerical simulations and discrete points, the corresponding from tests.

A permeability test was conducted for the case of water and no soil, in order to determine the head loss across the device. Test duration must exceed 100 sec to gather reliable data (Figure 5).

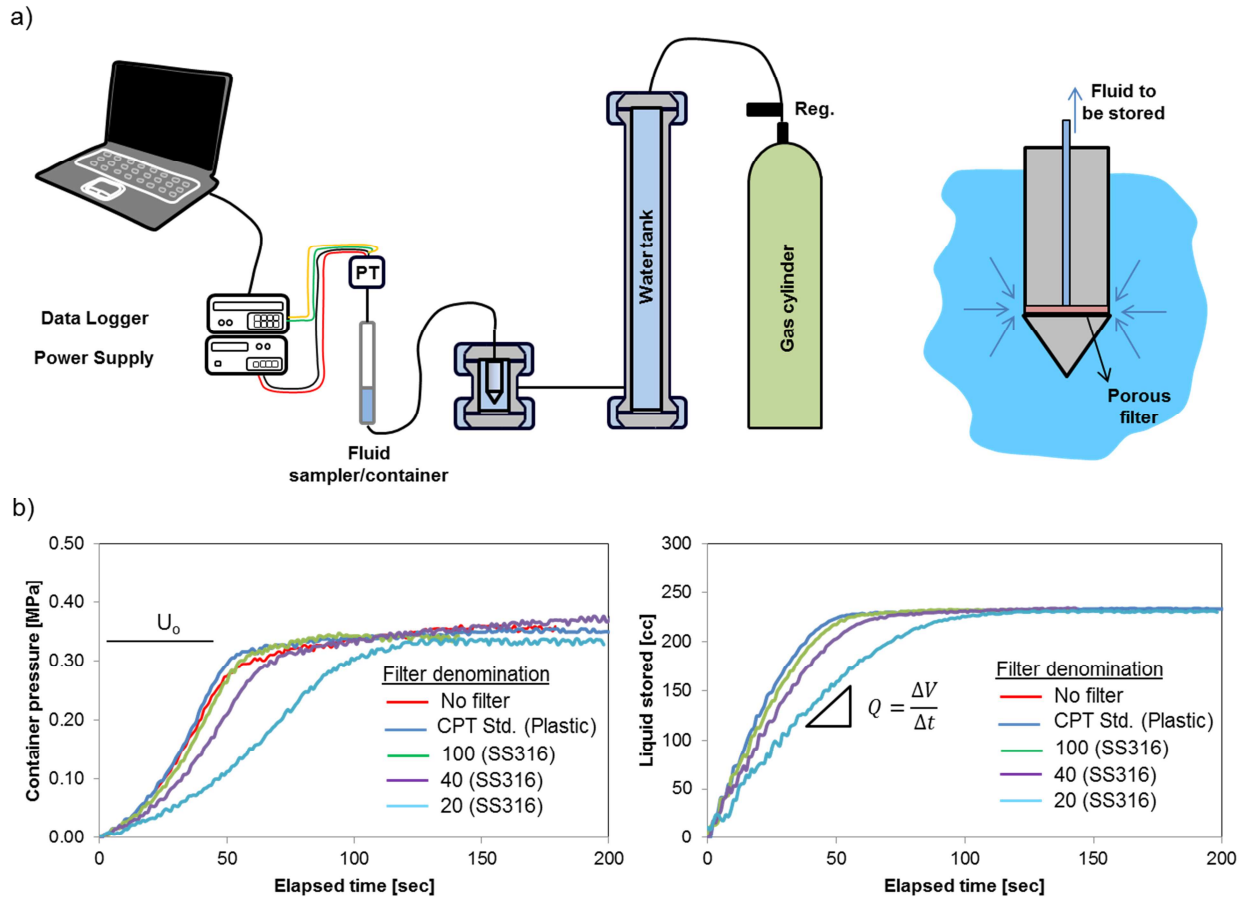


Figure 5: Permeability test: a) set-up; b) results for different porous filters.

Sampler

The insitu device includes two samplers next to it. A prototype was constructed to assess performance. It consists of a 60cm long, diameter OD=25mm sampler tube, a sharp cutting shoe, a plane catcher, and an extrusion device (Figure 6).

A field was conducted to review its performance compared with a standard pipe test (sandy beach, Lake Acworth, GA). Tests involve steady state continuous push and dynamic penetration (Figure 7).

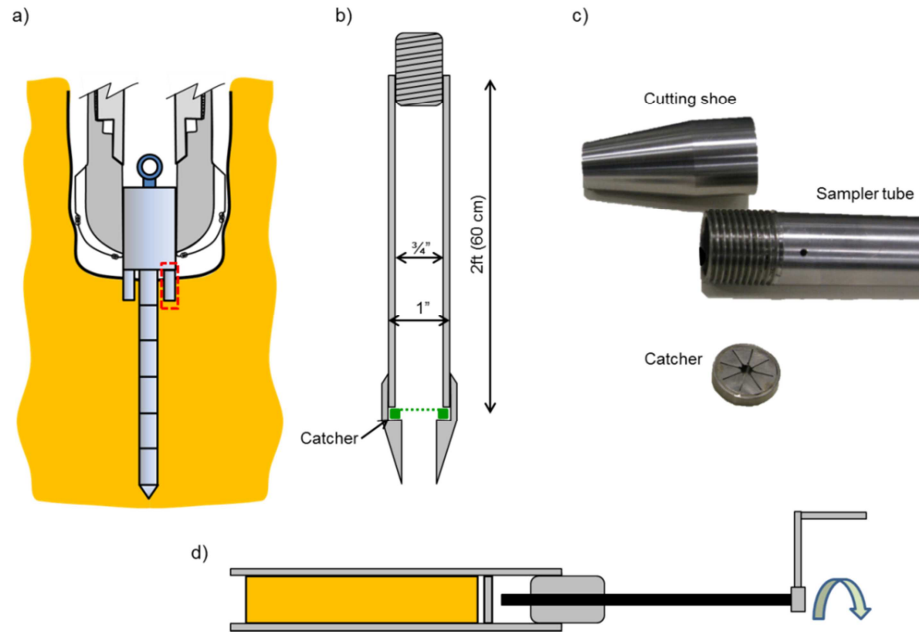


Figure 6: Sampler: a) location; b) dimensions; c) picture and d) extrusion device.

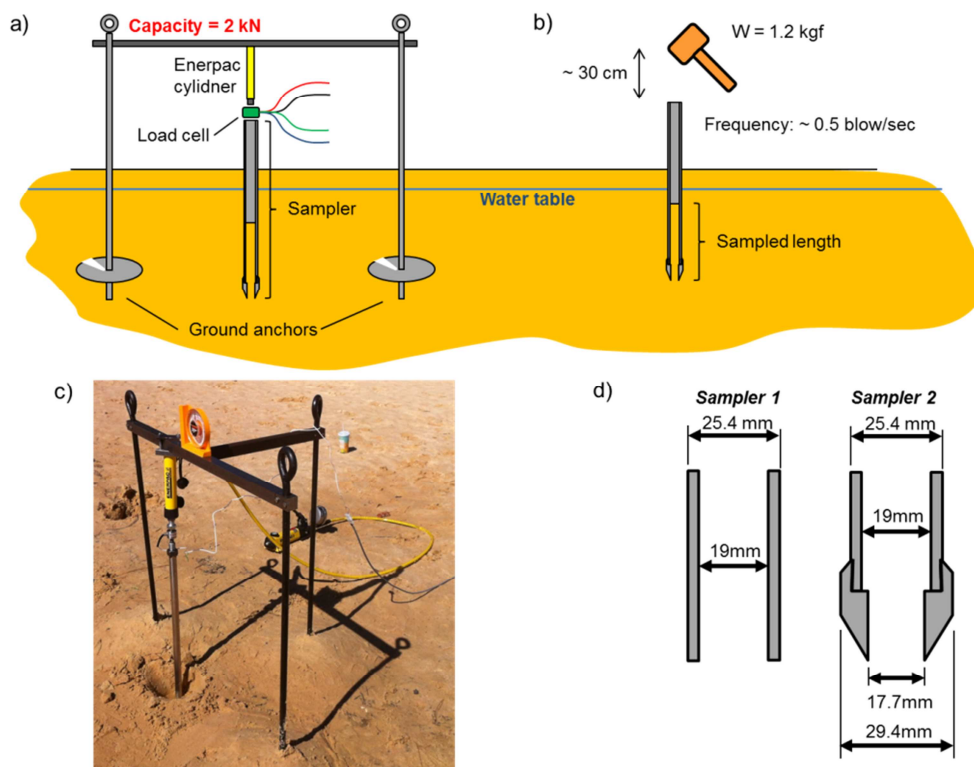


Figure 7: Experimental study: a) continuous push schematics; b) hammering; c) continuous push picture on site; d) samplers dimensions.

Figure 8 shows the results of the sampled length and penetration force used in each case. Observations follow:

- The dynamic driving allows for higher sample length without plugging.
- The cutting shoe favors longer samples: The internal diameter reduction hinders/delays the development of friction against the internal wall
- Force penetration results shows strong similarity between the two samplers.

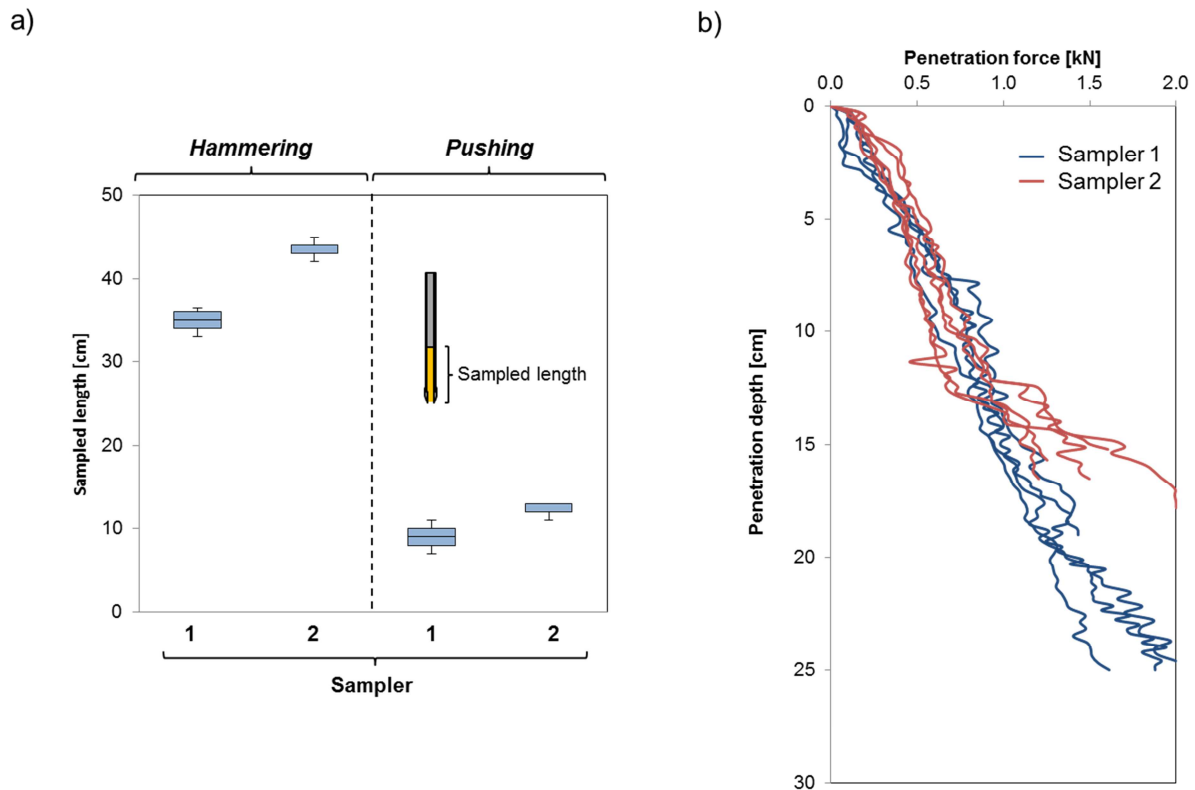


Figure 8: Field test results: a) dynamic and pushing sampled lengths and b) penetration force.

Electrical resistivity module

The electrical module was constructed as a “button” measurement type: made of PEEK plastic as electrical isolator. Calibration test results conducted with salt solutions show good agreement with table-top resistivity measurements (Figure 9).

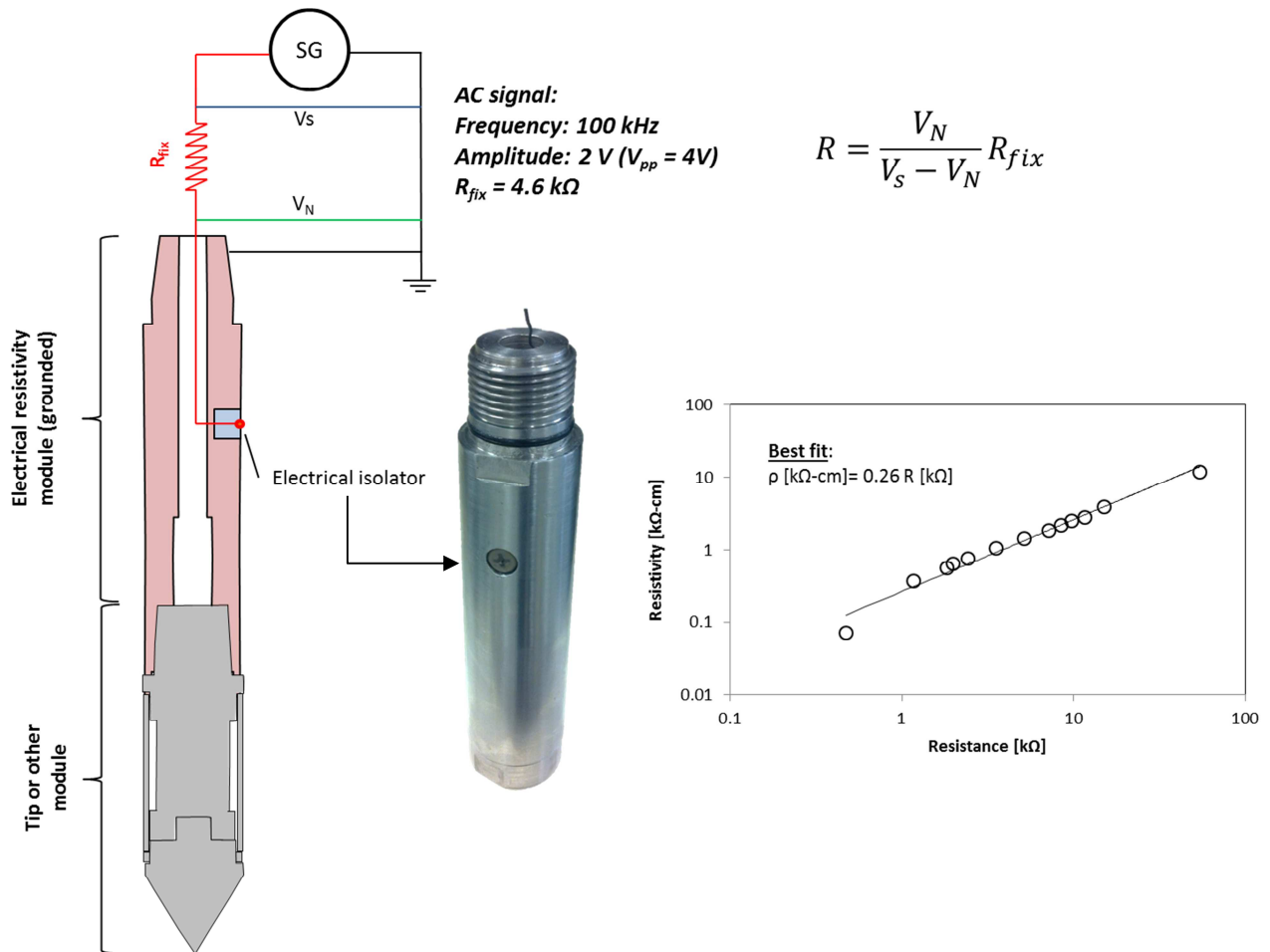


Figure 9: Electrical resistivity module: General schematics, picture and calibration.

Electronics

A new analog to digital converter A/D was tested to increase temperature and transducer resolutions. Figures 10-a, -b and -c show the tests ran with this new circuitry and its resolution on time. Results show a good resolution output for thermocouples, and load cells readings, but strain gauges are still inaccurate.

Figure 10-d shows the power consumption of the stand-alone system for different sensors and transducers. Time can be estimated for a standard 9V battery with a 400 mAh capacity.

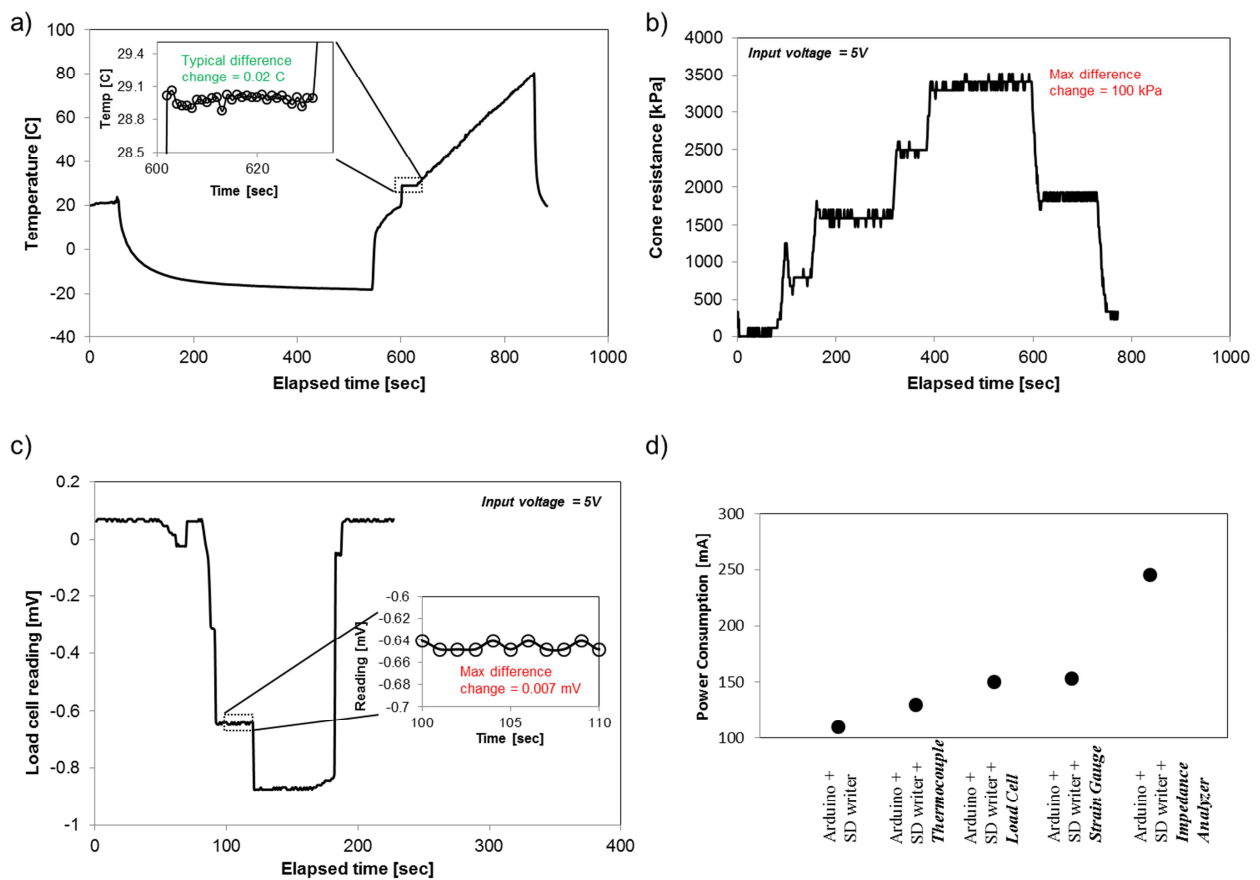


Figure 10: Resolution of the stand-alone system and power consumption: a) resolution of the thermocouple measurement; b) strain gauges resolution measured in stress; c) standard load cell resolution; d) power consumption for each component. Most of the consumption is taken by the system itself: Arduino and SD card writer procedures.

MILESTONE LOG

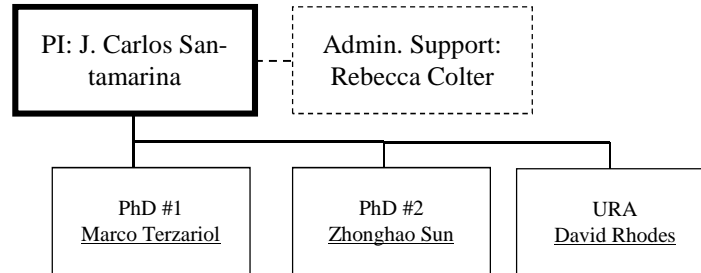
	Milestone	Completion Date	Comments
Title Planned Date Verification method	Completion PMP November 2013 Report	11/2013	
Title Planned Date Verification method	Insertion – Tool design September 2014 Report	9/2014	
Title Planned Date Verification method	Database and IT tool September 2014 Report	9/2014	Paper in preparation
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		Cumulative Total	
	10/1/13 - 12/31/13	1/1/14 - 3/31/14	4/1/14 - 6/30/14	7/1/14 - 9/30/14	Cumulative Total	Cumulative Total	Cumulative Total	Cumulative Total	Cumulative Total	Cumulative Total
Baseline Cost Plan										
Federal Share	34,736	34,736	34,736	34,736	69,472	104,208	138,944			
Non-Federal Share	13,326	13,327	13,327	13,327	26,653	39,980	39,980			
Total Planned	48,062	48,063	48,063	48,063	96,125	144,188	178,924			
Actual Incurred Cost										
Federal Share	-	20,865	20,865	20,865	41,730	62,595	83,460			
Non-Federal Share	-	-	-	-	-	-	-			
Total Incurred Costs	-	20,865	20,865	20,865	41,730	62,595	83,460			
Variance										
Federal Share	-34,736	-13,871	-13,871	-13,871	-48,607	-62,595	-83,460			
Non-Federal Share	-13,326	-13,327	-13,327	-13,327	-26,653	-39,980	-39,980			
Total Variance	-48,062	-27,198	-27,198	-27,198	-75,260	-102,575	-123,440			

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