NATIONAL ENERGY TECHNOLOGY LABORATORY

OIL & GAS

DOE Award No.: DE-FE0013961

Quarterly Research Performance Progress Report (Period Ending 03/31/2017)

Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

Project Period (10/1/2013 to 9/30/2017)

Submitted by:
J. Carlos Santamarina

Signature

Georgia Institute of Technology
DUNS #: 097394084
505 10th Street
Atlanta, GA 30332
Email: jcs@gatech.edu
Phone number: (404) 894-7605

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

Submission Date: 04/28/2017

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

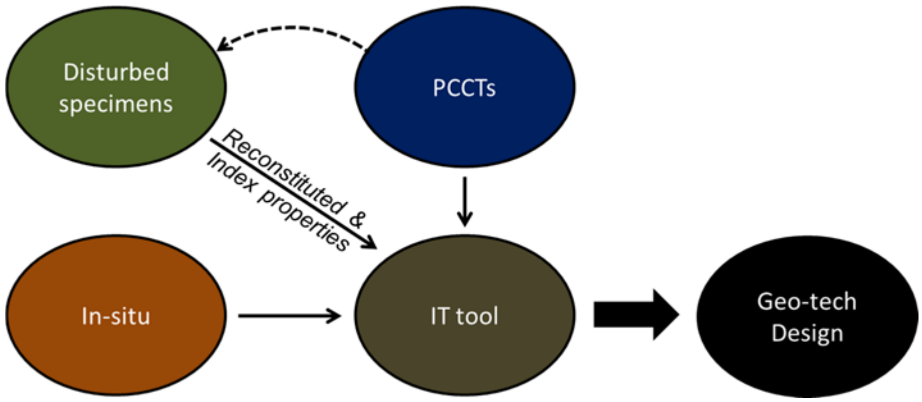
Office of Fossil Energy

DISCLAIMER:

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Context – Goals.

The physical properties of hydrate bearing sediments are critical for gas production strategies, geo-hazard mitigation and its impact on gas recovery engineering. Typically, the determination of physical properties relies on correlations and experimental data recovered from conventional and pressure cores. Inherent sampling disturbance and testing difficulties add significant uncertainty. In this research, we develop a new comprehensive borehole tool for the characterization of hydrate bearing sediments, and an IT tool for the physics-bases selection of appropriate parameters.



Accomplishments

The main accomplishments for this period include:

- Finalized tool design based on field deployment experience and geometric constrains in order to be coupled with PCTB BHA

Plan - Next reporting period

(1) Machining of the tool with new dimensions

(2) Updated electronics design

(3) Tool coupling with PCTB BHA

Research in Progress

Updated Tool Dimensions

Geometric constrains. Shallow depth cone-based site investigation typically uses a clump weight resting on the seafloor to anchor the drill string to avoid the residual heave from the drilling string. Previous two field deployment of this tool used a similar method. For deep depth tool deployment like IODP works, different mechanisms are used to avoid the residual heave problem. The borehole tool must be coupled with Collected Delivery system (CDS) or Mechanically Decoupled Hydraulic Delivery System (MDHDS) to be deployed in compatible with IODP tools. To be compatible with the PCTB BHA or the IDOP APC/XCB BHA, the maximum OD of the tool must be less than four inches, which is the OD of the current tool. Modifications of this tool have been made to meet this requirement.

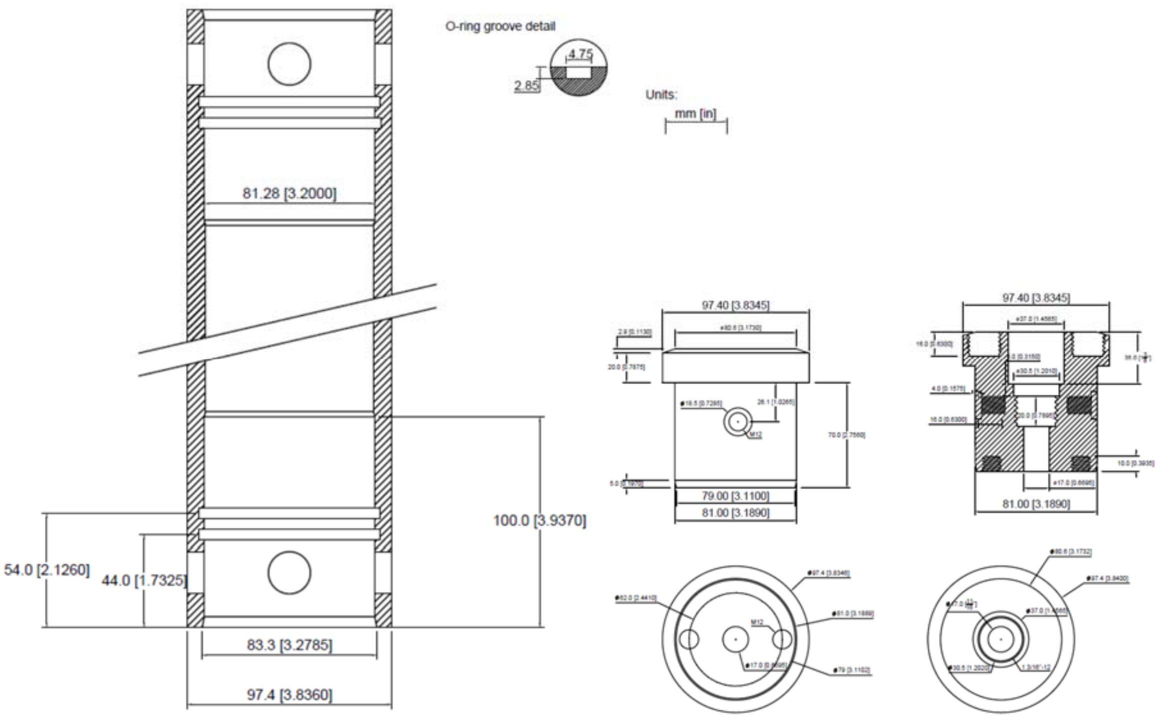


Figure 1. New dimension of the tool body (left) and bottom cap (right). The top cap is to be determined based on CSD design.

Limited by the size the solenoid value, the maximum inner diameter of the tool body is 3.2 inches. Thus, the buckling stress for the body with this dimension is shown in Figure 2. All these dimensions will be finalized and machined in next reporting period.

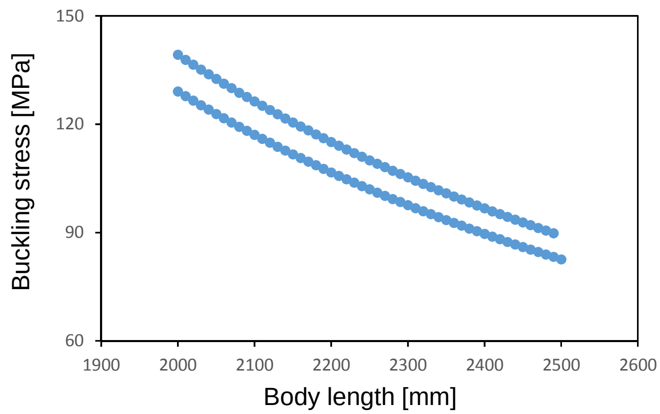


Figure 2. Length dependent buckling stress of the tool body with modified ID and OD dimensions. The double lines show the upper and lower bounds based on the maximum and minimum elastic modulus of SS316 from various manufacturers, i.e., E_{max} = 205GPa and E_{min}=190GPa.

Electronics configuration. Data measurement and collection systems have been updated as well after the field deployment. Further work will involve lab testing of each module and reconfiguration of installation within the modified tool body.

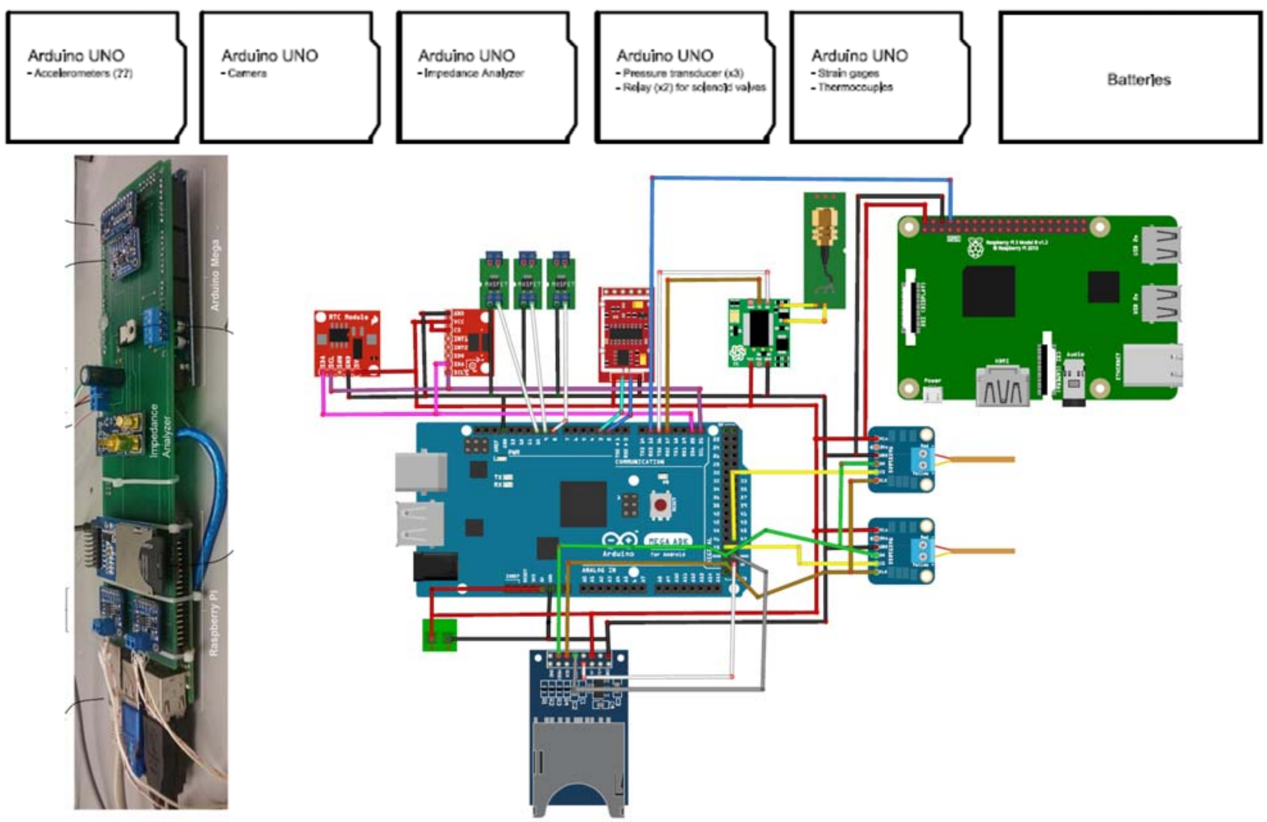


Figure 3. Latest version of electronics configuration (updated after field deployment). Left: joint connection of Raspberry Pi and Arduino Mega. Right: Arduino Mega with peripheral data amplifiers.

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	
Title Planned Date Verification method	Electronics in operation January 2015 Report	1/2015	Finalizing electronics and packaging method based on field tests.
Title Planned Date Verification method	Lab testing of prototype September 2015 Report	6/2015	Additional thermal module development.
Title Planned Date Verification method	Tool deployment Before September 2016 Report	9/2016	To be sent for machine shop work.

PRODUCTS

- **Publications – Presentations:**

  Yang, F. and Dai, S. (2017). Thermal properties measurements for hydrate-bearing sediments using single-sided heat source. *9th International Conference on Gas Hydrates*, June 25-30, 2017, Denver, CO. (submitted)

  Dai, S., Santamarina, J. C. (2017). Stiffness Evolution in Frozen Sands Subjected to Stress Changes. *Journal of Geotechnical and Geoenvironmental Engineering*, 04017042.

  Dai, S., Shin, H., Santamarina, J. C. (2016). Formation and development of salt crusts on soil surfaces. *Acta Geotechnica*, 11(5), 1103-1109.

  Dai, S., Santamarina, J. C. (2014). Sampling disturbance in hydrate-bearing sediment pressure cores: NGHP-01 expedition, Krishna–Godavari Basin example. *Marine and Petroleum Geology*, 58, 178-186.

  Dai, S., Lee, J. Y., Santamarina, J. C. (2014). Hydrate nucleation in quiescent and dynamic conditions. *Fluid Phase Equilibria*, 378, 107-112.

- **Website:** Publications and key presentations are included in http://egel.kaust.edu.sa/ (for academic purposes only)

- **Technologies or techniques:** None at this point.

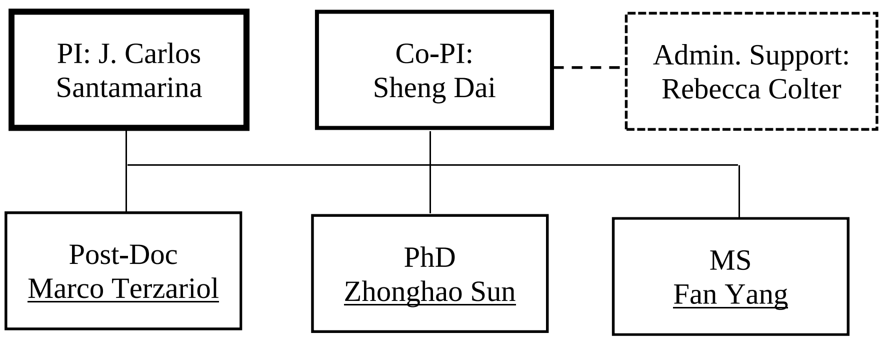
- **Inventions, patent applications, and/or licenses:** None at this point.
- **Other products:**

  Terzariol, M. (2015). Laboratory and field characterization of hydrate bearing sediments-implications. PhD Thesis, Georgia Institute of Technology.

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

Research Team: The current team involves:

- Marco Terzariol (Post-Doc)
- Zhonghao Sun (PhD student)
- Fan Yang (MS student)
- Sheng Dai (Assistant Professor)
- Carlos Santamarina (Professor)



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 that this project is within the 1st year NCE period; all personnel budget has been spent up to date and the left fund is only for borehole tool machining, electronics procurement, and CDS coupler design and machining.

Baseline Reporting Quarter DE-FE0013961	Budget Period 3						Budget Period 4			
	Q2		Q3		Q4		Q1		Q2	
	1/1/16 - 3/31/16		4/1/16 - 6/30/16		7/1/16 - 9/30/16		10/1/16 - 12/31/16		1/1/17 - 3/31/17	
	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total	Q1	Cumulative Total	Q2	Cumulative Total
Baseline Cost Plan										
Federal Share	30,000	375,515	30,000	405,515	71,510	477,025		477,025		477,025
Non-Federal Share	14,692	111,795	14,693	126,488	-	126,488		126,488		126,488
Total Planned	44,692	487,310	44,693	532,003	71,510	603,513	-	603,513	-	603,513
Actual Incurred Cost										
Federal Share	28,411	279,020	51,392	330,412	56,613	387,025	(28,317)	358,708	12,855	371,563
Non-Federal Share	10,436	104,196	5,218	109,415	2,744	112,158		112,158	5,488	117,646
Total Incurred Costs	38,848	383,216	56,611	439,826	59,357	499,183	(28,317)	470,866	18,343	489,209
Variance										
Federal Share	-1,589	-96,495	21,392	-75,103	-14,897	-90,000	-28,317	-118,317	12,855	-105,462
Non-Federal Share	-4,256	-7,599	-9,475	-17,073	2,744	-14,330	1,829	-14,330	5,488	-8,842
Total Variance	-5,844	-104,094	11,918	-92,177	-12,153	-104,330	-28,317	-132,647	18,343	-114,304

National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

13131 Dairy Ashford Road, Suite 225
Sugar Land, TX 77478

1450 Queen Avenue SW
Albany, OR 97321-2198

Arctic Energy Office
420 L Street, Suite 305
Anchorage, AK 99501

Visit the NETL website at:
www.netl.doe.gov

Customer Service Line:
1-800-553-7681

NATIONAL ENERGY TECHNOLOGY LABORATORY

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY