NATIONAL ENERGY TECHNOLOGY LABORATORY
OIL & GAS

DOE Award No.: ESD12011

Quarterly Research Performance Progress Report)

(Period Ending 6/30/2018)

PROPERTIES OF SEDIMENTS CONTAINING METHANE HYDRATE, WATER, AND GAS SUBJECTED TO CHANGING GAS COMPOSITIONS

Project Period (April 1, 2012 to open)

Submitted by:
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Signature

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Office of Fossil Energy

RESEARCH PERFORMANCE PROGRESS REPORT

DISCLAIMER

ACCOMPLISHMENTS:

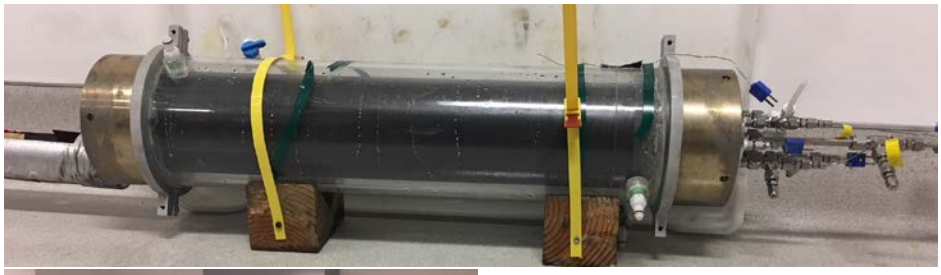
Task 11. Assessment of thermal gradient modification methods and Investigation of the effect of thermal gradient and gradient oscillation on hydrate behavior –

Accomplishments: F110 sand was mixed with water to establish 30% saturation and packed in a EPDM sleeve, placed in an Al pressure vessel, and mounted on the CT table. Confining fluid consisted of a 1% solution of gelatin in water to provide a highly viscous confining fluid. The sample was pressurized with methane and hydrate forming conditions were established (830 psi confining pressure, 710 psi pore pressure [560psi required], 4C). As described in previous reports, the vessel has an internal Al coil surrounding the inlet side of the sample in the confining fluid. The system chiller is applied to control the entire system , and separate gradient chiller connected to the Al coil so temperature gradients can be established. The system chiller was maintained at 4 C throughout the experiment while the gradient chiller applied a warmer temperature. With these controls, temperature can be maintained somewhat uniformly throughout sample, raised and lowered with the confining fluid, or a gradient formed along the length of the sample. (See Figures 1a, b, c). Temperature was measured at 6 locations in the sample: (1) confining fluid near inlet, (2) confining fluid mid sample, (3) confining fluid near outlet, (4) sample inlet, (5) sample outlet (6) on the outside surface of the cooling jacket.

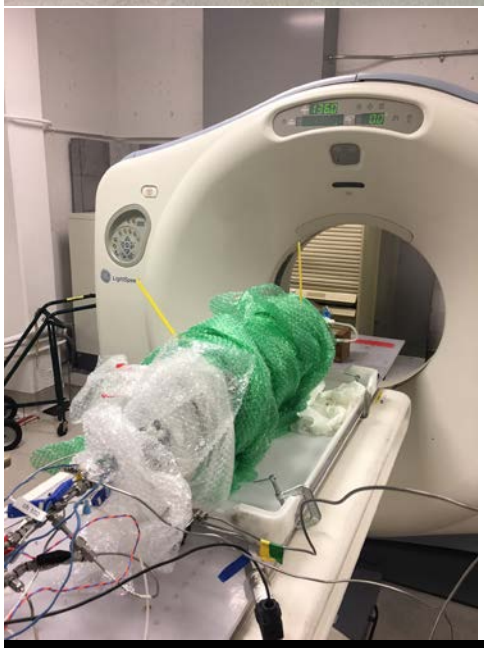
Temperature oscillations experiments were performed at a pore pressure of 620 psi and a confining pressure of 830 psi. Temperature of the confining fluid was raised to above the stability point, from 4C (560 psi stability) to 6C (681 psi stability). After 2 hours of warming, the system was recooled. This was repeated several times over a few days. Typical temperature data are shown in Figures 2a, and b. Figure 3 a shows X-ray CT data (in Hounsfield Units HU) over a warming cycle, with the density decreasing along the core with more hydrate loss near the inlet. Figure 3b shows hydrate formation along the core. These figures show the average density along the core (represented in HU). An intensity decrease indicates hydrate dissociation. Methane was also collected during warming and consumed during cooling. Figure 3a shows a warming cycle, with the density decreasing along the core with more hydrate loss near the inlet. Figure 3b shows hydrate formation along the core. Interestingly the standard deviation of the density does not significantly increase over the test as hypothesized.

Figure 1. a. Hydrate experiment on CT table. Bubble wrap was used for insulation. b. CT scan of set up. c. vessel without insulation before placing on table.

a.



b.



c.

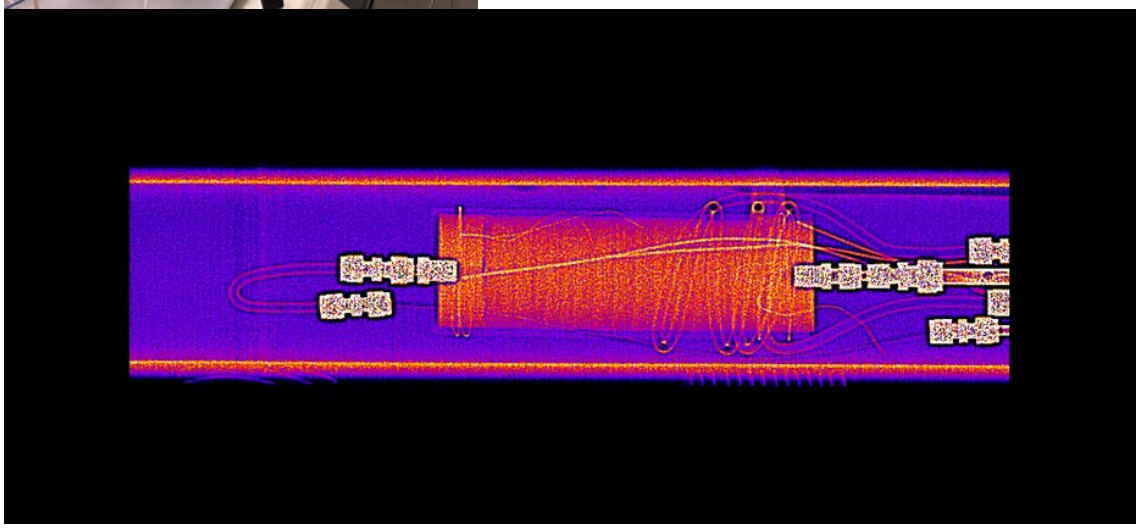
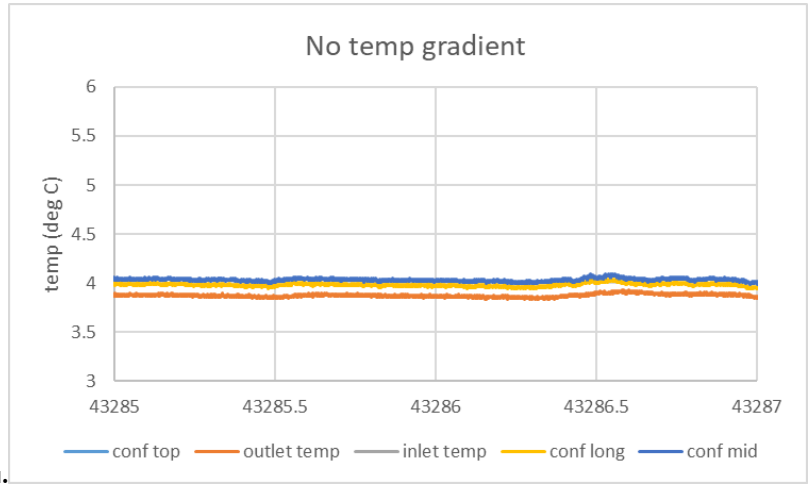


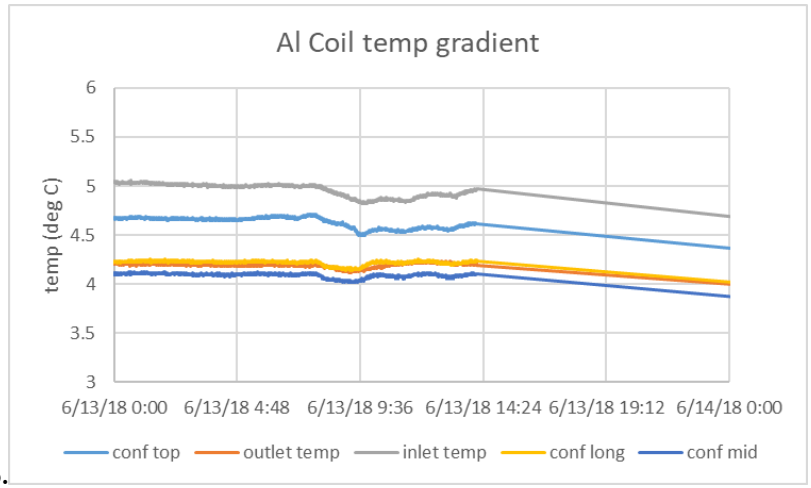
Figure 1. Examples of temperature condition in vessel. a. pressure vessel with external temperature control jacket, b. insulated pressure vessel on CT table. c. X-ray scan of sample assembly inside the pressure vessel. orange rectangle – cross section of the sample with 1-inch thick end caps on right and

left sides, speckled white shapes – stainless steel fittings, parallel "warmer" color curves – internal tubing, single lines – thermocouples.

a.



b.



c.

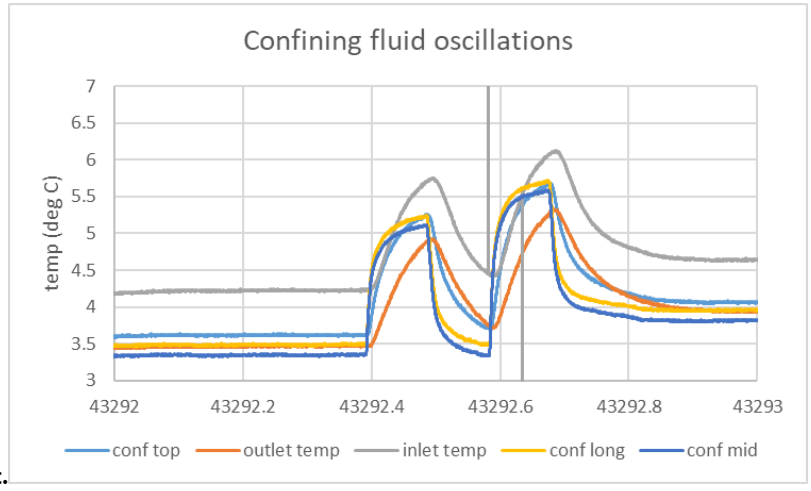
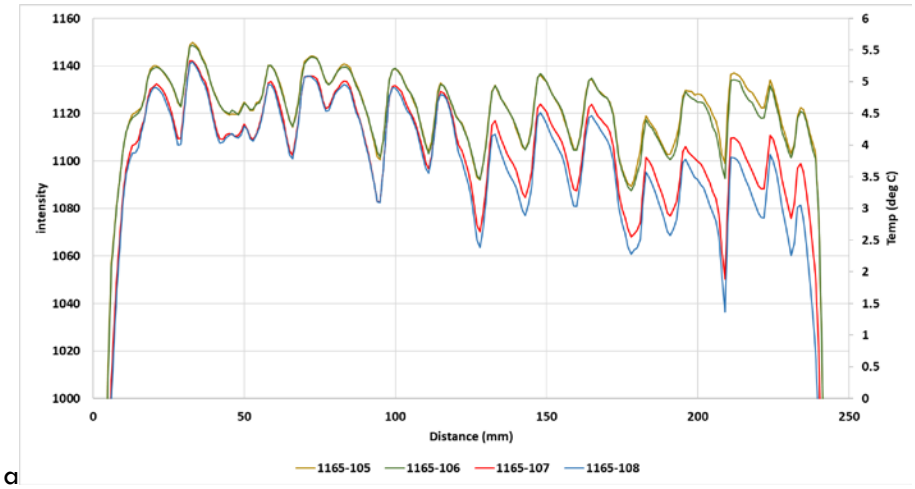
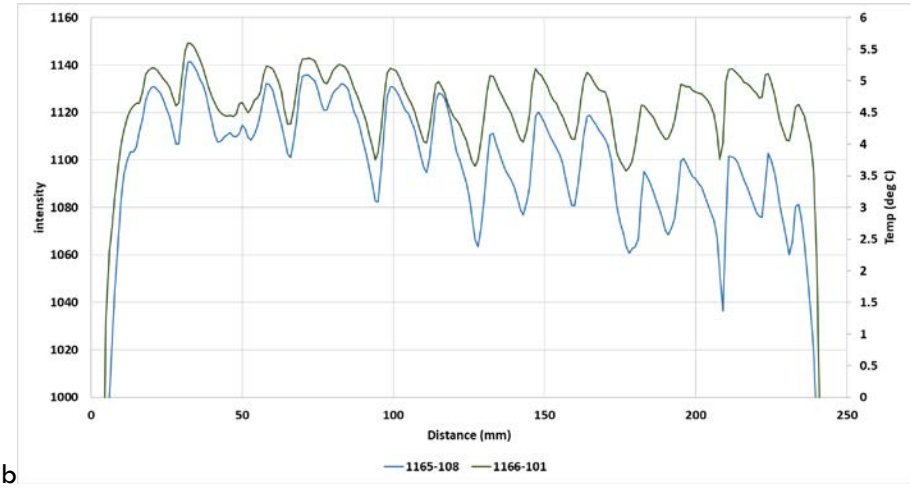


Figure 2. Recorded temperatures showing limited gradient (a.), enhanced gradient (b.), and temperature oscillations.



a



b

Figure 3. CT scans showing X-ray attenuation in Hounsfield units during a warming/cooling cycle. Decrease in intensity correlates to decrease in sample density and indicates hydrate dissociation. Panal a shows data over about 2.5 hours during a warming cycle (2 hr total). CT scans1165-105 is the initial condition, 1165-106 76 minutes, 1165-107 129 minutes, and 1165-108 157 minutes. Panal b is a cooling cycle (1165-108 initial condition, 1166-101 after 2 hrs of cooling.

Task 16. Continued investigation of layered systems

Several preliminary hydrate experiments have been run on layered systems. The test presented above contained anisotropy and layers that are perpendicular to the long axis of the sample. No tests with core axis layers and hydrate instability zones due to temperature gradients have been completed to date. As the build out of the system has been completed (Task 11) these experiments should be completed in the next quarter.

Task 17. Comparison of the effect of vertical and horizontal wells for gas production in a layered hydrate-bearing system.

No work on this task was completed this quarter.

Milestone Table

Milestone Title	Milestone Description	Planned Completion Date	Actual Completion Date	Status / Results
Report on Layered Hydrate	A report describing the data collected in our first layered hydrate test will be submitted.	January 31, 2015 Delayed – expected by September 30, 2015	Included with quarterly update 5/05/16	Complete
Go/NoGo on vessel	A brief letter report will be submitted following Task 10a to inform the DOE of the go/no go decision on vessel remanufacture. (Tasks 10).	September 30, 2015	Informally contained in update 11/16	Complete
Topical Report	A report documenting the results of laboratory tests examining the effects of thermal gradients and gradient oscillation on hydrate behavior will be submitted. (Task11)	March 31, 2016	Delayed	Will resume in new vessel in Q4
Topical Report	A report documenting the results of laboratory tests investigating the gas hydrate equilibrium point versus the gas production rate will be submitted. (Task 12)	June 30, 2016	June 30, 2016	Laboratory work complete and powerpoint presentation assembled. Letter report in preparation.
Topical Report	A report documenting the results of laboratory tests on layered systems.	July 31, 2017	Delayed	Work will resume in Q4
Grain-scale Computation of Hydrate-Bearing Sand Properties Based on microCT Sample Description	A report documenting the results of numerical simulations on multigrain scale flow and mechanical simulations.	May 31, 2017	Delayed, data fields generated and shared with NETL	Simulations will resume in Q4
Topical Report	A report documenting the results of current challenge laboratory tests and their interpretation.	July 31, 2017	Delayed	Experimental work will resume in Q4 with new vessel
Topical Report	A report adding to the observations on layered systems	January 31, 2018	March 31, 2018	Work is under way in a number of projects to support this.
Topical Report	An experiment report documenting the results of gas production from laboratory-simulated vertical and horizontal wells.	July 31, 2018	In progress, completion delayed	Expected within next two months.
Conference Papers/ Proceedings/ Articles	Documents include conference papers, proceedings, presentations, journal articles, and press releases.	Minimum of 7 business days prior to submission		

PRODUCTS:

None to report this quarter.

CHANGES/PROBLEMS:
Our new student, Bin Wang, is integrating into our laboratory group. In addition, Chun Chang, a post-doctoral researcher with experience in controlled pressure/temperature core flood work is providing assistance to broaden his experience and guiding image analysis.

SPECIAL REPORTING REQUIREMENTS:

NA

BUDGETARY INFORMATION:

BP6 = July 2017 - June 2018	Actual Cost (this quarter)	Actual Cost (cumulative for BP)	Funds available (for the BP)	Balance of unspent funds (for the BP)	Actual Cost (cumulative for the full FWP)	Funds available (for the full FWP)	Balance of unspent funds (for the full FWP)
Jul-Sep 2017	$29,402	$29,402	$125,000	$95,598	$457,399	$685,000	$227,601
Oct-Dec 2017	$43,189	$72,591		$52,409	$500,588		$184,412
Jan-Mar 2018	$24,510	$97,101		$27,899	$525,098		$159,902
Mar-Jun 2018	$43,132	$140,233		($15,233)	$568,230		$116,770

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