Borehole Tool for the Comprehensive Characterization of Hydrate-Bearing Sediments

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

Submitted by:
J. Carlos Santamarina

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

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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:

- Borehole tool design:
  - New main body: construction and pressure testing completed
  - New camera module: completed machining
  - Thermal module: preliminary proof-of-concept design

Plan - Next reporting period

Field deployment of this borehole tool is scheduled beginning the 2nd week of August. We plan to deliver in next reporting period:

1. a report on field tests on KAUST marina,
2. lab testing of the prototype thermal module,
3. modifications / updates of the tool and electronics after field deployment.
Research in Progress

**Borehole Tool – Pre-deployment Modification**

The newly constructed tool main body and modules are ready for deployment at KAUST marina (Figure 1). The modified tool has passed the high-pressure leaking testing (Figure 2). Full deployment in Red Sea is scheduled in early December.

**Figure 1.** Newly constructed tool main body to be deployed in KAUST marina.

**Figure 2.** Results of the leaking test for the newly constructed tool.
Thermal Module Development: Preliminary Studies

The original proposal does not include a thermal module; yet, the no-cost time extension of this project intends to develop a thermal module that allows to characterize the thermal properties of hydrate deposits at in situ conditions. The design of the thermal module is based on the single-sided transient plane source (S-TPS) technique that developed at NETL. We report herein numerical investigations on the factors influencing heat conduction and sensor design.

Impacts of contact size, stainless steel of the cone, and potential dual S-TPS on measured thermal properties have been thoroughly investigated (Figure 3).

Figure 3. Impacts of the S-TPS probe configuration on measured thermal properties of the specimens. The x-axis reflects the effusivity (density x thermal conductivity x thermal diffusivity) ratio between the thermal probe and the tested specimen; the y-axis reflects the thermal flux ratio between the probe and the tested specimen. Scenarios of different duration of current injection have also been considered (from 10s to 200s) in order to identify optimum measurement duration.
Numerical investigations also include investigating the effects of material heterogeneity on the thermal properties measurement (Figure 4). Laboratory prototype probe testing is undergoing. Several influencing factors, such as probe diameter, cone penetration disturbance, etc., will be studied and summarized in next report.

**Figure 4.** Effects of layering and heterogeneity on measured bulk thermal properties. Heat conduction occurs from the left boundary to the right, with the upper and lower boundaries insulated. $k_{xx}$ and $k_{yy}$ are material thermal conductivity at horizontal and vertical directions.

**Coupling with IODP BHAs**

We are working together with Pettigrew Engineering to develop a CDS-type coupling system that allow the deployment of this borehole tool within the IODP APC/XCB BHA, which is compatible with the PCTB BHA as well. The PCTB and all of the IODP tools use a 4” OD landing ring, which causes the major needed modification of the borehole tool to be preferentially 3.75” OD (Note that our current borehole tool has an OD = 4”). This will be modified together with others after several times of tool deployment at KAUST marina and in the Red Sea.
Figure 5. Preliminary design of a CDS-type coupling between the borehole tool and the IODP BHA. Top: standard XCB latch assembly. Bottom: Core barrel quick release adapter. Other designs include safety release collet, sliding collet, landing sub, and internal/external stoppers (Pettigrew Engineering).
MILESTONE LOG

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PRODUCTS

- **Publications – Presentations**: None at this point
- **Website**: Publications and key presentations are included in [http://egel.kaust.edu.sa/](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**: None at this point.
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:
No-cost time extension to 9/30/2017 has been requested.

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.
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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