OIL & GAS

DOE Award No.: DE-FE-0028967

Quarterly Research Performance Progress Report (Period Ending 9/30/2017)

A multi-scale experimental investigation of flow properties in coarse-grained hydrate reservoirs during production

Project Period (10/1/2016-9/30/2019)

Submitted by:

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National Energy Technology Laboratory

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

Office of Fossil Energy

DISCLAIMER

1. ACCOMPLISHMENTS:

What was done? What was learned?

This report outlines the progress of the fourth quarter of the first year of the first budget period. The majority of the progress made was purchasing parts to build the laboratory equipment and beginning to test that equipment.

A. What are the major goals of the project?

The goals of this project are to provide a systematic understanding of permeability, relative permeability and dissipation behavior in coarse-grained methane hydrate - sediment reservoirs. The results will inform reservoir simulation efforts, which will be critical to determining the viability of the coarse-grained hydrate reservoir as an energy resource. We will perform our investigation at the macro- (core) and micro- (pore) scale.

At the macro- (core) scale, we will: 1) measure the relative permeability of the hydrate reservoir to gas and water flow in the presence of hydrate at various pore saturations; and 2) depressurize the hydrate reservoir at a range of initial saturations to observe mass transport and at what time scale local equilibrium describes disassociation behavior. Simultaneously, at the micro (pore) scale, we will 1) use micro-CT to observe the habit of the hydrate, gas, and water phases within the pore space at a range of initial saturations and then image the evolution of these habits during dissociation, and 2) use optical micro-Raman Spectroscopy to images phases and molecules/salinity present both at initial saturations and at stages of dissociation. We will use our micro-scale observations to inform our macro-scale observations of relative permeability and dissipation behavior.

In Phase 1, we will first demonstrate our ability to systematically manufacture sand-pack hydrate samples at a range of hydrate saturations. We will then 1) measure the permeability of the hydrate-saturated sand pack to flow of a single phase (water or gas), 2) depressurize the hydrate-saturated sand packs and observe the kinetic (time-dependent) behavior. Simultaneously we will build a micro-CT pressure container and a micro-Raman Spectroscopy chamber to image the pore-scale habit, phases, and pore fluid chemistry of our sand-pack hydrate samples. We will then make these observations on our hydrate-saturated sand-packs.

In Phase 2, we will measure relative permeability to water and gas in the presence of hydrate in sand-packs using co-injection of water and gas. We will also extend our measurements from sand-pack models of hydrate to observations of actual Gulf of Mexico material. We will also measure relative permeability in intact samples to be recovered from the upcoming Gulf of Mexico 2017 hydrate coring expedition. We will also perform dissipation experiments on intact Gulf of Mexico pressure cores. At the micro-scale we will perform micro-Raman and micro-Ct imaging on hydrate samples composed from Gulf of Mexico sediment.

The Project Milestones are listed in the table below.

Milestone Description	Planned Completion	Actual Completion	Verification Method	Comments
Milestone 1.A: Project Kick-off Meeting	11/22/2016 (Y1Q1)	11/22/2016	Presentation	Complete
Milestone 1.B: Achieve hydrate formation in sand-pack	6/27/2017 (Y1Q3)	8/11/2017	Documentation of milestone achievement within required project reporting / deliverables (Deliverable 2.1)	Complete
Milestone 1.C: Controlled and measured hydrate saturation using different methods	3/27/2018 (Y2Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 2.1)	In progress
3 Milestone 1.D: Achieved depressurization and demonstrated mass balance	3/27/2018 (Y2Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 3.1)	In progress
Milestone 1.E: Built and tested micro-consolidation device	6/27/2017 (Y1Q3)	6/27/2017	Documentation of milestone achievement within required project reporting / deliverables (Deliverable 4.1)	Complete
Milestone 1.F: Achieved Hydrate formation and measurements in Micro-CT consolidation device	3/27/2018 (Y2Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 4.1)	In progress
Milestone 1.G: Built and integrated high-pressure gas mixing chamber	3/27/2018 (Y2Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 5.1)	In progress
Milestone 1.H: Micro-Raman analysis of synthetic complex methane hydrate	3/28/2018 (Y2Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 5.1)	In progress
Milestone 2.A - Measurement of relative permeability in sand-pack cores.	1/17/2019 (Y3Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 6.1)	
Milestone 2.B - Measurement of relative permeability in intact pressure cores.	9/30/2019 (Y3Q4)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 6.1)	
Milestone 2.C - Depressurization of intact hydrate samples and documentation of thermodynamic behavior.	9/30/2019 (Y3Q4)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 7.1)	
Milestone 2.D - Achieved gas production from GOM^2 samples monitored by micro-CT.	9/30/2019 (Y3Q4)		Documentation of milestone achievement within required project reporting / deliverables Report (Deliverable 8.1)	
Milestone 2.E - Building a chamber to prepare natural samples for 2D-3D micro-Raman analysis;	1/17/2019 (Y3Q2)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 9.1)	
Milestone 2.F - 2D micro-Raman analysis of natural methane hydrate samples at depressurization;	9/30/2019 (Y3Q4)		Documentation of milestone achievement within required project reporting / deliverables (Deliverable 9.1)	

B. What was accomplished under these goals?

<u>CURRENT- BUDGET PERIOD 1</u>

Task 1.0 Project Management and Planning

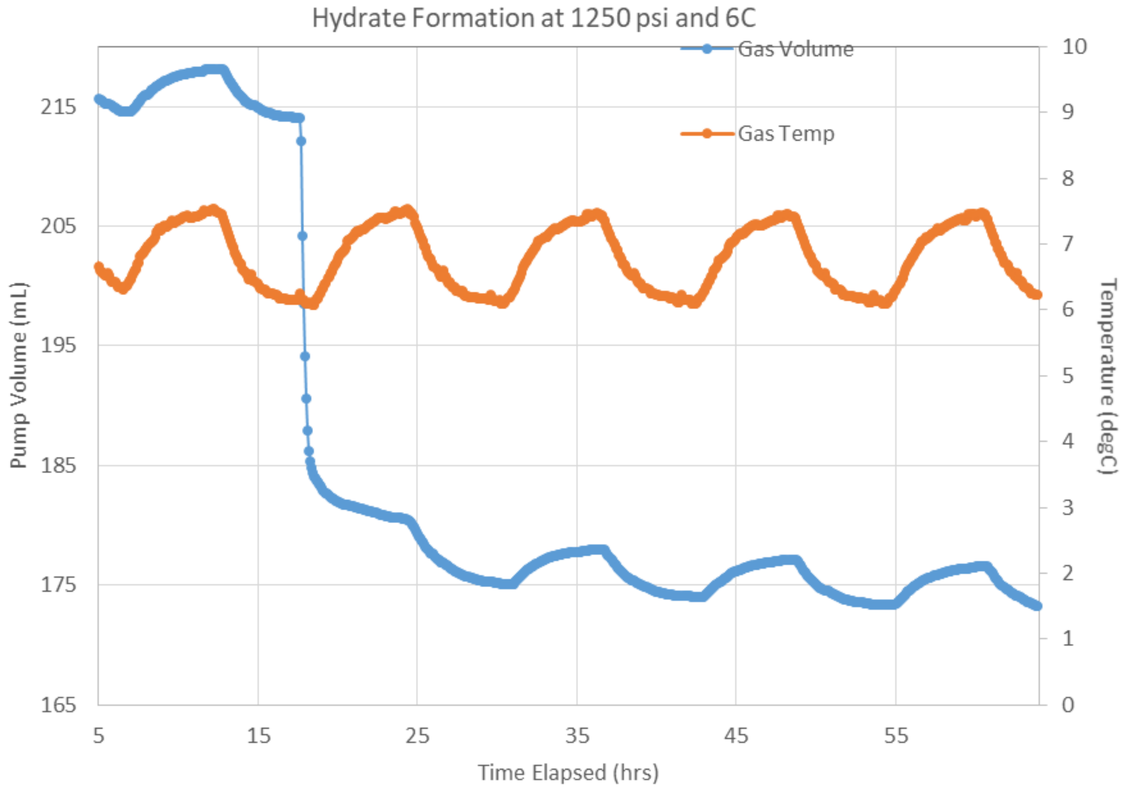
Planned Finish: 09/30/19
Actual Finish: In progress

- The third Quarterly Report was submitted on July 27, 2017

Task 2.0 Macro-Scale: Relative Permeability of Methane Hydrate Sand Packs

Subtask 2.1 Laboratory Creation of Sand-Pack Samples at Varying Hydrate Levels
Planned Finish: 6/ 27/17
Actual Finish: 8/11/17

- Sand was prepared in a moist state, mixed with kaolinite for better hydrate nucleation, and tamped into the core holder to a porosity of 35% and water saturation of 40%.
- Core holder was raised to 1300 psi confining pressure and 1250 psi pore (methane) pressure.
- Entire setup placed in cold room at 6°C, and pore pressure was maintained as 1250 psi as hydrate formed and consumed methane.
- Hydrate formation was evidenced by rapid consumption of methane that was detectable by the pump. This shows up in the data as a large drop in pump volume around 16 hours:



- In order to determine the hydrate saturation, the properties of the core and of methane hydrate were used. Since the core had a volume of 180.18 cm^3, a porosity of 35%, and a water saturation of 40%, the amount of methane that should theoretically be consumed can be calculated.
    - Initial water volume = 25.23 cm^3; Density of water=1.000 g/cm^3; Density of methane= 0.07224 g/cm^3; Density of hydrate = 0.925 g/cm^3; molar mass of hydrate = 119.5 g/mol.
    - We assume 1 mole of hydrate contains 1 mole of methane and 5.75 moles of water
    - Initial moles of water present: (25.23 cm^3)*(1/(18.02 g/mol))=1.40 mol
    - Moles of methane required for complete coversion of water: 1.40/5.75 = 0.243 mol
    - Mass of methane required for complete conversion: 0.243*(16.04 g/mol) = 3.91 g
    - Volume of hydrate required for complete conversion = 3.91/0.07224 = 54.13 mL
    - In example 1, there was about 40 mL of methane consumed which is a 74% conversion rate. This 40 mL of methane is equal to 0.1801 mol, so 0.1801 mol of hydrate was formed with a mass of 21.52 g and a volume of 23.27 cm^3. This filled 37% of the pore volume for a 37% hydrate saturation.
- In a subsequent experiment, we converted 86% of the initial methane to achieve a hydrate saturation of 43%.

Subtask 2.2 Steady-State Permeability of Gas and Water of Sand-Pack Hydrate Samples
Planned Finish: 3/27/18
Actual Finish: In progress

- All equipment has been received and is being assembled
- We will test the setup by performing relative permeability measurements of nitrogen in the presence of water

- Following that, we will form hydrate and commence with permeability measurements for gas and water in the presence of hydrate in the sand pack.

Task 3.0 Macro-Scale: Depressurization of Methane Hydrate Sand Packs

Subtask 3.1 Depressurization Tests
Planned Finish: 6/27/17
Actual Finish: In progress

- We have begun forming methane hydrate in a sand pack, and after formation we will depressurize to compare pressure rebounds at multiple stages of depressurization.

Subtask 3.2 Depressurization Tests with CAT scan
Planned Finish: 03/27/18
Actual Finish: In progress

- We have set up and are leak testing an experiment in the CT lab. We will form hydrate and then depressurize and monitor with CT scans to observe changes in density immediately after perturbation and during pressure rebound.

Task 4.0 Micro-Scale: CT Observation of Methane Hydrate Sand Packs

Subtask 4.1 Design and Build a Micro-CT compatible Pressure Vessel
Planned Finish: 6/27/17
Actual Finish: 6/27/2017 Complete

Subtask 4.2 Micro-Scale CT Observations and Analysis
Planned Finish: 03/27/18
Actual Finish: In Progress

During this quarter, we started performing hydrate dissociation experiments monitored by X-ray time-lapse radiography. Figure 4.1 shows an example of time-lapse X-ray radiography images for one experiment of hydrate in a quartz sand-pack. From top to bottom, the vessel contains a PTFE spacer, packed sand at 100 kPa of effective vertical stress, another PTFE spacer with sand inside, and a compressed stainless steel spring. Hydrate crystals appear as dark pixels that gradually disappear with time. In the sand, hydrate is heterogeneously distributed with the bottom having higher hydrate saturation. In the spring area, there is a large hydrate chunk.

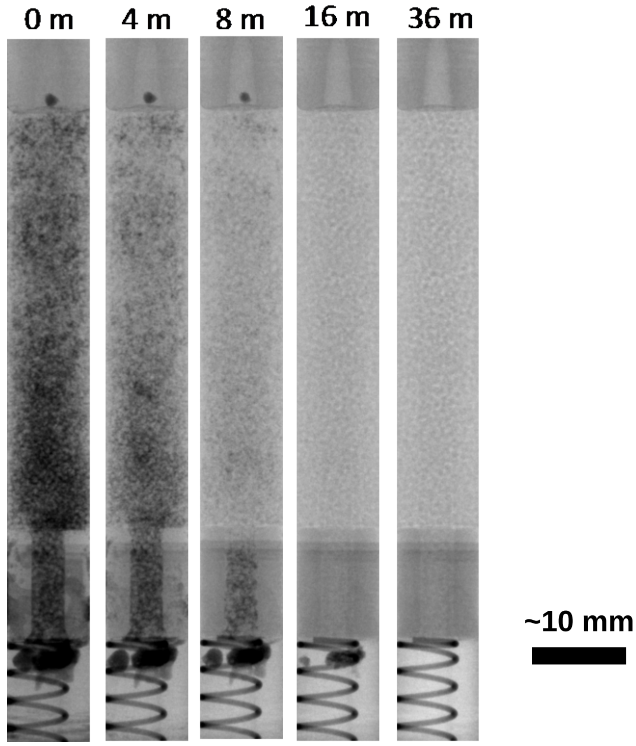


Figure 4.1. X-ray radiography images of the micro-consolidation device at various times in minutes (m) after crossing the hydrate stability boundary. Xenon hydrate reveals as dark pixels that gradually disappear with time. The sand is packed between two PTFE spacers stressed by a stainless steel spring in the bottom. The depressurization port is on the top.

We calculate the axial profiles of grayscale number using the radiography images in Figure 1. Then we subtract the profile at the end of dissociation from each profile. The grayscale number difference profile is approximately linear with respect to xenon hydrate volume, since xenon hydrate has the strongest X-ray attenuations and its saturation change determines the grayscale number. Figure 2 shows the grayscale number difference profiles at different dissociation times. The sand is between 0 and 54 mm and the spring area is between 54 and 64 mm. One key feature is that, from 0 to 8 minute, the total hydrate in sand decreases by 2/3 and the total hydrate in the spring area decreases by less than one half. The dissociation rates in the sand and the spring areas differ due to differences in pore size and hydrate surface area. These experimental observations provide evidence for controls of pore size and hydrate saturation on hydrate dissociation rate.

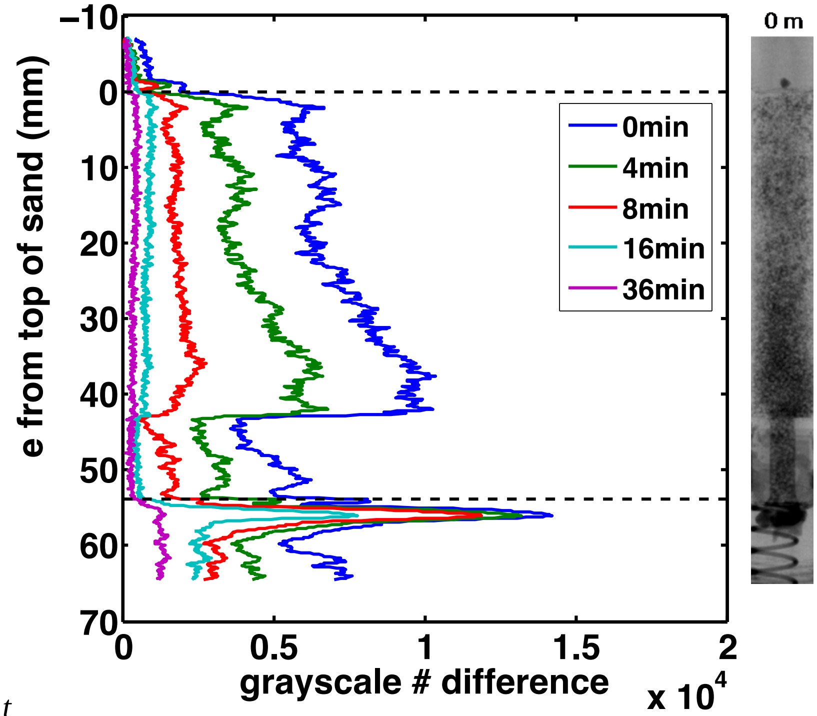


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Figure 4.2. Axial profiles of grayscale number difference between radiographies at a given time -after crossing the hydrate stability zone- and the time at the end of dissociation. A higher grayscale number means higher hydrate saturation. The radiography at 0 minutes is displayed on the right to compare relative positions of micro-consolidation device parts and grayscale profiles.

Task 5.0 Micro-Scale: Raman Observation of Methane-Gas-Water Systems

Subtask 5.1 Design and Build a Micro-Raman compatible Pressure Vessel
Planned Finish: 6/27/17
Actual Finish: Complete

Subtask 5.2 Micro-scale petrochemistry
Planned Finish: 03/31/18
Actual Finish: In progress
During this quarter, we synthesized and dissociated methane hydrates with deionized water in glass beads in the “static” cell. Methane hydrates were synthesized by initially fill the pore space with a known amount of methane vapor and then injecting abundant water to maintain a constant pressure. We performed optical and Raman mapping of pore spaces as a function of time. By taking advantage of the high molecular sensitivity of Raman spectroscopy, we identify methane and water in hydrate lattice, vapor methane, and liquid water. Figure 5.1 shows a representative Raman spectrum of structure I methane hydrates. Figure 5.2 shows optical and Raman mapping as a function of time. By the area ratio of methane peaks at 2902 cm^{-1} to 2913 cm^{-1}, we identify structure I (ratio ~3) and structure II (ratio ~0.5) hydrates in different regions within the pore space. Structure I hydrates grow from grain surfaces into the pore center at the consumption of structure II hydrates slowly over days. In Figure 5.3, Raman spectra at the same location shows the structure II to structure I hydrate transition as a function of time.

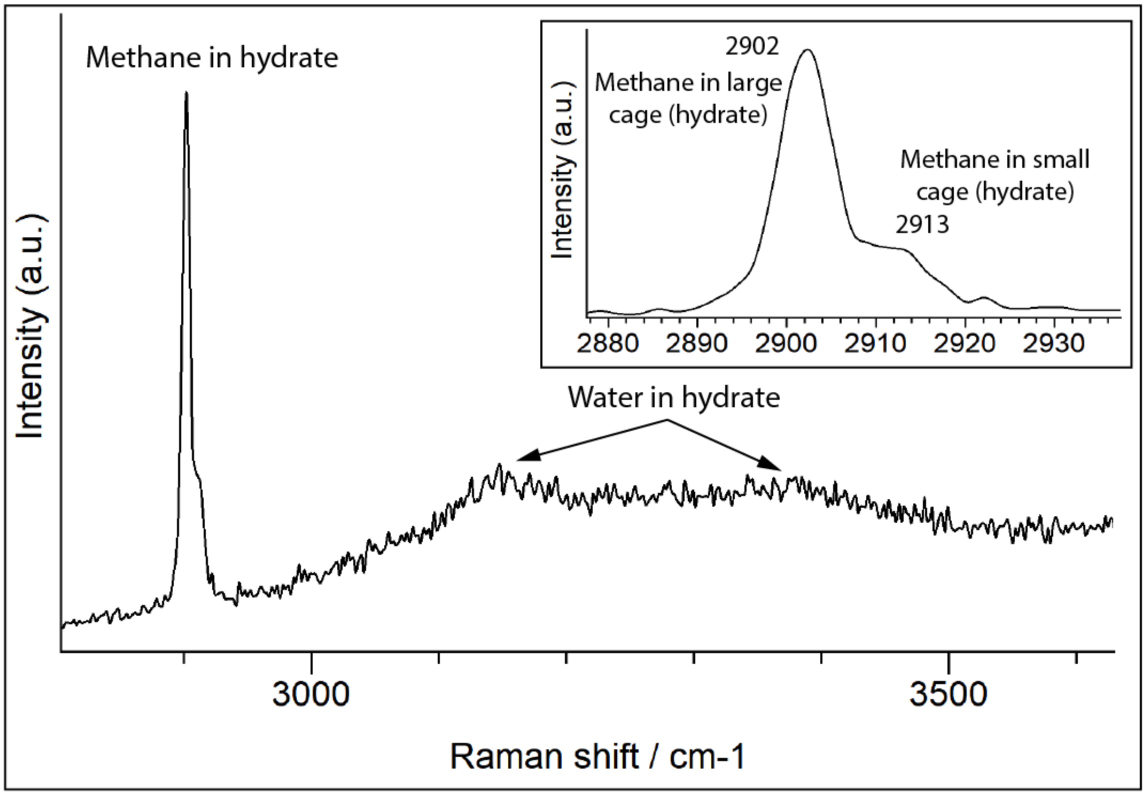

Figure 5.1. Raman spectra of methane and water molecules in the hydrate structure. We assign the peaks at 2902 cm^{-1} and 2913 cm^{-1} to methane molecules (C-H symmetrical stretching) in large cages and small cages of the hydrate lattice, respectively. The broad peaks around 3000–3500 cm^{-1} indicate water in the hydrate lattice.

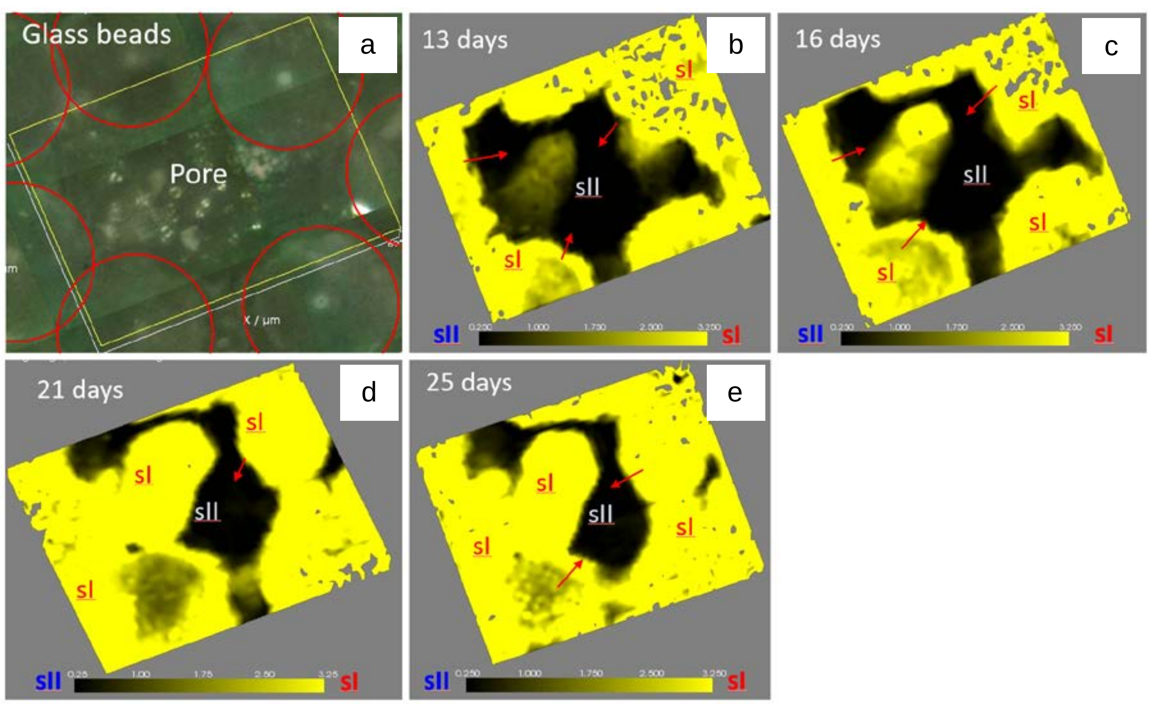

Figure 5.2. Optical and Raman mappings of methane hydrates at the pore scale at constant temperature of 4 °C. **(a)** An optical image of the mapped region. Red circles outlines the glass beads. Methane hydrates completely fill the pore space. **(b) –(e)** False color Raman mappings of the same region over time. Indicated by the area ratio of methane peaks at 2902 cm^{-1} to 2913 cm^{-1}, black color represents structure II hydrates (peak area ratio ~0.5) and yellow color represents structure I hydrates (peak area ratio ~3). Over days, structure I hydrates grow towards pore center with the consumption of structure II hydrates.

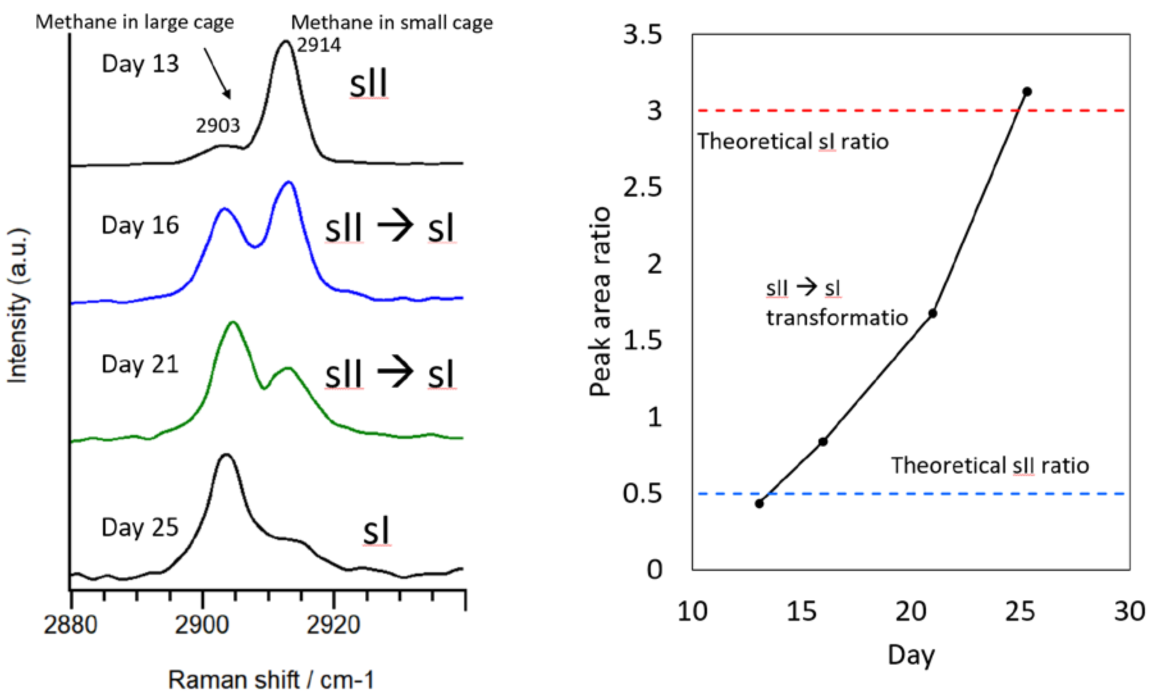

Figure 5.3. Raman spectra of methane hydrates at a single location as a function of time. **Left:** Raman spectra over time. **Right:** The ratio of 2903 cm^{-1} to 2914 cm^{-1} peak areas over time. The red and blue dashed lines indicate the theoretical values of structure I and structure II hydrates, respectively.

Subtask 5.2 Diffusion kinetics of methane release
Planned Finish: 3/27/18
Actual Finish: In progress

We dissociated methane hydrates (synthesized with deionized water) by depressurization at a constant temperature of 4 °C. In Figure 5.4, we show a comparison of Raman spectra before and immediately after hydrate dissociation. The methane in small cages dissociated into vapor methane faster than its large cage counterparts. After hydrate dissociation, the large cages in hydrates existed as a metastable phase for a short period of time.

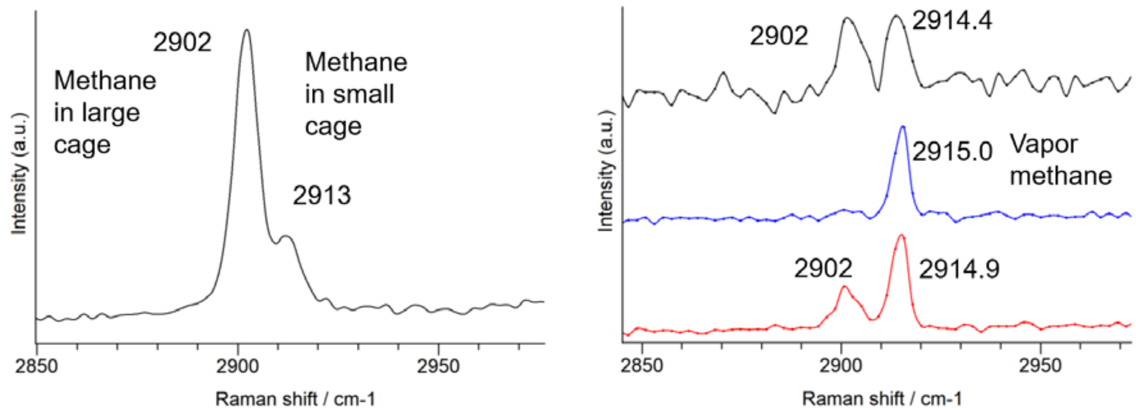

Figure 5.4. Raman spectra before and immediately after hydrate dissociation. **Left:** Before dissociation, we observe structure I methane hydrates. **Right:** Hydrate dissociation was achieved by decrease the pressure at isothermal condition. Immediately after hydrate dissociation, we show three representative spectra in the mapping region. We assign the peaks at 2914.9 cm^{-1} and 2915.0 cm^{-1} to vapor methane, indicating methane dissociated from hydrates. Methane in large cage (2902 cm^{-1}) are present in some regions within the pore space. However, the methane in small cage (2913 cm^{-1}) no longer registers in any Raman spectrum. We interpret that the small cages are kinetically faster to dissociate than the large cages. Large cages exist as a metastable phase outside the hydrate stability zone.

Decision Point: Budget Period 2 Continuation

Nothing to report this period.

<u>FUTURE – BUDGET PERIOD 2</u>

Task 6.0 Macro-Scale: Relative Permeability of Methane Hydrate Sand Packs and Intact Pressure Core Samples

Subtask 6.1 Steady-State Relative Permeability Measurements of Sand-Pack Hydrate Samples
Planned Finish: 1/17/19
Actual Finish: Not Started

Subtask 6.2 Steady-State Relative Permeability Measurements of Intact Pressure Cores
Planned Finish: 9/30/19
Actual Finish: Not Started

Task 7.0 Macro-Scale: Depressurization of Methane Hydrate Sand Packs and Intact Pressure Core Samples

Subtask 7.1 Depressurization of sand-pack hydrate samples
Planned Finish: 1/17/19
Actual Finish: Not Started

Subtask 7.2 Depressurization of intact pressure cores
Planned Finish: 9/30/19
Actual Finish: Not Started

Task 8.0 Micro-Scale: CT experiments on Gulf of Mexico Sand Packs

Subtask 8.1 GOM2 Sample Preparation for Micro-CT
Planned Finish: 1/17/19
Actual Finish: Not Started

Subtask 8.2 Production Testing on GOM2 Samples Observed with Micro-CT
Planned Finish: 9/30/19
Actual Finish: Not Started

Task 9.0 Micro-Scale: Raman Observation on hydrate-bearing sand packs

Subtask 9.1 3D Imaging of methane hydrate sandpacks
Planned Finish: 1/17/19
Actual Finish: Not Started

Subtask 9.2 Micro-Raman Imaging of methane hydrate sandpacks
Planned Finish: 9/30/19
Actual Finish: Not Started

C. What opportunities for training and professional development has the project provided?

Nothing to Report

D. How have the results been disseminated to communities of interest?

- A presentation was made at the Third Deep Carbon Observatory International Science Meeting, St. Andrews, Scotland, 23-25, March.
- A poster was presented at the 9th International Conference on Gas Hydrates, June 25-30, 2017, Denver, CO.

E. What do you plan to do during the next reporting period to accomplish the goals?

a. Task 1.0 Project Management and Planning

Planned Finish: 09/30/19
Actual Finish: In progress

- Continue working on external project website

b. Task 2.0 Macro-Scale: Relative Permeability of Methane Hydrate Sand Packs

Subtask 2.1 Laboratory Creation of Sand-Pack Samples at Varying Hydrate Levels
Planned Finish: 6/27/17
Actual Finish: Complete

Subtask 2.2 Steady-State Permeability of Gas and Water of Sand-Pack Hydrate Samples
Planned Finish: 3/27/18
Actual Finish: In process

- Complete assembling equipment
- Test system by performing steady-state relative permeability measurement of nitrogen in the presence of brine
  Form hydrates in the core and measure relative permeability to brine in the presence of hydrate

c. Task 3.0 Macro-Scale: Depressurization of Methane Hydrate Sand Packs

Subtask 3.1 Depressurization Tests
Planned Finish: 6/27/17
Actual Finish: In progress

- Continued depressurization experiments in which we vary the magnitude of gas release at various stages of depressurization to test the pressure rebound due to salt diffusion to varying volumes of freshwater release.
- Additional depressurization experiments at hydrate saturation higher than we've previously accomplished (greater than 27%) with a goal of 50% hydrate saturation.

Subtask 3.2 Depressurization Tests with CAT scan
Planned Finish: 3/27/18
Actual Finish: In progress

- We are now setting up an experiment to form and dissociate methane hydrate in the CT scanner. We will take scans before and after hydrate dissociation and multiple times during the pressure rebound to observe density changes from which we can infer hydrate and gas distribution.

d. Task 4.0 Micro-Scale: CT Observation of Methane Hydrate Sand Packs

Subtask 4.1 Design and Build a Micro-CT compatible Pressure Vessel
Planned Finish: 6/27/17
Actual Finish: Complete

Subtask 4.2 Micro-Scale CT Observations and Analysis
Planned Finish: 3/27/18
Actual Finish: In Progress

- Continue with methane hydrate growth, monitoring, and dissociation. We are building a mini gas-collection chamber to perform mass balance calculations during dissociation.

e. **Task 5.0 Micro-Scale: Raman Observation of Methane-Gas-Water Systems**

Subtask 5.1 Design and Build a Micro-Raman compatible Pressure Vessel
Planned Finish: 6/27/17
Actual Finish: Complete

Subtask 5.2 Micro-scale petrochemistry
Planned Finish: 03/21/18
Actual Finish: In progress

- Repeat experiments at different pressure-temperature conditions.
- We will synthesize methane hydrates at higher temperature and pressure conditions (up to 22 MPa in pressure) with salt dissolved in water
- We are building a "flow-through" Raman cell in which we can create advection flow and pressure gradient to simulate natural production environments
- We will synthesize methane hydrates by wetting the glass beads with a known amount of water and thereafter injecting abundant methane vapor

Subtask 5.2 Diffusion kinetics of methane release
Planned Finish: 03/27/18
Actual Finish: In progress

- We will obtain the activation energy of hydrate formation and dissociation as a function of temperature, described by the Arrhenius equation, by varying temperature conditions during the experiment.

2. PRODUCTS:

What has the project produced?

a. **Publications, conference papers, and presentations**

Dong, T., Lin, J. F., Flemings, P. B., Polito, P. J. (2016), Pore-scale study on methane hydrate dissociation in brine using micro-Raman spectroscopy, presented at the 2016 Extreme Physics and Chemistry workshop, Deep Carbon Observatory, Palo Alto, Calif., 10-11 Dec.

Lin, J. F., Dong, T., Flemings, P. B., Polito, P. J. (2017), Characterization of methane hydrate reservoirs in the Gulf of Mexico, presented at the Third Deep Carbon Observatory International Science Meeting, St. Andrews, Scotland, 23-25, March.

Phillips, S.C., You, K., Flemings, P.B., Meyer, D.W., and Dong, T., 2017. Dissociation of laboratory-synthesized methane hydrate in coarse-grained sediments by slow depressurization. Poster presented at the 9th International Conference on Gas Hydrates, June 25-30, 2017, Denver, CO.

Phillips, S.C., You, K., Flemings, P.B., Meyer, D.W., and Dong, T., in review. Dissociation of laboratory-synthesized methane hydrate in coarse-grained sediments by slow depressurization. Marine and Petroleum Geology

Chen, X., Espinoza, N., Verma, R., and Prodanovic, M. X-Ray Micro-CT Observations of Hydrate Pore Habit and Lattice Boltzmann Simulations on Permeability Evolution in Hydrate Bearing Sediments (HBS). To be presented at the 2017 AGU Fall Meeting, December 11-15, 2017, New Orleans, LA.

Dong, T., Lin, J.-F., Gu, J.T., Polito, P.J., O'Connell, J., Flemings, P.B. (2017), Spatial and temporal dependencies of structure II to structure I methane hydrate transformation in porous media under moderate pressure and temperature conditions, Abstract OS53B-1188 To be presented at 2017 Fall Meeting, December 11-15, New Orleans, LA,

b. Website(s) or other Internet site(s)

- Project SharePoint: https://sps.austin.utexas.edu/sites/GEOMech/HP3/_layouts/15/start.aspx#/SitePages/Home.aspx

c. Technologies or techniques

Nothing to Report.

d. Inventions, patent applications, and/or licenses

Nothing to Report.

e. Other products

Research Performance Progress Report (Period ending 12/31/16)
Research Performance Progress Report (Period ending 3/31/17)
Research Performance Progress Report (Period ending 6/30/17)

3. CHANGES/PROBLEMS:

This section highlights changes and problems encountered on the project.

a. Changes in approach and reasons for change

Nothing to Report.

b. Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to Report.

c. Changes that have a significant impact on expenditures

Nothing to Report.

d. Change of primary performance site location from that originally proposed

Nothing to Report.

4. SPECIAL REPORTING REQUIREMENTS:

Special reporting requirements are listed below.

CURRENT - BUDGET PERIOD 1

Nothing to Report

FUTURE – BUDGET PERIOD 2

Nothing to Report

5. BUDGETARY INFORMATION:

The Cost Summary is located in Exhibit 1.

EXHIBIT 1 – COST SUMMARY

Baseline Reporting Quarter	Budget Period 1 (Year 1)							
	Q1 10/01/16-12/31/16		Q2 01/01/17-03/31/17		Q3 04/01/17-06/30/17		Q4 07/01/17-09/30/17	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 283,497	$ 283,497	$ 82,038	$ 365,535	$ 79,691	$ 445,226	$ 79,691	$ 524,917
Non-Federal Share	$ 170,463	$ 170,463	$ 7,129	$ 177,593	$ 7,129	$ 184,722	$ 7,129	$ 191,851
Total Planned	$ 453,960	$ 453,960	$ 89,167	$ 543,128	$ 86,820	$ 629,948	$ 86,820	$ 716,768
Actual Incurred Cost								
Federal Share	$ 6,749	$ 6,749	$ 50,903	$ 57,652	$ 67,795	$ 125,447	$ 162,531	$ 287,977
Non-Federal Share	$ 10,800	$ 10,800	$ 10,800	$ 21,600	$ 10,800	$ 32,400	$ 158,478	$ 190,878
Total Incurred Cost	$ 17,549	$ 17,549	$ 61,703	$ 79,252	$ 78,595	$ 157,847	$ 321,009	$ 478,855
Variance								
Federal Share	$ (276,748)	$ (276,748)	$ (31,135)	$ (307,883)	$ (11,896)	$ (319,779)	$ 82,840	$ (236,940)
Non-Federal Share	$ (159,663)	$ (159,663)	$ 3,671	$ (155,993)	$ 3,671	$ (152,322)	$ 151,349	$ (973)
Total Variance	$ (436,411)	$ (436,411)	$ (27,465)	$ (463,876)	$ (8,226)	$ (472,101)	$ 234,188	$ (237,913)

Baseline Reporting Quarter	Budget Period 1 & 2 (Year 2)							
	Q1		Q2		Q3		Q4	
	10/01/17-12/31/17		01/01/18-03/31/18		04/01/18-06/30/18		07/01/16-09/30/18	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 109,248	$ 634,165	$ 89,736	$ 723,901	$ 128,914	$ 852,815	$ 106,048	$ 958,863
Non-Federal Share	$ 7,342	$ 199,193	$ 19,369	$ 218,562	$ 7,342	$ 225,904	$ 31,393	$ 257,297
Total Planned	$ 116,590	$ 833,358	$ 109,105	$ 942,463	$ 136,256	$ 1,078,719	$ 137,441	$ 1,216,160
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

Baseline Reporting Quarter	Budget Period 2 (Year 3)							
	Q1		Q2		Q3		Q4	
	10/01/18-12/31/18		01/01/19-03/31/19		04/01/19-06/30/19		07/01/19-09/30/19	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 80,035	$ 1,038,898	$ 53,698	$ 1,092,596	$ 53,698	$ 1,146,294	$ 53,695	$ 1,199,989
Non-Federal Share	$ 7,581	$ 264,878	$ 7,579	$ 272,457	$ 7,579	$ 280,036	$ 19,965	$ 300,001
Total Planned	$ 87,616	$ 1,303,776	$ 61,277	$ 1,365,053	$ 61,277	$ 1,426,330	$ 73,660	$ 1,499,990
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

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