NATIONAL ENERGY TECHNOLOGY LABORATORY

OIL & GAS

DOE Award No.: DE-FE0013961

Quarterly Research Performance Progress Report (Period Ending 06/30/2017)

Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

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

Submitted by:
Sheng Dai / J. Carlos Santamarina

Signature

Georgia Institute of Technology
DUNS #: 097394084
505 10th Street
Atlanta, GA 30332
Email: jcs@gatech.edu
Phone number: (404) 385 - 4757

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

Submission Date: 07/18/2017

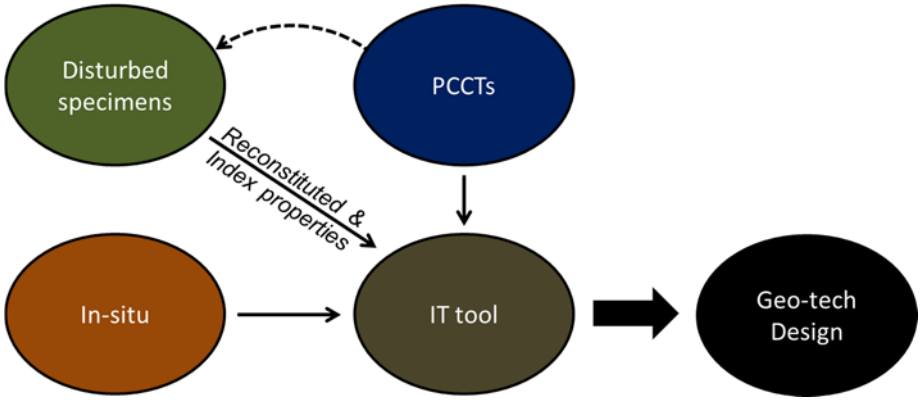
U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Office of Fossil Energy

DISCLAIMER:

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:

- Tool fabrication
- Design and fabrication of tool coupling with PCTB BHA

Plan - Next reporting period

(1) Fabricated products of the borehole tool and CDS-type coupling with PCTB BHA

(2) Updated electronics

Research in Progress

Latest Tool Dimensions and Tool Fabrication

Penetrometers for offshore Cone Penetration Tests (CPT) to obtain fundamental physical, hydraulic, and geomechanical properties of marine sediments have been developed for decades. They vary in penetration mechanisms, dimensions, and mostly for shallow soil depth characterization (Table 1). None of these is specifically for the characterization of hydrate deposits.

Table 1. Offshore CPT development (updated from T. Lunne, 2012)

Penetration mechanism	Date	Equipment	Features
Discontinuous push	1972	Dead weight, platform	Max 4m penetration
	1972	Seacalf	Max 25m penetration
	1976	Diving bell	60 m penetration achieved
	1991	SCOPE	Self-leveling
Continuous push	1983	ROSON	Roller wheels
	1984	Modified BORROS rig	Synopticated hydraulic cylinders
	1984	Wheeldrive Seacalf	Roller wheels
	2010	DeepCPT	Suction anchor; 10 and 15 cm^2 cones
Coiled Rod	2000	Penfeld	Selfpowered by lead batteries. Can penetrate to 30 m
Seabed drilling	2001	PROD	Rods stored in carousel on sea bottom
Combined rig	1997	Searobin	10 cm^2 cone
	2001	Geoceptor	10 cm^2 cone
Mini-rigs	1992	Seascout	Coiled rod, 1 cm^2 cone
	2000	Neptun	Coiled rod; 5 and 10 cm^2 cones; 20 m penetration
	1999	MiniCPT	Coiled rod; 2 cm^2 cone; up to 12 m penetration
ROV mounted	1983	Mini Wison	1 m stroke, 5 cm^2 cone penetrometer
	2014	GOST	5 cm^2 cone; to 4000 m water depth
Hydraulic/mud pressure	1972-1984	WINSON (XP, EP)	3m stroke, memory unit
		Dolphin	Memory unit
Coupled with drilling	2001	CPTWD	Memory unit
	2016	**This project**	**Comprehensive physical properties, memory unit**

The latest dimension has a 10cm^2 cone and a 130mm^2 sleeve area. No any cross sectional diameter of the tool exceeds 3-3/4 inches, so that it can go through the seal bore drill collar and the landing seat. The fabrication of the tool is in progress.

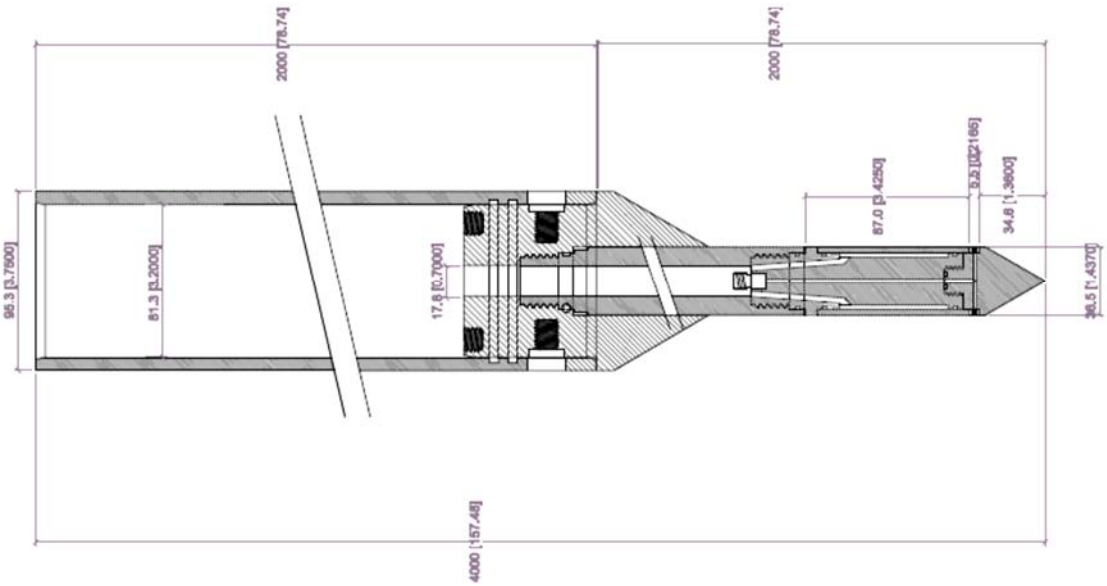


Figure 1. Overall dimension of the assembled tool.

The CDS will drive the probe into the formation 1.8 meters and provide for ±2 meters heave compensation. The maximum designed load is 9,000 lbs. If exceeded, the overload collet will release to allow the probe be retract inside the BHA. The designed CDS is compatible with both the PCTB BHA and the APC/XCB BHA. The fabrication CDS is in process.

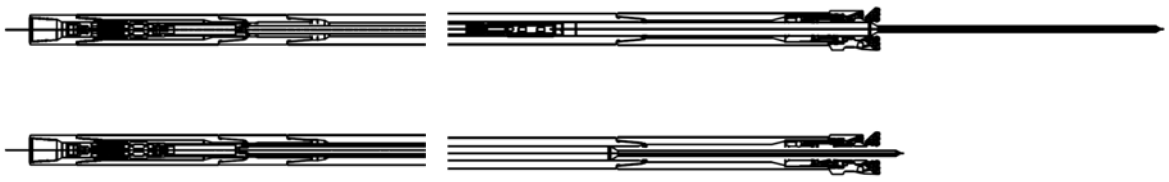


Figure 2. Illustration of the cone in run in and collet release status with PCTB BHA.

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	
Title Planned Date Verification method	Lab testing of prototype September 2015 Report	6/2015	Tool (with latest dimensions) fabrication
Title Planned Date Verification method	Tool deployment Before September 2016 Report	9/2016	PCTB BHA coupler design and fabrication

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.

  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.

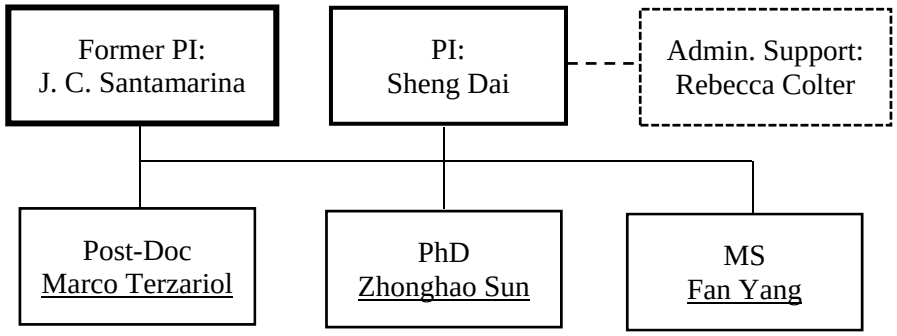
- **Inventions, patent applications, and/or licenses:** None at this point.
- **Other products:**

  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:

None at this point.

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 remainder budget is only for tool fabrication, electronics, and CDS coupler design and machining.

Baseline Reporting Quarter DE-FE0013961	Budget Period 4							
	Q1		Q2		Q3		Q4	
	10/1/16 - 12/31/16		1/1/17 - 3/31/17		4/1/17 - 6/30/17		7/1/17 - 9/30/17	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share		477,025		477,025		477,025		477,025
Non-Federal Share		126,488		126,488		126,488		126,488
Total Planned	-	603,513	-	603,513	-	603,513	-	603,513
Actual Incurred Cost								
Federal Share	(28,317)	358,708	12,855	371,563	56,483	428,046		428,046
Non-Federal Share	5,488	117,646	5,488	123,134	2,744	125,878		125,878
Total Incurred Costs	(22,829)	476,354	18,343	494,697	59,227	553,924	-	553,924
Variance								
Federal Share	-28,317	-118,317	12,855	-105,462	56,483	-48,979	0	-48,979
Non-Federal Share	1,829	-8,842	5,488	-3,354	2,744	-610	0	-610
Total Variance	-22,829	-127,159	18,343	-108,816	59,227	-49,589	0	-49,589

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