Oil & Natural Gas Technology

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Quarterly Research Performance Progress Report (Period ending 12/31/2012)

Hydrate-Bearing Clayey Sediments: Morphology, Physical Properties, Production and Engineering/Geological Implications

Project Period (10/1/2012 to 12/31/2012)

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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ACCOMPLISHMENTS

Fine grained sediments host more than 90% of the global gas hydrate accumulations. Yet, hydrate formation in clayey sediments is least understood and characterized. This research focuses on hydrate bearing clayey sediments. The goals of this research are (1) to gain a fundamental understanding of hydrate formation and ensuing morphology, (2) to develop laboratory techniques to emulate "natural" formations, (3) to assess and develop analytical tools to predict physical properties, (4) to evaluate engineering and geological implications, and (5) to advance gas production alternatives to recover methane from these sediments.

Accomplished

The main accomplishments for this first period address Tasks 1 and 2 of the original research plan, and include:

- completion of contractual documents (Task 1)
- selection of PhD Students that will form the team
- preliminary training
- early studies

The preliminary studies include (Task 2)

- Extensive literature review (Task 2a – ongoing)
    - hydrate morphology in fine grained sediments based on in situ and pressure core-based observations (Figure 1 – from our previous results)
    - topological analyses
    - phase boundaries for stable/efficient exchange (Figure 2)
- Exploratory study of analogue specimens for hydrate bearing clayey sediments using consolidation and freezing techniques (Figure 3 - Task 2b)
- Imaging studies (Figure 3 - Task 2c)
    - chamber design for high resolution CAT scan tomographer
    - first images obtained using the new chamber body to study frozen clayey specimens
- Development of expertise in using a new gas chromatograph to analyze gas produced in replacement techniques (in view of needs for future tasks)

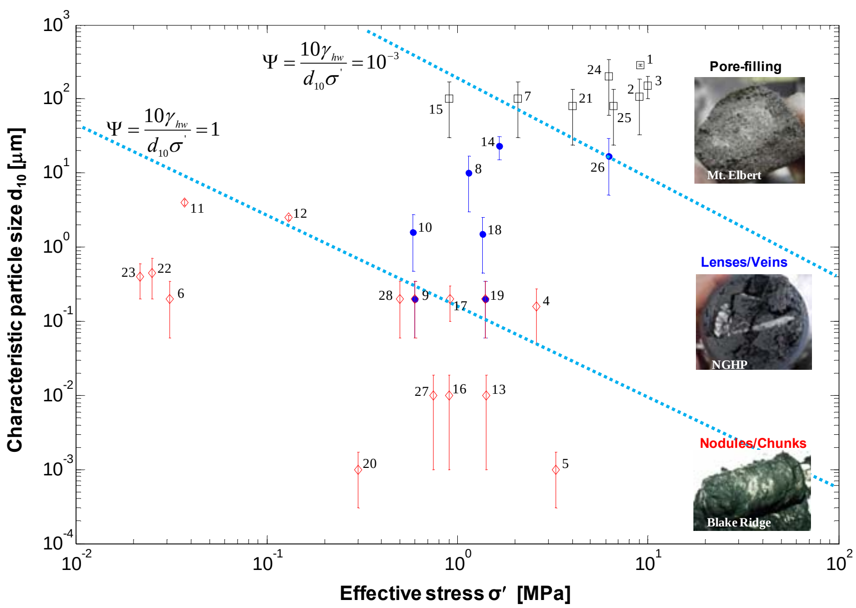
Training

The two PhD students joined the project towards the end of last semester. Besides their course work, they have been fully dedicated to advancing their understanding of hydrates, hydrate formation, natural sediments, and experimental methods in hydrates research (high pressure chambers, sensors, electronics, etc). In particular, training has included two new tools/devices not previously deployed in our research, namely a gas chromatograph (newly purchased) and a high resolution tomographer (at a neighboring material science facility at Georgia Tech).

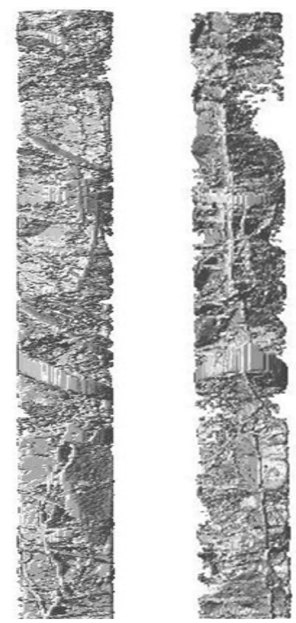
Plan - Next reporting period

We will advance analytical, numerical and experimental fronts to enhance robustness and repeatability, with renewed emphasis on simulating the natural processes and in situ conditions.

Figure 1: Previous compilation of hydrate morphology in different sediments



Morphology. Effective stress and particle size controlled hydrate morphology in natural unlithified sediments. Dimensionless parameter Ψ defines the ratio of capillarity over skeleton force, where γ_{hw} is the interfacial tension between hydrate and water; d_{10} is the finest 10th percentile in the grain size distribution; and σ' is the vertical effective stress. Data from Mallik, Blake Ridge, Nankai Trough, Krishna-Godavari Basin, Cascadia Margin, Offshore Peru, Okushiri Ridge, Ulleung Basin, Orca Basin GoMx, Alaminos Canyon GoMx, Sea of Okhotsk, Mt. Elbert, Atwater Valley GoMx, Hydrate Ridge.



Interconnected hydrate lenses (Ulleung Basin - with Geotech)

Figure 2. P-T phase equilibria diagram for hydrate mixtures of varying percent molar concentrations of carbon dioxide and nitrogen gas. [1] van Cleef and Diepen (1960), [2] Kang et al (2001)

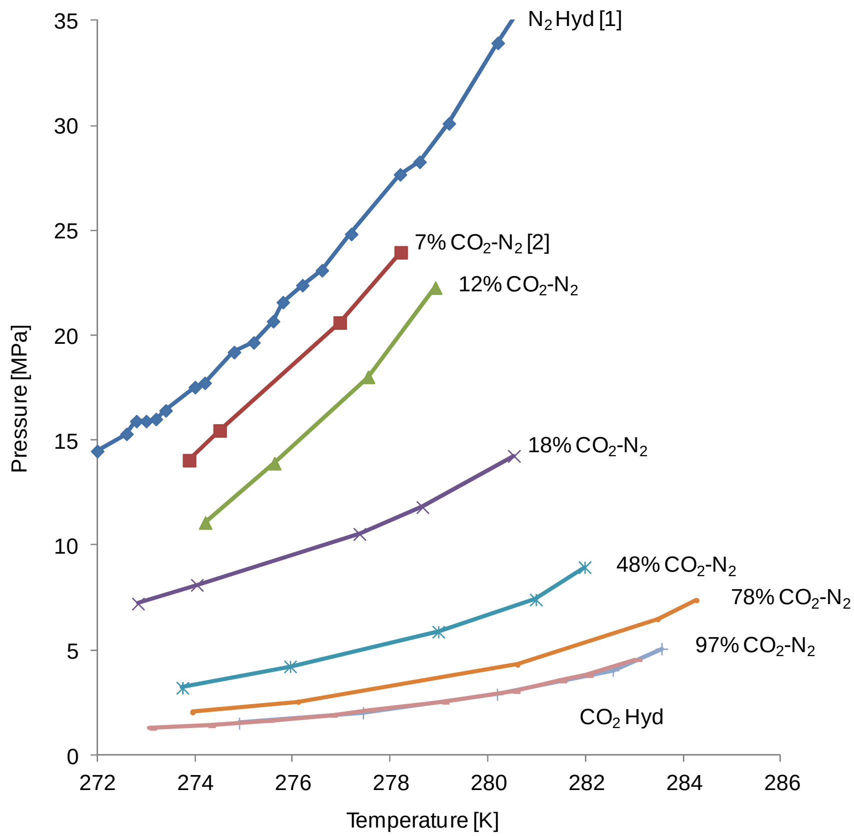
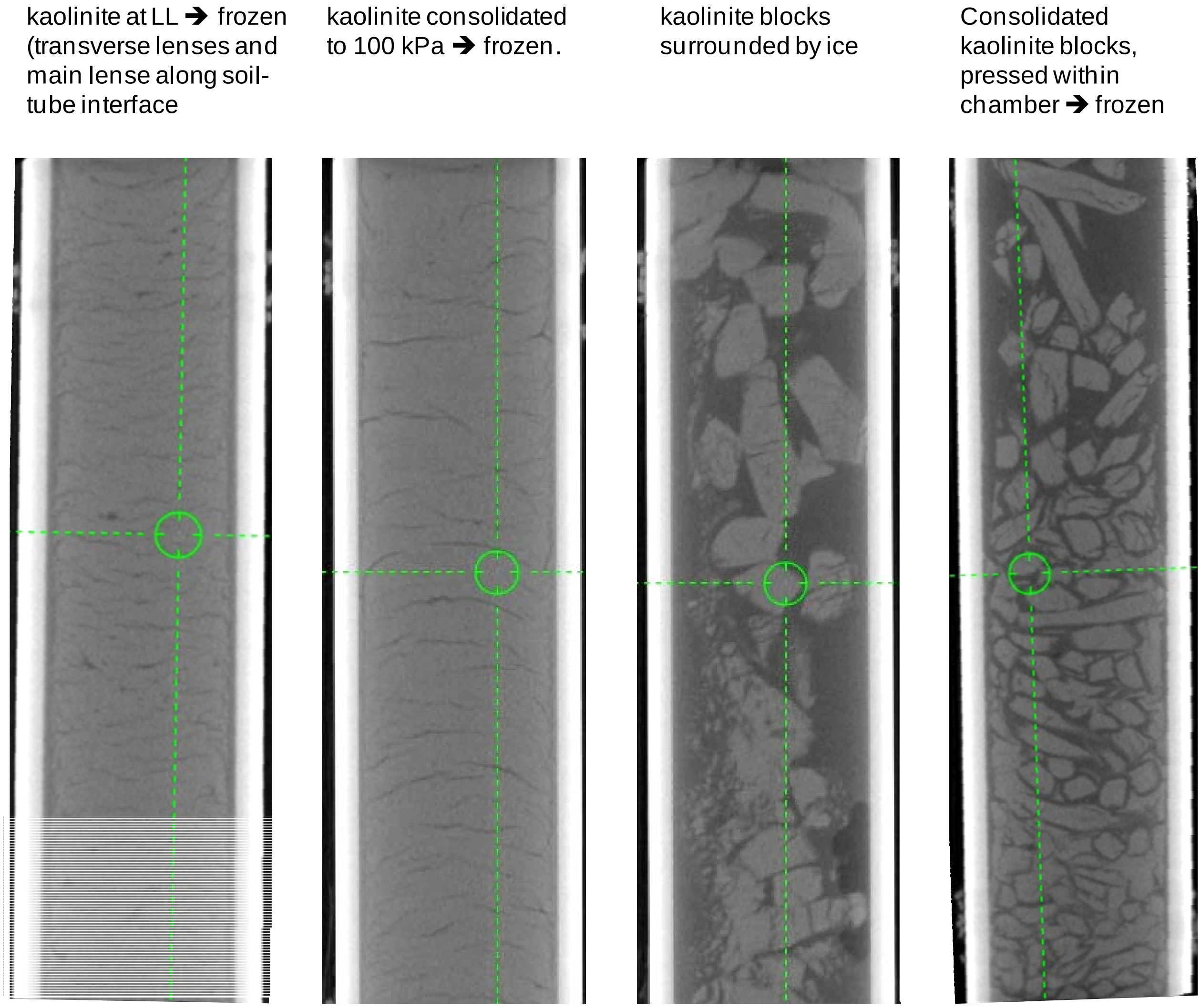


Figure 3: High resolution images of ice lenses in bulk kaolinite and of blocky kaolinite/ice system. Specimens were prepared within the body of a new chamber that is currently being designed for these high pressure imaging studies (design pressure 30 MPa)



PRODUCTS

Publications – Presentations: None at this point

Website: Publications (for academic purposes only) and key presentations are included in http://pmrl.ce.gatech.edu/.

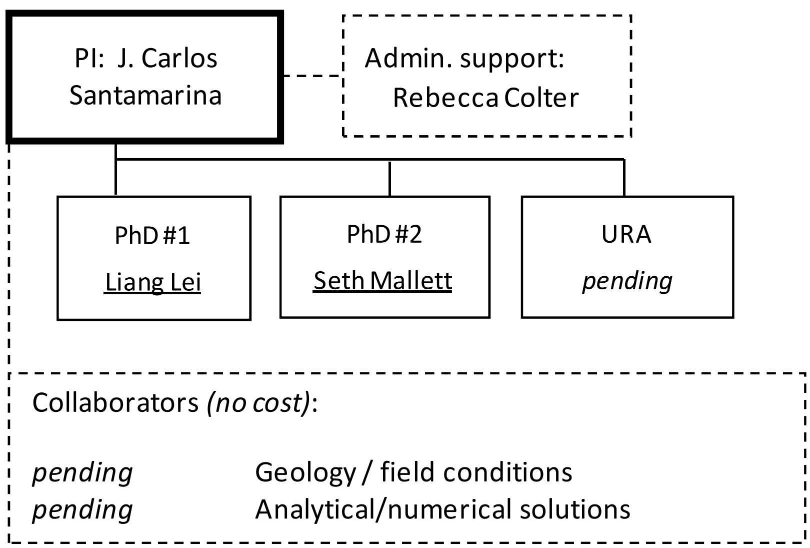
Technologies or techniques: None at this point.

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

While it is still too early to assess impact, we can already highlight preliminary success of exploring hydrate lenses morphology in real systems, and analogue studies using a high resolution tomographer.

CHANGES/PROBLEMS:

None so far.

SPECIAL REPORTING REQUIREMENTS:

We are progressing towards the required check point on the ability to obtain high resolution images of hydrate bearing clayey sediments.

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

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