DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report

Period Ending 09/30/2018

Deepwater Methane Hydrate Characterization and Scientific Assessment

Project Period 3: 01/15/2018-09/30/2019

Submitted by:

Peter B. Flemings

Signature

The University of Texas at Austin

DUNS #: 170230239

101 East 27th Street, Suite 4.300

Austin, TX 78712-1500

Email: pflemings@jsg.utexas.edu

Phone number: (512) 475-8738

Prepared for:

United States Department of Energy

National Energy Technology Laboratory

October 31, 2018

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

Office of Fossil Energy

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

1 ACCOMPLISHMENTS

What was done? What was learned?

This report outlines the progress of the fourth quarter of the fourth fiscal year in the third budget period. Highlights from this period include:

- **CPP2-887 / GOM^2-2**: The European Consortium for Ocean Research Drilling (ECORD) Facility Board (EFB) met on September 10, 2018 to review CPP2-887 and evaluate implementing GOM^2-2 as a Mission Specific Platform (MSP). As a meeting outcome, EFB recommended that the European Science Operator support an abridged CPP2-887 expedition as an MSP for implementation in 2021. The ECORD Council is expected to make a determination in November, 2018.
- **GOM^2 Workshop**: Ohio State University (OSU) coordinated and hosted a workshop on GOM^2 at OSU on September 24 and 25, 2018. The workshop had 32 attendees between the two days. Day 1 focused on initial GOM^2-1 core analysis results and ongoing work. Day 2 was organized by UT Austin and focused on the GOM^2-2 drilling project. Major tasks were identified and new teams were developed to address these tasks.
- **Core Analysis**: Having confirmed that our methodology works on compromised cores (cores recovered outside the hydrate stability zone during coring or processing phases) we are now conducting quantitative degassing and resultant gas analysis on uncompromised cores.
- **Pressure Core Transfer**: Four 30 cm pressure core segments from GOM^2-1 were transferred from UT to NETL from September 10-19, 2019. Segments were removed from three pressure cores and transferred at ~ 24MPa.

1.1 WHAT ARE THE MAJOR GOALS OF THE PROJECT?

The primary objective of this project is to gain insight into the nature, formation, occurrence and physical properties of methane hydrate-bearing sediments for the purpose of methane hydrate resource appraisal. This will be accomplished through the planning and execution of a state-of-the-art drilling, coring, logging, testing and analytical program that assess the geologic occurrence, regional context, and characteristics of marine methane hydrate deposits in the Gulf of Mexico Continental Shelf. Project Milestones are listed in Tables 1-1, 1-2, and 1-3.

Table 1-1: Previous Milestones

Project Phase	Milestone	Task	Milestone Description	Planned Completion	Actual Completion	Verification Method
Phase 1	M1A	1.0	Project Management Plan	03/02/15	03/18/15	Project Mgmt. Plan
	M1B	1.0	Project Kick-off Meeting	01/14/15	12/11/14	Presentation
	M1C	2.0	Site Location and Ranking Report	09/30/15	09/30/15	Phase 1 Report
	M1D	3.0	Preliminary Field Program Operational Plan Report	09/30/15	09/30/15	Phase 1 Report
	M1E	4.0	Updated CPP Proposal Submitted	05/01/15	10/01/15	Phase 1 Report
	M1F	2.0	Demonstration of a viable PCS Tool: Lab Test	09/30/15	09/30/15	Phase 1 Report
	M1G	--	Document results of BP1/Phase 1 Activities	12/29/15	01/12/16	Phase 1 Report
Phase 2	M2A	6.0	Complete Updated CPP Proposal Submitted	11/02/15	Nov-15	QRPPR
	M2B	6.0	Scheduling of Hydrate Drilling Leg by IODP	05/18/16	May-15	Report status to DOE PM
	M2C	7.0	Demonstration of a viable PCS tool for hydrate drilling through completion of land-based testing	12/21/15	Dec-15	PCTB Land Test Report (in QRPPR)
	M2D	8.0	Demonstration of a viable PCS tool for hydrate drilling through completion of a deepwater marine field test	01/02/17	May-17	QRPPR
	M2E	11.0	Update Field Program Operational Plan	02/28/18	04/12/18	Phase 2 Report
	M2F	--	Document results of BP2/Phase 2 Activities	04/15/18	04/13/18	Phase 2 Report

Table 1-2: Current Milestones

Project Phase	Milestone	Task	Milestone Description	Planned Completion	Actual Completion	Verification Method
Phase 3	M3A	14.0	Demonstration of a viable PCS tool for hydrate drilling: Lab Test	12/31/18	--	PCTB Lab Test Report (in QRPPR)
	M3B	14.0	Demonstration of a viable PCS tool for hydrate drilling: Land Test	03/29/19	--	PCTB Land Test Report (in QRPPR)
	M3C	15.0	Complete Refined Field Program Operational Plan Report	12/31/18	--	QRPPR
	M3D	15.0	Completion of required Field Program Permit(s)	12/31/18	--	QRPPR
	M3E	--	Document results of BP3/Phase 3 Activities	12/31/19	--	Phase 3 Report

Table 1-3: Future Milestones

Project Phase	Milestone	Task	Milestone Description	Planned Completion	Actual Completion	Verification Method
Phase 4	M4A	16.0	Completion of planned field Research Expedition operations	03/31/20	--	QRPPR
	M4B	17.0	Complete Preliminary Expedition Summary	09/30/20	--	Report directly to DOE PM
	M4C	17.0	Complete Project Sample and Data Distribution Plan	05/31/20	--	Report directly to DOE PM
	M4D	17.0	Contribute to IODP Proceedings Volume	09/30/21	--	Report directly to DOE PM
	M4E	17.0	Initiate comprehensive Scientific Results Volume with appropriate scientific journal	09/30/21	--	Report directly to DOE PM

1.2 WHAT WAS ACCOMPLISHED UNDER THESE GOALS?

1.2.1 PREVIOUS PROJECT PERIODS

Tasks accomplished in previous project phases (Phase 1 and Phase 2) are summarized in Table 1-4.

Table 1-4: Tasks completed during Phase 1 and Phase 2

Project Phase	Task	Description	QRPPR with Task Information
Phase 1	**Task 1.0**	**Project Management and Planning**	Y1Q1 - Y1Q4
	Task 2.0	**Site Analysis and Selection**	Y1Q1 - Y1Q4
	Subtask 2.1	*Site Analysis*	
	Subtask 2.2	*Site Ranking / Recommendation*	
	Task 3.0	**Develop Pre-Expedition Operational Plan**	Y1Q3 - Y1Q4
	Task 4.0	**Complete IODP CPP Proposal**	Y1Q2 - Y1Q4
	Task 5.0	**Pressure Coring and Core Analysis System Modifications and Testing**	Y1Q2 - Y1Q4
	Subtask 5.1	*Pressure Coring Tool with Ball Scientific Planning Workshop*	
	Subtask 5.2	*Pressure Coring Tool with Ball Lab Test*	
	Subtask 5.3	*Pressure Coring Tool with Ball Land Test Prep*	
Phase 2	**Task 1.0**	**Project Management and Planning *(Cont'd)***	Y2Q1 - Y4Q1
	Task 6.0	**Technical and Operational Support of CPP Proposal**	Y2Q1 - Y4Q1
	Task 7.0	**Cont'd. Pressure Coring and Core Analysis System Mods. and Testing**	Y2Q1 - Y3Q2
	Subtask 7.1	*Review and Complete NEPA Requirements (PCTB Land Test)*	
	Subtask 7.2	*Pressure Coring Tool with Ball Land Test*	
	Subtask 7.3	*PCTB Land Test Report*	
	Subtask 7.4	*PCTB Tool Modification*	
	Task 8.0	**Pressure Coring Tool with Ball Marine Field Test**	Y2Q1 - Y4Q1
	Subtask 8.1	*Review and Complete NEPA Requirements*	
	Subtask 8.2	*Marine Field Test Operational Plan*	
	Subtask 8.3	*Marine Field Test Documentation and Permitting*	
	Subtask 8.4	*Marine Field Test of Pressure Coring System*	
	Subtask 8.5	*Marine Field Test Report*	
	Task 9.0	**Pressure Core Transport, Storage, and Manipulation**	Y2Q2 - Y3Q3
	Subtask 9.1	*Review and Complete NEPA Requirements*	
	Subtask 9.2	*Hydrate Core Transport*	
	Subtask 9.3	*Storage of Hydrate Pressure Cores*	
	Subtask 9.4	*Refrigerated Container for Storage of Hydrate Pressure Cores*	
	Subtask 9.5	*Hydrate Core Manipulator and Cutter Tool*	
	Subtask 9.6	*Hydrate Core Effective Stress Chamber*	
	Subtask 9.7	*Hydrate Core Depressurization Chamber*	

	Task 10.0 *Subtask 10.1* *Subtask 10.2* *Subtask 10.3*	**Pressure Core Analysis** *Routine Core Analysis* *Pressure Core Analysis* *Hydrate Core-Log-Seismic Synthesis*	Y3Q3 - Y4Q1
	Task 11.0	**Update Pre-Expedition Operational Plan**	Y3Q3 - Y4Q1
	Task 12.0	**Field Program / Research Expedition Vessel Access**	Y3Q3

1.2.2 CURRENT PROJECT PERIOD

TASK 1.0 - PROJECT MANAGEMENT AND PLANNING

Status: Ongoing

Objective 1: Assemble teams according to project needs.

- No new hires this period.

Objective 2: Coordinate the overall scientific progress, administration and finances of the project.

- Managed current project phase tasks.
- Monitored project costs.
- Managed ongoing experimental analysis of pressure cores.
- Managed and coordinated transfer of GOM^2-1 pressure core samples from UT Pressure Core Center to DOE-NETL.
- Continued to coordinate and support transition of CPP2-887 from the Integrated Ocean Drilling Program (IODP) to the European Consortium for Ocean Drilling (ECORD).
- Continued to engage with ECORD and provide supporting information as they evaluate implementing CPP2-887 as a Mission Specific Platform (MSP).
- Evaluated scope, budget, and schedule implications of implementing GOM^2-2 without the scientific and operational capacities of the *JOIDES Resolution* (*JR*). Developed alternative GOM^2-2 scenarios and presented them to ECORD as options for potential implementation as an MSP.
- Provided technical summary document of GOM^2-2 and GOM^2-2 Plan B options to ECORD Facility Board (EFB) on September 7, 2018, for consideration in EFB planning meeting on September 10, 2018.

Objective 3: Communicate with project team and sponsors.

- Organized and coordinated regular project team meetings:
  - Monthly sponsor meetings,
  - PCTB development team meetings, and
  - GOM^2-2 operations team meetings.
- Managed SharePoint sites, email lists, and archive/website.
- Provided regular updates to project team and sponsors with regard to transitioning CPP2-887 from IODP to ECORD.

- Coordinated and participated in GOM^2 workshop, hosted by Ohio State University (OSU) on September 24-25, 2018.

Objective 4: Coordinate and supervise subcontractors and service agreements to realize deliverables and milestones according to the work plan.

- Actively managed subcontractors and service agreements.
- Finalized comprehensive scope of work for continued services from Geotek Coring Inc. and Ltd (Geotek) throughout BP3 and BP4 in accordance with the GOM^2 Scope of Project Objectives (SOPO), including Task 14 (PCTB performance assessment, modifications, and testing) and Task 16 (research expedition field operations).
- Executed service agreement between The University of Texas at Austin (UT) and Geotek.
- Initiated contract negotiations with Reaction Engineering International (Reaction Engineering) for computation fluid dynamics (CFD) modeling of the Pressure Coring Tool with Ball-valve (PCTB).
- Completed a Request for Qualifications (RFQ) questionnaire to pre-qualify vessel contractors for participating in a Request for Proposal (RFP) for GOM^2-2. RFQ was posted publically online and emailed to targeted vessel contractors on September 3, 2018. It is currently pending final evaluation by the RFQ evaluation team and UT Purchasing Office.
- Amended service agreement with Pettigrew Engineering for continued engineering and consulting services throughout BP3.

Objective 5: Compare identified risks with project risks to ensure all risks are identified and monitored. Communicate risks and possible outcomes to project team and stakeholders.

- Actively monitored project risks as needed and reported identified risks to project team and stakeholders.

TASK 6.0 - TECHNICAL AND OPERATIONAL SUPPORT OF COMPLIMENTARY PROJECT PROPOSAL

Status: Ongoing

- OSU provided an Environmental Protection and Safety Panel (EPSP) response letter to Michiko Yamamoto of IODP.
- On September 7, 2018, UT provided the European Facilities Board (EFB) of the International Ocean Discovery Program (IODP) a PowerPoint document presenting an overview of the original GOM^2-2 field program and multiple scenarios for how this program could be achieved on a Mission Specific Platform supported by the European Consortium for Ocean Research Drilling (ECORD). Informal feedback indicated that the presentation was positively received at the EFB meeting held on September 10, 2018.
- OSU and UT continued to working to fulfill permitting requirements for Orca Basin and Terrebonne locations (see Subtask 15.3 for additional information).

A timeline of tasks associated with the submittal of the Complimentary Project Proposal is provided in Table 1-5.

Table 1-5: Timing of Complimentary Project Proposal Submission

DATE	ACTIVITY
Apr 1, 2015	First Submittal of CPP
May 1, 2015	Upload data to IODP SSDB
Oct 1, 2015	Revised Submittal of CPP
Jan 8, 2016	Upload data to IODP SSDB
Jan 12-14, 2016	SEP Review Meeting
Apr 1, 2016	CPP Addendum Submittal
May 2, 2016	Upload data to IODP SSDB
May 15, 2016	Proponent Response Letter Submitted
Jun 21-23, 2016	SEP Review Meeting
June 2016	Safety Review Report Submitted
July 2016	Safety Presentation PowerPoint
July 11 – 13, 2016	Environmental Protection and Safety Panel Meeting
March 2, 2017	Submit CPP Addendum2
March 10, 2017	Upload Revised Site Survey Data
April 2017	Submit EPSP Safety Review Report V2
May 3, 2017	EPSP Safety Review Presentation V2
May 24, 2017	Scheduling of CPP-887 Hydrate Drilling Leg by JR Facility Board: Exp. 386, Jan-March 2020
May 15-16, 2018	Expedition 386 removed from *JR* schedule
September 10, 2018	EFB recommends that ESO support an MSP expedition based on Plan B-3 for implementation in 2021

TASK 9.0 - PRESSURE CORE TRANSPORT, STORAGE, AND MANIPULATION

Status: Complete (See Task 13 for continued UT Pressure Core Center (PCC) activities).

TASK 10.0 - PRESSURE CORE ANALYSIS

Status: Ongoing

All Expedition Report Chapters and the GOM^2-1 Data Directory were made public at the end of the Quarter. https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/reports/

Ohio State University (OSU) coordinated and hosted a workshop on GOM^2 at OSU (Figure1-1).

Figure 1-1: Attendees at the GOM^2 Workshop

The workshop took place on September 24th and 25th and had 32 attendees between the two days (list below, Table 1-6); almost all people attended on both days. Day 1 focused on initial results and ongoing work, and included a number of excellent talks (Table 1-7) and posters. Day 2 was organized by UT Austin and focused on the GOM^2-2 drilling project.

Two major tasks related to refining our science goals and approach were identified on Day 1: 1) Gain a better understanding of the microbial factory and the origin of water and methane in the system at GC 955; and 2) Refine/build a better Physical Pore Model. More details can be found in the workshop summary **(Appendix A).**

Table 1-6: List of GOM² Workshop participants (32)

Tom Darrah	Ohio State University	darrah.24@osu.edu
Myles Moore	Ohio State University	moore.3222@buckeyemail.osu.edu
Emma Oti	Ohio State University	oti.4@buckeyemail.osu.edu
Alexey Portnov	Ohio State University	portnov.1@osu.edu
Kevin Meazell	University of Texas at Austin	kevin.meazell@gmail.com
Carla Thomas	University of Texas at Austin	carla.thomas@utexas.edu
Bill Waite	United States Geological Survey	wwaite@usgs.gov
Junbong Jang	United States Geological Survey	jjang@usgs.gov
Steve Phillips	University of Texas at Austin	phillips.stephen.c@gmail.com
Evan Solomon	University of Washington	esolomn@uw.edu
Peter Flemings	University of Texas at Austin	pflemings@jsg.utexas.edu
Li Wei	Ohio State University	wei.732@buckeyemail.osu.edu
Yi Fang	University of Texas at Austin	yi.fang@utexas.edu
Manasij Santra	University of Texas at Austin	manasij30@gmail.com
Ann Cook	Ohio State University	cook.1129@osu.edu
Yongkoo Seol	Department of Energy	Yongkoo.Seol@NETL.DOE.GOV
Tim Collett	United States Geological Survey	tcollett@usgs.gov
Ray Boswell	Department of Energy	Ray.Boswell@NETL.DOE.GOV
Derek Sawyer	Ohio State University	sawyer.144@osu.edu
Kehua You	University of Texas at Austin	khyouml@gmail.com
Gabby Intihar	Department of Energy	Gabby.Intihar@hq.doe.gov
Bill Shedd	BOEM	william.shedd@boem.gov
Joel Johnson	University of New Hampshire	Joel.Johnson@unh.edu
Ryan Heber	Ohio State University	heber.8@osu.edu
Will Fortin	Columbia University	wfortin@ldeo.columbia.edu
Jiachao Liu	University of Texas at Austin	jiacliu@utexas.edu
Tim Reinhardt	Department of Energy	Timothy.Reinhardt@hq.doe.gov
Rick Baker	Department of Energy	Richard.Baker@NETL.DOE.GOV
Urmi Majumdar	Ohio State University	urmi.geology@gmail.com
Evgeniy M Myshakin	Department of Energy	Evgeniy.Myshakin@NETL.DOE.GOV
David Goldberg	Columbia University	goldberg@ldeo.columbia.edu
Tom Pettigrew	Pettigrew Engineering	pettigrew.engineering@windstream.net

Table 1-7: GOM² Workshop Day 1 Agenda – September 24, 2018

GOM2 Workshop Schedule. September 24 (Day 1). Mendehall Laboratory Room 291.						
Theme	**Begin**	**End**	**Length of Time* Includes 2 min of questions**	**Talk/Activity**	**Talk Title**	**Presenter**
	8:00 AM	8:30 AM	30	Arrival/Breakfast/Hang Posters		
Background	8:30 AM	8:45 AM	15	Welcome, basic information, goals		Ann Cook/Peter Flemings
	8:45 AM	9:05 AM	20	Overview of GC955, including history, science, NGHP-2 context.		Ray Boswell
	9:05 AM	9:25 AM	20	GOM2 Drilling Program, forward looking; first results.		Peter Flemings
	9:25 AM	9:45 AM	20	Core Lab at UT Austin, core recovery; what kind of science is planned at UT/Other places.	Pressure Coring at GC 955	Carla Thomas/Steve Phillips
	9:45 AM	10:20 AM	35	Break+Posters		
Theme 1: The Main Reservior	10:20 AM	10:35 AM	15	Salt influence on the GC955 system + 1 minute teaser on AC810.		Alexey Portnov
	10:35 AM	10:50 AM	15	Evolution of the GC955 System		Manasij Santra
	10:50 AM	11:00 AM	10	Seismic Inversion at GC955		Will Fortin
	11:00 AM	11:15 AM	15	Pressure Core Sedimentology	The deposition of a silty hydrate reservoir at GC 955	Kevin Meazell
	11:15 AM	11:25 AM	10	Core		Joel Johnson
	11:25 AM	11:27 AM	2	1-minute teaser: XRD for Litho 2/3		Ryan Heber
	11:27 AM	11:42 AM	15	What do we know about the depositional system, lithofacies and pore scale properties of the reservoir? What do we need to know?		Discussion Lead: Tim Collett
Theme 2: Saturation	11:42 AM	11:52 AM	10	Saturation from Well Logs.	Gas hydrate saturation using resistivity and velocity well logs	Ann Cook
	11:52 AM	12:07 PM	15	Saturation from Pressure Core.	High saturation of methane hydrate in a coarse-grained reservoir in the northern Gulf of Mexico from quantitative degassing of pressure cores	Steve Phillips
	12:07 PM	12:17 PM	10	Pore water geochemistry and impications for hydrate saturation and sample contamination.		Evan Solomon
	12:17 PM	12:19 PM	2	1-minute teaser: XCT and hydrate saturation		Emma Oti
	12:19 PM	12:34 PM	15	What do we know about the hydrate saturation? What do we need to know?		Discussion Lead: Ann Cook
	12:34 PM	1:49 PM	75	Lunch + Posters		
Theme 3: Gas Migration	1:49 PM	2:04 PM	15	Reservior Modeliing		Kehua You
	2:04 PM	2:06 PM	2	1-minute teaser: Short migration		Li Wei
	2:06 PM	2:26 PM	20	Carbon Isotopes, Microbio/Isotopolouges		Steve Phillips
	2:26 PM	2:46 PM	20	Nobel Gas Geochemistry, OSU carbon isotopes		Tom Darrah/Myles Moore
	2:46 PM	3:01 PM	15	What do we know about the hydrate source gas? What do we need to know?		Discussion Lead: Steve Phillips
	3:01 PM	3:36 PM	35	Break +Posters		
Theme 4: Perturbation	3:36 PM	3:51 PM	15	Permeability from Pressure Core	Permeability, compression behavior, and lateral stress ratio of hydrate-bearing siltstone from UT-GOM2-1 pressure core (GC 955—northern Gulf of Mexico): Initial Results	Yi Fang
	3:51 PM	4:01 PM	10	Compressibiilty (future plans)		Yongkoo Seol
	4:01 PM	4:16 PM	15	PCCT - what will we learn		Bill Waite
	4:16 PM	4:31 PM	15	What do we know about permeabilty and reservior perturbation? What do we need to know?		Discussion Lead: Peter Flemings
	4:31 PM	4:41 PM	10	Reflection on Day + Topics we need to focus on going forward		Discussion Lead: Peter Flemings
	4:41 PM	4:51 PM	10	Plan for Day 2		Peter Flemings
*** Time includes 2 minutes of questions, except for 1 minute teasers.**						

Subtask 10.4 - Continued Pressure Core Analysis

A. Pressurized Core Analysis

A.1. Quantitative Degassing and Gas Analysis

- Quantitative depressurization of pressure core and analysis of the resultant gasses continues:
  - Having confirmed that our methodology works on compromised cores (cores that were outside the hydrate stability zone either during the initial coring or subsequent processing phases), we are now analyzing sections from uncompromised cores. Samples were selected to fill in the gaps and increase the resolution of estimated variation in hydrate saturation downhole. We cut samples for degassing during the cutting transfer of NETL cores from H005-3FB-4 and H005-8FB-2 (see section A.3) to be degassed during Q4.

Table 1-8: Results of five sections of compromised core containing multiple lithofacies that were degassed in the UT Pressure Core Lab, including total methane, methane, saturation, and C1/C2.

Hole	Core-Section	Top depth (mbsf)	Bottom depth (mbsf)	Lithofacies	Core volume (L)	Total methane (L)	Maximum dissolved methane (mmol)	Methane saturation (%)	C1/C2
H005	06FB-2	428.47	428.57	Compromised	0.18	10	12	74	-
H005	06FB-2	428.62	428.69	Compromised	0.14	3.13	10	32	-
H005	06FB-2	428.82	429.02	Compromised	0.41	9.52	28	33	8333
H005	06FB-2	429.02	429.10	Compromised	0.16	4.82	11	44	-
H005	06FB-2	429.10	429.42	Compromised	0.65	32.61	44	76	-

- OSU continued working to determine the C1 to C5 hydrocarbon, N_2, and CO_2 molecular composition using their Gas Chromatography fitted with thermal conductivity detector (TCD) and flame ionization detector (FID). These analyses allow us to quantify the relative contributions of each component and determine the genetic source of gases (thermogenic, biogenic, mixed). Analyses of 13 samples is complete. Data processing was done in August/September, and is shown in Table 1-9.
- OSU continued to work on determining noble gas geochemistry composition, and continued analysis of carbon and hydrogen isotopes using their Thermo Fisher Helix Split Flight Tube Mass Spectrometer. These analyses are key for understanding noble and hydrocarbon gas partitioning into/between the hydrates and pore fluids, evaluating the residence time of natural gases/hydrate formation. Initial noble gas experiments showed low residence ages that were below 500,000 years (Fig. 1-2). However, as mentioned above these samples had very high nitrogen content, making the age estimates questionable. ^{4}He is highest during the initial dissociation of the sample (Fig. 1-3). Analyses of 13 samples was completed. Data is shown in Table 1-9.
- Gas analysis preliminary conclusions are as follows:
  - Methane in this core is dominantly formed via biogenic processes based on the depleted $\delta^{13}C$-CH_4. It is unclear whether the microbial methane was formed directly from sedimentary organic matter or from oxidation of thermogenic hydrocarbons.

- There appears to be trace thermogenic components based on the presence of low concentrations of C3-C5 hydrocarbons.
- Gases associated with hydrate formation appear to have residence times ranging from 2 x 10^4 to ~5.6 x 10^5 years (Fig. 1-2) based on the ^4He and a noble gas diffusion/production model (Hunt, 2000).
- The noble gas ratios suggest that hydrates in these cores appear to form at exceedingly low gas/water ratios, implying that a low concentration of gas in water at the time of formation.
- Noble gas content is highest in gas samples collected at the start of dissociation (Fig. 1-3).

- UT continued work on estimating downhole in-situ salinity from depressurization curves based on the initial pressure and temperature of dissociation during degassing.
- UT is working on completing a draft of a paper summarizing the hydrate saturation, gas composition, and sample salinity from quantitative degassing experiments.

Table 1-9 (next page): Major gas, hydrocarbon gas, and noble gas abundances and isotopic composition for a controlled core depressurization experiment of core H005-6FB. Note significantly lower levels of atmospheric gases compared to previous studies and changes in gas composition by more than a factor of 10 according to the stage of depressurization. Mean residence time estimates vary from ~1.8 x 10^4 to 5.6 x 10^5 years.

Sample	Project Name	Client	H_2 ccSTP/cc	CH_4 ccSTP/cc	C_2H_6 ccSTP/cc	C3 ccSTP/cc	Ci-4 ccSTP/cc	Cn-4 ccSTP/cc	Ci-5 ccSTP/cc
H005-6FB-2 #2_MM+GW	GoM	DOE	8.76E-03	0.679	4.74E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #2 ABC_MM+GW	GoM	DOE	1.21E-03	0.974	1.19E-04	8.36E-06	4.57E-06	1.87E-06	b.d.l.
H005-6FB-2 #10_MM+GW	GoM	DOE	3.55E-03	0.947	8.24E-04	5.01E-04	2.90E-04	4.01E-04	2.35E-04
H005-6FB-2 #8_MM+GW	GoM	DOE	3.84E-03	0.974	1.03E-04	1.15E-05	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #6_MM+GW	GoM	DOE	3.88E-03	0.938	2.27E-04	9.45E-05	5.56E-05	8.62E-05	4.50E-05
H005-6FB-2 #3_MM+GW	GoM	DOE	8.41E-03	0.957	5.83E-05	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #7_MM+GW	GoM	DOE	1.36E-03	0.979	8.78E-05	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #9_MM+GW	GoM	DOE	4.03E-03	0.977	1.36E-04	1.44E-05	8.24E-06	4.08E-06	4.32E-06
H005-6FB-2 #1_MM+GW	GoM	DOE	4.03E-03	0.977	1.03E-04	1.09E-05	4.40E-06	2.42E-06	2.34E-06
H005-6FB-2 #4_MM+GW	GoM	DOE	2.56E-03	0.963	1.32E-04	3.34E-05	1.75E-05	1.99E-05	1.09E-05
H005-6FB-2 #5_MM+GW	GoM	DOE	7.00E-03	0.957	6.84E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #11_MM+GW	GoM	DOE	4.04E-03	0.858	2.08E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #1 ABC_MM+GW	GoM	DOE	2.33E-03	0.903	4.95E-07	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2, #3 ABC	GoM	DOE	2.35E-03	0.969	6.27E-07	b.d.l.	b.d.l.	b.d.l.	b.d.l.

Sample	Cn-5 ccSTP/cc	C-6 ccSTP/cc	N_2 ccSTP/cc	O_2 ccSTP/cc	CO_2 ccSTP/cc	TOTAL	GROSS BTU (BEFORE CO_2 REMOVAL)	NET BTU (BEFORE CO_2 REMOVAL)	^{3}He pcc/cc
H005-6FB-2 #2_MM+GW	b.d.l.	b.d.l.	0.274	0.00	0.027	0.991	687.4	618.8	3.85
H005-6FB-2 #2 ABC_MM+GW	b.d.l.	b.d.l.	0.011	0.00	0.001	0.987	985.5	887.2	0.54
H005-6FB-2 #10_MM+GW	2.74E-04	6.65E-05	0.037	0.00	0.002	0.993	964.8	868.6	0.66
H005-6FB-2 #8_MM+GW	b.d.l.	b.d.l.	0.011	0.00	0.003	0.992	985.9	887.5	0.15
H005-6FB-2 #6_MM+GW	7.12E-05	b.d.l.	0.015	0.00	0.035	0.993	950.5	855.7	0.49
H005-6FB-2 #3_MM+GW	b.d.l.	b.d.l.	0.019	0.00	0.007	0.992	968.3	871.7	0.58
H005-6FB-2 #7_MM+GW	b.d.l.	b.d.l.	0.006	0.00	0.001	0.987	990.9	892.0	0.16
H005-6FB-2 #9_MM+GW	2.52E-06	b.d.l.	0.009	0.00	0.003	0.993	988.7	890.1	0.15
H005-6FB-2 #1_MM+GW	b.d.l.	b.d.l.	0.009	0.00	0.002	0.992	988.5	889.8	0.11
H005-6FB-2 #4_MM+GW	1.58E-05	b.d.l.	0.023	0.00	0.001	0.990	975.2	877.9	0.34
H005-6FB-2 #5_MM+GW	b.d.l.	b.d.l.	0.014	0.00	0.014	0.992	968.1	871.5	0.33
H005-6FB-2 #11_MM+GW	b.d.l.	b.d.l.	0.129	0.00	0.002	0.993	868.6	781.9	3.44
H005-6FB-2 #1 ABC_MM+GW	b.d.l.	b.d.l.	0.079	0.00	0.003	0.991	913.6	822.4	4.91
H005-6FB-2, #3 ABC	b.d.l.	b.d.l.	0.018	0.00	0.001	0.991	981.1	883.1	0.44

Sample	^{4}He μcc/cc	^{20}Ne μcc/cc	^{21}Ne μcc/cc	^{22}Ne μcc/cc	^{20}Ne ncc/cc	^{21}Ne ncc/cc	^{22}Ne ncc/cc	Ne μcc/cc	^{36}Ar μcc/cc
H005-6FB-2 #2_MM+GW	3.06	6.209	0.0179	0.636	6209.39	17.89	636.19	6.86	7.35
H005-6FB-2 #2 ABC_MM+GW	0.70	0.654	0.0020	0.067	654.23	2.05	67.31	0.72	1.24
H005-6FB-2 #10_MM+GW	0.58	1.044	0.0032	0.111	1044.26	3.17	111.18	1.16	6.68
H005-6FB-2 #8_MM+GW	0.17	0.195	0.0006	0.021	194.78	0.60	20.57	0.22	0.83
H005-6FB-2 #6_MM+GW	1.61	0.324	0.0005	0.018	324.27	0.55	17.96	0.34	1.02
H005-6FB-2 #3_MM+GW	3.43	0.214	0.0006	0.023	213.91	0.63	22.56	0.24	2.52
H005-6FB-2 #7_MM+GW	0.15	0.128	0.0004	0.013	127.95	0.39	13.33	0.14	0.50
H005-6FB-2 #9_MM+GW	0.26	0.102	0.0003	0.011	102.07	0.31	10.78	0.11	0.45
H005-6FB-2 #1_MM+GW	0.13	0.113	0.0003	0.012	112.64	0.35	11.95	0.12	0.40
H005-6FB-2 #4_MM+GW	0.53	0.465	0.0014	0.049	465.26	1.35	48.73	0.52	0.93
H005-6FB-2 #5_MM+GW	0.20	0.209	0.0006	0.022	209.11	0.65	22.14	0.23	0.94
H005-6FB-2 #11_MM+GW	2.66	4.498	0.0131	0.470	4497.76	13.08	470.26	4.98	6.41
H005-6FB-2 #1 ABC_MM+GW	4.65	4.152	0.0125	0.429	4152.13	12.49	429.03	4.59	5.43
H005-6FB-2, #3 ABC	0.57	0.618	0.0018	0.064	618.08	1.78	64.12	0.68	1.34

Sample	^{38}Ar μcc/cc	^{40}Ar μcc/cc	Ar μcc/cc	Kr ncc/cc	^{84}Kr ncc/cc	^{132}Xe ncc/cc	Xe ncc/cc	R/R_A	R_C/R_A
H005-6FB-2 #2_MM+GW	1.41	2104.41	2113.17	393.48	223.89	24.05	89.40	0.9081	0.83
H005-6FB-2 #2 ABC_MM+GW	0.23	352.55	354.02	83.84	47.70	5.25	19.50	0.5540	0.42
H005-6FB-2 #10_MM+GW	1.26	1935.33	1943.27	471.37	268.21	18.00	66.92	0.8193	0.68
H005-6FB-2 #8_MM+GW	0.16	245.90	246.88	50.15	28.54	2.30	8.56	0.6294	0.48
H005-6FB-2 #6_MM+GW	0.19	300.08	301.29	87.93	50.03	4.35	16.18	0.2195	0.18
H005-6FB-2 #3_MM+GW	0.48	746.62	749.63	205.03	116.66	8.20	30.50	0.1231	0.11
H005-6FB-2 #7_MM+GW	0.09	145.06	145.65	30.06	17.11	0.93	3.45	0.7630	0.70
H005-6FB-2 #9_MM+GW	0.09	131.17	131.71	38.69	22.02	1.56	5.79	0.4052	0.34
H005-6FB-2 #1_MM+GW	0.07	115.47	115.94	30.47	17.34	1.33	4.96	0.6116	0.50
H005-6FB-2 #4_MM+GW	0.17	268.70	269.81	36.12	20.55	0.96	3.56	0.4616	0.31
H005-6FB-2 #5_MM+GW	0.18	278.21	279.33	101.00	57.47	7.17	26.66	1.2147	1.30
H005-6FB-2 #11_MM+GW	1.20	1834.91	1842.53	363.22	206.67	18.50	68.76	0.9340	0.90
H005-6FB-2 #1 ABC_MM+GW	0.99	1526.69	1533.11	192.38	109.46	6.51	24.21	0.7620	0.70
H005-6FB-2, #3 ABC	0.25	375.11	376.70	74.78	42.55	5.83	21.65	0.5668	0.41

Sample	(He/Ne)	$(He/Ne)_{AIR}$	(He/Ne) X-Factor	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$	$^{38}Ar/^{36}Ar$	$^{40}Ar/^{36}Ar$	$^{4}He/^{20}Ne$	$^{20}Ne/^{36}Ar$
H005-6FB-2 #2_MM+GW	0.45	1.55	1.29	9.760	0.0281	0.1926	286.487	0.49	0.845
H005-6FB-2 #2 ABC_MM+GW	0.97	3.36	2.80	9.719	0.0304	0.1887	284.214	1.07	0.527
H005-6FB-2 #10_MM+GW	0.50	1.73	1.45	9.393	0.0285	0.1883	289.651	0.55	0.156
H005-6FB-2 #8_MM+GW	0.79	2.75	2.29	9.470	0.0290	0.1892	297.961	0.88	0.236
H005-6FB-2 #6_MM+GW	4.69	16.29	13.57	18.051	0.0305	0.1869	293.818	4.96	0.317
H005-6FB-2 #3_MM+GW	14.45	50.17	41.81	9.482	0.0281	0.1902	295.811	16.01	0.085
H005-6FB-2 #7_MM+GW	1.07	3.72	3.10	9.599	0.0289	0.1866	288.410	1.19	0.254
H005-6FB-2 #9_MM+GW	2.32	8.05	6.71	9.473	0.0286	0.1885	288.590	2.57	0.225
H005-6FB-2 #1_MM+GW	1.01	3.49	2.91	9.423	0.0290	0.1842	290.680	1.12	0.284
H005-6FB-2 #4_MM+GW	1.04	3.60	3.00	9.548	0.0277	0.1879	289.490	1.15	0.501
H005-6FB-2 #5_MM+GW	0.86	2.98	2.48	9.445	0.0291	0.1897	294.479	0.95	0.221
H005-6FB-2 #11_MM+GW	0.53	1.85	1.54	9.564	0.0278	0.1874	286.045	0.59	0.701
H005-6FB-2 #1 ABC_MM+GW	1.01	3.52	2.93	9.678	0.0291	0.1827	281.279	1.12	0.765
H005-6FB-2, #3 ABC	0.83	2.88	2.40	9.639	0.0277	0.1869	280.398	0.92	0.462

Sample	$^{4}He/^{36}Ar$	$^{84}Kr/^{36}Ar$	$^{132}Xe/^{84}Kr$	$^{4}He/^{21}Ne^*$	$^{4}He/^{40}Ar^*$	$CO_2/^{3}He$	$CH_4/^{3}He$	$CH_4/^{4}He$	$^{4}He/CH_4$
H005-6FB-2 #2_MM+GW	0.42	0.0305	0.107	-0.01	-0.05	6.95E+09	1.76E+11	2.22E+05	4.51E+00
H005-6FB-2 #2 ABC_MM+GW	0.56	0.0385	0.110	0.01	-0.05	1.03E+09	1.82E+12	1.39E+06	7.19E-01
H005-6FB-2 #10_MM+GW	0.09	0.0401	0.067	-0.01	-0.01	3.29E+09	1.44E+12	1.64E+06	6.11E-01
H005-6FB-2 #8_MM+GW	0.21	0.0346	0.081	0.10	0.08	1.69E+10	6.54E+12	5.70E+06	1.76E-01
H005-6FB-2 #6_MM+GW	1.57	0.0490	0.087	0.06	-0.94	7.16E+10	1.92E+12	5.83E+05	1.71E+00
H005-6FB-2 #3_MM+GW	1.36	0.0462	0.070	-0.20	4.37	1.25E+10	1.64E+12	2.79E+05	3.58E+00
H005-6FB-2 #7_MM+GW	0.30	0.0340	0.054	1.16	-0.04	3.62E+09	6.10E+12	6.45E+06	1.55E-01
H005-6FB-2 #9_MM+GW	0.58	0.0484	0.071	-0.07	-0.08	2.09E+10	6.64E+12	3.72E+06	2.69E-01
H005-6FB-2 #1_MM+GW	0.32	0.0436	0.077	0.12	-0.07	1.46E+10	9.17E+12	7.77E+06	1.29E-01
H005-6FB-2 #4_MM+GW	0.58	0.0221	0.047	-0.01	-0.10	2.97E+09	2.82E+12	1.80E+06	5.55E-01
H005-6FB-2 #5_MM+GW	0.21	0.0608	0.125	0.04	-0.21	4.08E+10	2.86E+12	4.81E+06	2.08E-01
H005-6FB-2 #11_MM+GW	0.41	0.0322	0.090	-0.01	-0.04	4.95E+08	2.50E+11	3.23E+05	3.10E+00
H005-6FB-2 #1 ABC_MM+GW	0.86	0.0202	0.059	0.05	-0.06	5.61E+08	1.84E+11	1.94E+05	5.15E+00
H005-6FB-2, #3 ABC	0.42	0.0318	0.137	-0.01	-0.03	1.72E+09	2.18E+12	1.71E+06	5.85E-01

Sample	$CH_4/^{36}Ar$	N_2/Ar	CH_4/C_2H_6+	CH_4/CO_2	Liters of Water Equivalent	Terrigenic ^{4}He	Terrigenic ^{4}He per kg	Age years	Clathrate Age (yrs)
H005-6FB-2 #2_MM+GW	9.25E+04	129.64	143181	25.36	0.00413	3.06	7.42E+02	1.48E+03	1.78E+04
H005-6FB-2 #2 ABC_MM+GW	7.85E+05	32.17	7278	1754.38	0.00044	0.70	1.60E+03	3.20E+03	3.84E+04
H005-6FB-2 #10_MM+GW	1.42E+05	19.08	365	438.40	0.00072	0.58	8.02E+02	1.60E+03	1.92E+04
H005-6FB-2 #8_MM+GW	1.18E+06	43.07	8510	386.09	0.00013	0.17	1.28E+03	2.56E+03	3.07E+04
H005-6FB-2 #6_MM+GW	9.18E+05	51.01	1618	26.84	0.00012	1.61	1.38E+04	2.76E+04	3.31E+05
H005-6FB-2 #3_MM+GW	3.79E+05	25.11	16412	130.72	0.00015	3.43	2.34E+04	4.68E+04	5.61E+05
H005-6FB-2 #7_MM+GW	1.95E+06	40.27	11146	1684.92	0.00009	0.15	1.76E+03	3.51E+03	4.21E+04
H005-6FB-2 #9_MM+GW	2.15E+06	65.61	5769	317.85	0.00007	0.26	3.75E+03	7.50E+03	9.00E+04
H005-6FB-2 #1_MM+GW	2.46E+06	81.93	7952	628.42	0.00008	0.13	1.62E+03	3.24E+03	3.89E+04
H005-6FB-2 #4_MM+GW	1.04E+06	85.15	4193	950.46	0.00032	0.53	1.69E+03	3.38E+03	4.06E+04
H005-6FB-2 #5_MM+GW	1.01E+06	51.13	139886	70.14	0.00014	0.20	1.38E+03	2.76E+03	3.32E+04
H005-6FB-2 #11_MM+GW	1.34E+05	69.85	413571	505.01	0.00305	2.66	8.71E+02	1.74E+03	2.09E+04
H005-6FB-2 #1 ABC_MM+GW	1.66E+05	51.41	1822769	328.08	0.00279	4.65	1.67E+03	3.34E+03	4.01E+04
H005-6FB-2, #3 ABC	7.25E+05	47.79	1545492	1270.02	0.00042	0.57	1.36E+03	2.72E+03	3.27E+04

Sample	4He μcc/cc	20Ne ncc/cc	36Ar μcc/cc	84Kr ncc/cc	132Xe ncc/cc
H005-6FB-2 #2_MM+GW	3.06	6209.39	7.35	223.89	24.05
H005-6FB-2 #2 ABC_MM+GW	0.70	654.23	1.24	47.70	5.25
H005-6FB-2 #10_MM+GW	0.58	1044.26	6.68	268.21	18.00
H005-6FB-2 #8_MM+GW	0.17	194.78	0.83	28.54	2.30
H005-6FB-2 #6_MM+GW	1.61	324.27	1.02	50.03	4.35
H005-6FB-2 #3_MM+GW	3.43	213.91	2.52	116.66	8.20
H005-6FB-2 #7_MM+GW	0.15	127.95	0.50	17.11	0.93
H005-6FB-2 #9_MM+GW	0.26	102.07	0.45	22.02	1.56
H005-6FB-2 #1_MM+GW	0.13	112.64	0.40	17.34	1.33
H005-6FB-2 #4_MM+GW	0.53	465.26	0.93	20.55	0.96
H005-6FB-2 #5_MM+GW	0.20	209.11	0.94	57.47	7.17
H005-6FB-2 #11_MM+GW	2.66	4497.76	6.41	206.67	18.50
H005-6FB-2 #1 ABC_MM+GW	4.65	4152.13	5.43	109.46	6.51
H005-6FB-2, #3 ABC	0.57	618.08	1.34	42.55	5.83

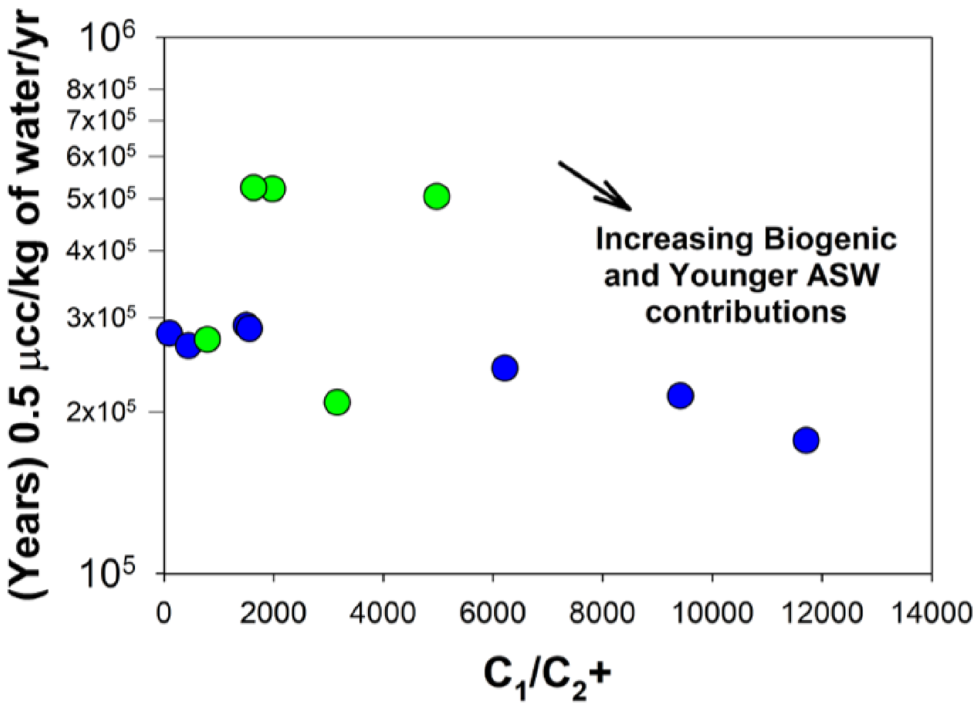


Figure 1-2: Predicted residence time range of 150,000 to 525,000 years methane gas from noble gas measurements versus methane/ethane and larger hydrocarbons (C1/C2+). Green dots represent Hole H002 and blue dots Hole H005. Air-saturated water (ASW) is the expected atmospheric gases in crustal fluids (waters) as determined by Henry's Law equilibrium between the atmosphere and water (assumed to be seawater in this case) (see Hunt, 2000 for methodology).

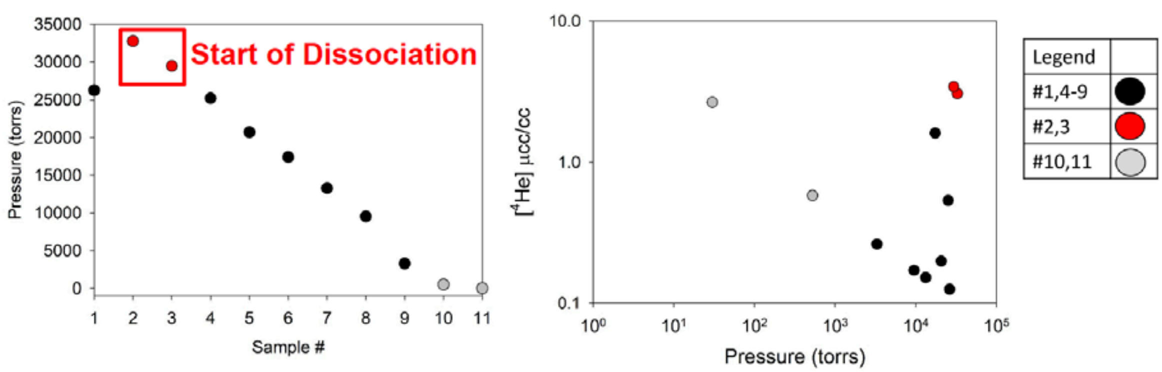


Figure 1-3: Significant enrichment in He and other heavy noble gasses occurs at the beginning of hydrate dissociation.

A2. Steady-state Permeability Tests

- In Year 4, Quarter 3 (*DE-FE0023919_Y4Q3_RPPR*), we reported on steady state permeability and consolidation measurements on sample 6FB-2 (149-157 cm). In this quarter, UT completed post-sample characterization of this sample (Fig. 1-4).
  - o We completed particle size distribution analysis of sediments of 6FB-2 (149-157 cm) at 3 locations using the laser diffraction method (marked in zone 1, zone 2, and zone 3 in Figure 1-4) and one location using the hydrometer (the combined zones 2 and 3 in Figure 1-4a).
  - o We performed a Mercury Injection Capillary Pressure measurement on one sample (Figure 1-4c and 1-4d).
  - o Particle size analysis by laser diffraction method does not show significant size variations with subsampling locations. The hydrometer analysis shows different result – a smaller D_{50} value than that of laser result. This is a reasonable mismatch because that the laser diffraction analysis assumes all the particles are round and therefore does not fully capture the clay particles with thin sheet structures.

- UT completed multiple steady-state permeability tests on 4FB-8-1 (207-215 cm) and started tests on 4FB-8-2 (Fig. 1-4 and 1-5):
  - o Completed consolidation under 5 effective vertical stresses increasing from 0.4 to 3.8 MPa (effective vertical stress) at uniaxial strain condition (Fig 1-7 and 1-9).
  - o Completed 5 permeability tests at each effective vertical stress with pore pressure = 24.8 MPa (shown as black solid circle in Fig 1-8).
  - o Completed 1 permeability test at 3.8 MPa (effective vertical stress) with pore pressure = 6.0 MPa (shown as the red solid circle in Fig 1-8).
  - o Completed 3 permeability test at 3.8 MPa (effective vertical stress) after sample is dissociated with pore pressure = 4.5 MPa, 6.0 MPa and 24.8 MPa respectively (shown as the empty symbols in Fig. 1-8).
  - o Applied procedure for quantitative degassing from the K_0 chamber.
  - o Testing and improving the re-saturation method of dissociated sample
  - o Characterized the K_0 permeability sample post-testing using X-ray computed tomography (XCT) scanning.
  - o Effective horizontal stress (i.e., effective confining stress) is measured during the consolidation under increasing effective stresses. With effective vertical stress and effective horizontal stress, we use MIT t-s' plot to show the measured lateral stress ratio under uniaxial strain in Fig 1-7. The K0 coefficient is constrained between 0.5 and 0.6. Based on the measured void ratio – effective vertical stress relation in Fig 1-9, the calculated compression index C_c is 0.07, which is slightly smaller than that of sample 6FB-2 (C_c = 0.09).
  - o Effective permeability of 4FB-8-1 decreases from ~10 mD to ~ 1mD with increasing effective vertical stress from 0.4 MPa to 3.8 MPa. The hydrate sample was dissociated with constant effective vertical and horizontal stress applied. After hydrate dissociation and sample re-saturation, the measured absolute permeability drops to 0.1 mD (empty symbols in Fig 1-8). The absolute permeability results of hydrate-dissociated sample at 4MPa, 6 MPa and 24.8 MPa do

not change. This suggests that the sample has been re-saturated to an extent that the amount of residual gas in the sample does not change the absolute permeability results. The permeability drop after hydrate dissociation is believed to be a result of fines migration; fines migrate towards downstream direction during hydrate dissociation and accumulate on the filter paper, forming a thin layer of mudcake, reducing the permeability.

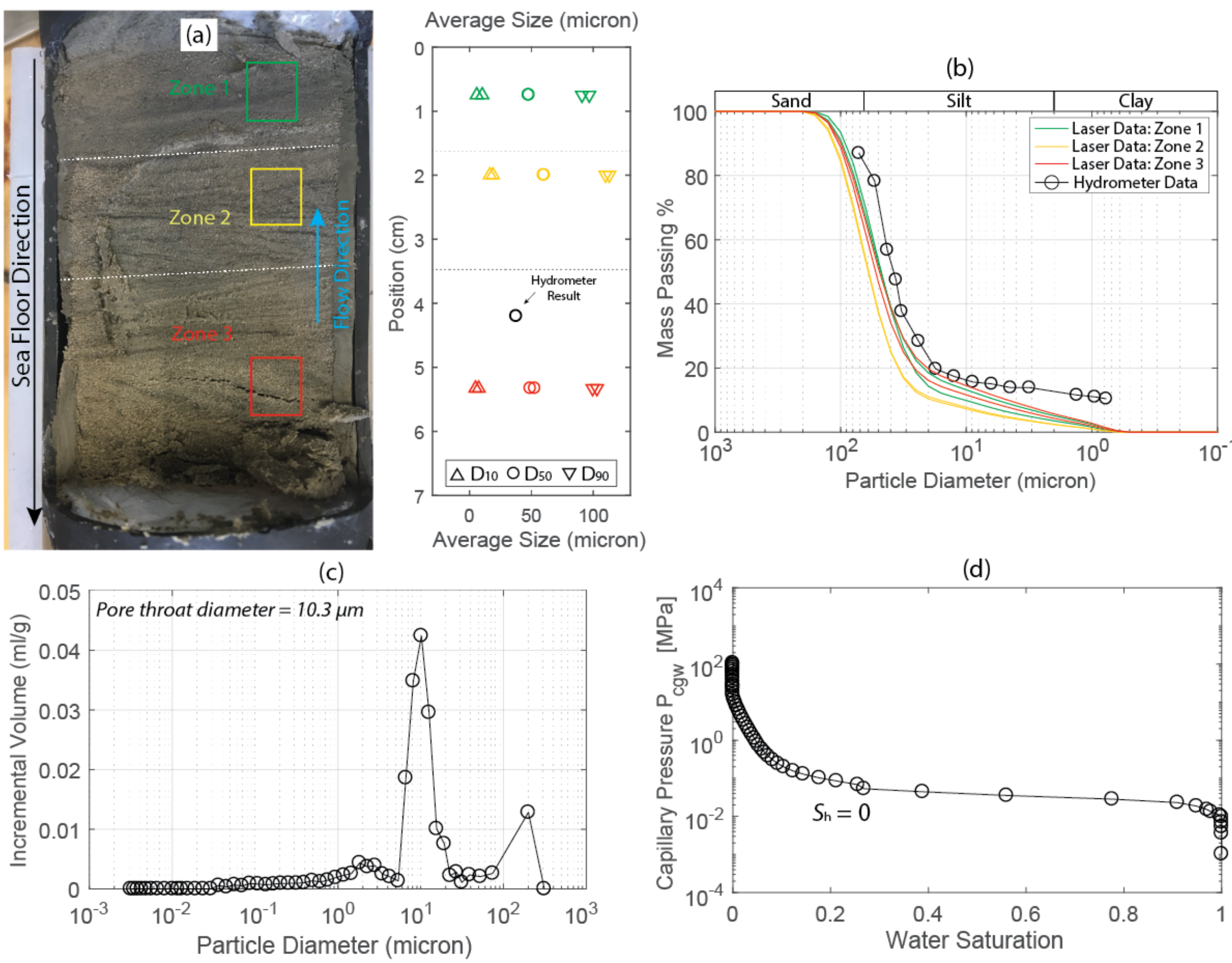


Figure 1-4: (a) cutting face of dissociated 6FB-2 pressure core after removing from test section. The cutting face was divided in three zones. Each zone was sub-sampled at the square label for particle size distribution analysis. The average particle sizes of 10% (D_{10}), 50% (D_{50}) and 90% (D_{90}) of the cumulative mass are illustrated for each location. (b) Particle size distribution measured by hydrometer analysis. (c) Pore throat diameter measured by MICM. (d) Capillary pressure curve of 6FB-2.

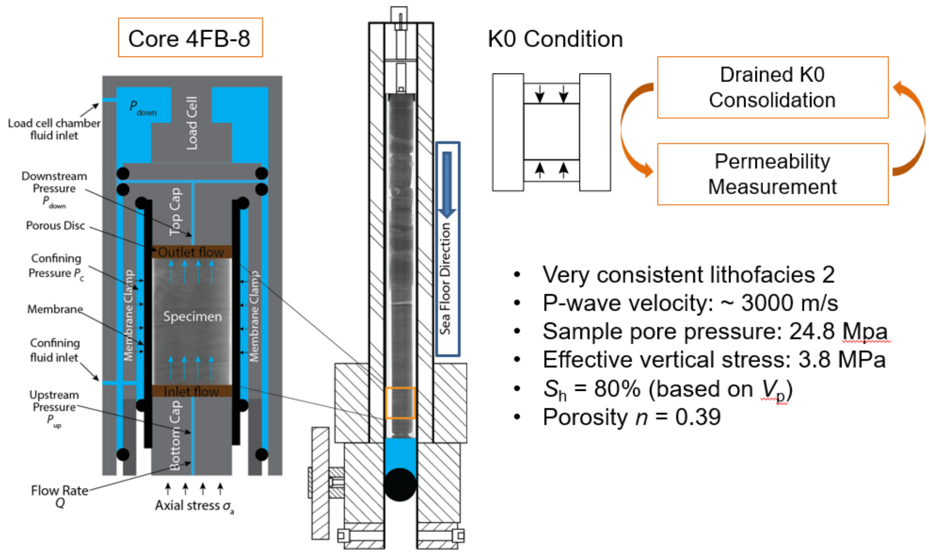


Figure 1-5: Expanded view of permeability measurement apparatus and summary of measurement program and pressure stress conditions.

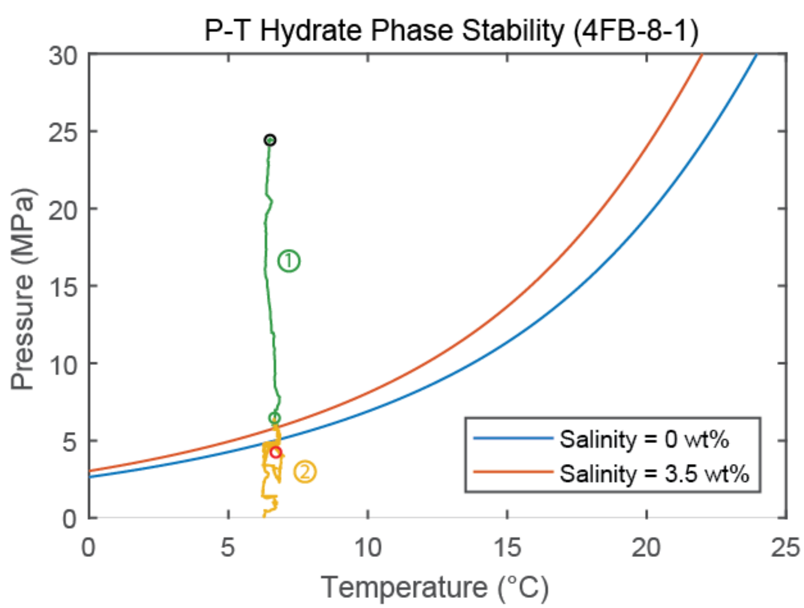


Figure 1-6: Initial experimental program in pressure-temperature space. We measured permeability within the hydrate stability zone at 24.8 MPa(black circle) and 6 MPa (green circle) and then dissociated the sample and measured permeability at 4.5 MPa (red circle),6MPa (green circle) and 24.8 MPa (black circle).The corresponding permeability results are presented in Fig 1-8.

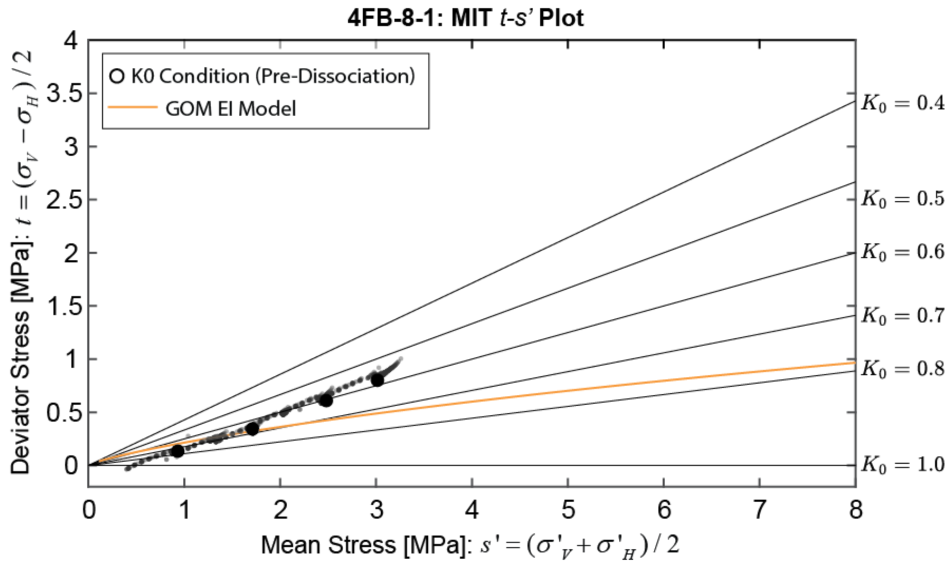


Figure 1-7: Stress path of experiments performed on Core 4FB8-1. At each sample point, permeability was measured. Initially the experiments were run within the hydrate stability zone under increasing effective vertical stresses (black dots). The K_0 coefficient (the ratio of lateral to vertical effective stress ($K_0 = \frac{\sigma_h'}{\sigma_v'}$) is between 0.5 and 0.6.

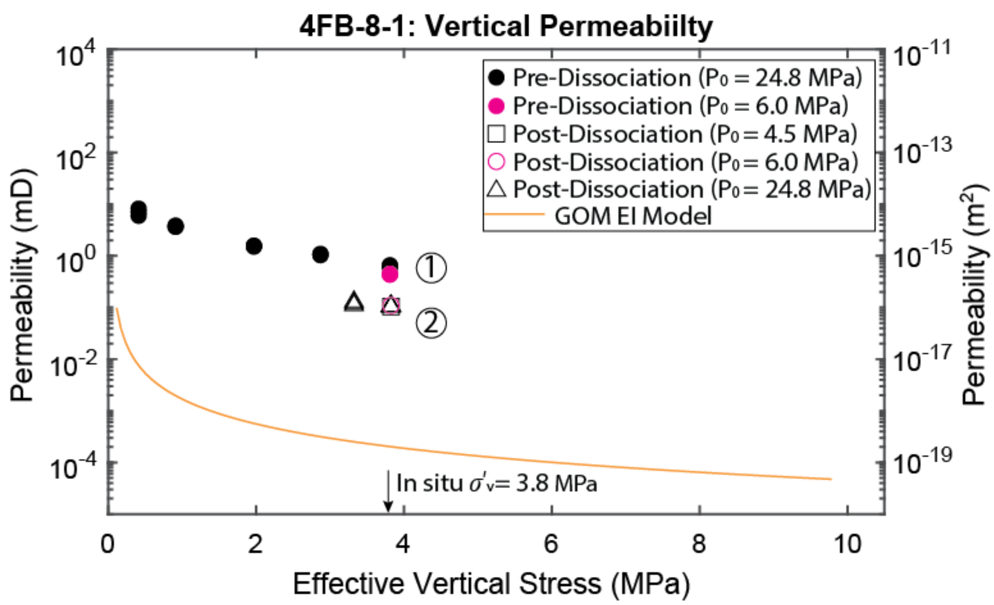


Figure 1-8: Steady state liquid permeability measurements on Core 4FB-8-1. The effective permeability measured in the presence of hydrate lies between ~1 mD to ~10 mD (~10^{-15} m^2 to ~10^{-14} m^2). After dissociation and after flowing multiple pore volumes of water through the sample, the absolute permeability drops to ~0.1 mD, possibly due to fines migration. We emphasize that this is a preliminary measurement. We will quantify the particle size distribution of the sample.

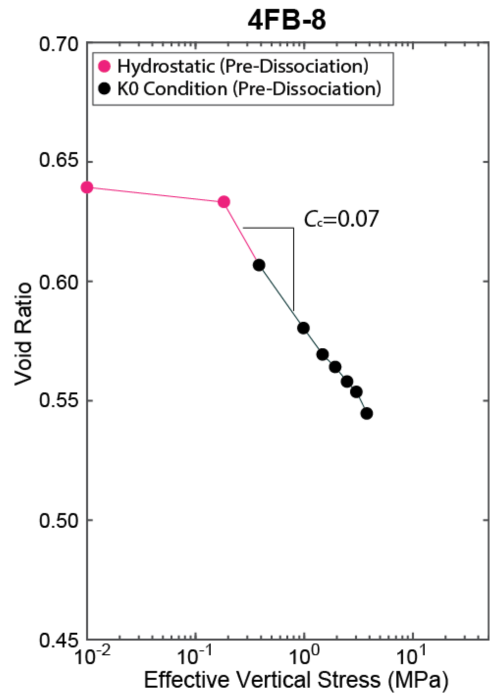


Figure 1-9: Measured compression behavior of 4FB8-1 before hydrate dissociation. Compression index is 0.07.

A3. Pressure Core Distribution

- From September 10 to 19, 2018, four 30 cm core segments were transferred at ~24 MPa from UT to NETL (Figure 1-10). Segments were removed from 3 pressure cores:
  - 1 segment from Core 3FB-4
  - 1 segment from Core 5FB-3
  - 2 segments from Core 8FB-2
- Six actions were identified to improve the process for the next transfer:
  1. All Geotek flanges should have the four holes around the perimeter plugged with Swagelok or Parker ½" NPT plugs.
  2. Any cylinders with pressure accumulators should come with the appropriate charging kit setup for the correct charging gas.
  3. No tape should be used to cover holes or flange openings.
  4. O-ring seals for Geotek flanges need to be supplied with each shipment.
  5. Shipping pallets need to be robust and in good condition.
  6. All shipments should be made on a truck with a lift gate so that a forklift is not required.
- Continued dialogue with USGS regarding transfer chamber design, and executed a Material Transfer Agreement.

- o Continued working on the research agreement and material transfer agreement between UT and the National Institute of Advanced Industrial Science and Technology (AIST) (Japan) for the transfer of two 35 cm pressure core sections from UT-GOM^2-1-3FB-5 and 5FB-3.

Figure 1-10: Images from the Pressure Core transfer from UT to NETL. Top, NETL storage and transfer chamber attached to UT Mini-PCATS. Lower left, chamber tagged w/ core info, certified by PCC lab manager and staff scientist. Lower center and lower right, NETL storage chambers ready for transfer to reefer van.

B. Depressurized Pressure Core Analysis

- OSU continued to review the XCT data collected by PCATS, and is testing if it is feasible to try to determine hydrate saturation using a combination of the PCATS data and grain density. OSU received new XCT datasets from UT. Results will be linked to saturation estimates from depressurized core.

- The University of Washington (UW) continued working on pore water chemistry analysis completed the measurement of CS tracers. Onboard GOM^2-1, the shipboard scientific party prepared a cesium tracer solution for the PCATS system at a concentration of 75.23 μM. The three pore water samples that underwent quantitative degassing within the PCATs have Cs concentrations ranging from 0 to 0.014 μM. The detection limit of the Cs concentration analyses at UW is 0.002 μM. Assuming the Cs tracer concentration was made correctly shipboard during the GOM^2-1 expedition, pore water samples exhibited very low contamination ranging from <0.003-0.02% contamination.

- The University of New Hampshire (UNH) continued working on bulk CHNS elemental and isotopic analysis, and laser-particle grain size analysis (Figure 1-11).
  40 samples (of 40 planned) for CHNS analyses and C, N, and S isotopes from holes H002 and H005 were prepared by grinding into a fine powder using a mortar and pestle and acidification (sulfurous acid) to remove inorganic carbon ($CaCO_3$) (Figure 1-12). Sulfurous acid treated samples are currently in the queue for TOC measurement at UNH. Non-acid treated samples are currently being weighed and will be sent to the University of California Berkeley for TS, TN, and TC measurements and S and N stable isotopes.

Figure 1-11: CHNS Elemental Analyzer at UNH

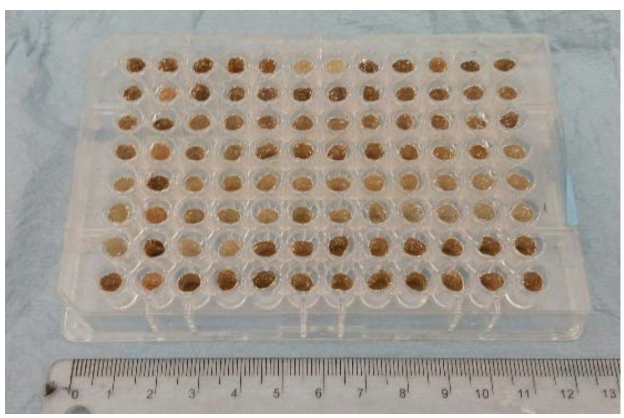


Figure 1-12: Bulk sediment samples, replicates, and standards weighed into in silver capsules in preparation for sulfurous acid additions.

- Grain size using a laser particle size analyzer
  40 samples (of 40 planned) for sediment grain size from holes H002 and H005 using the laser particle size analyzer at UNH (Figure 1-13) were prepared using multiple hydrogen peroxide treatments to remove organic carbon (Figure 1-14). Over the course of several weeks, visible reaction of the samples continued to persist after repeated additions of hydrogen peroxide, suggesting an unrealistic amount of organic carbon was still present in the samples. We discontinued the additions and suspect the

continued apparent reaction of the hydrogen peroxide occurred due to the catalyzing effect calcium carbonate has on the dissolution of hydrogen peroxide. Once we have measured the TOC content in each of these samples, we will revisit the hydrogen peroxide treated sample set to confirm additional additions of peroxide are not needed. Once we are convinced the organic carbon is removed, we will measure the grain size of the organic carbonate-free sediments. We are now running splits of the original samples for bulk sediment grain size (without peroxide treatment), which will be compared directly to existing, non-peroxide treated samples measured post-cruise by GOM^2 collaborators at UT-Austin.

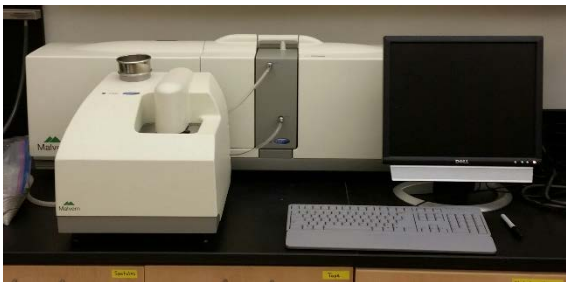


Figure 1-13: Malvern Mastersizer 2000 Laser Particle Size Analyzer in lab at UNH

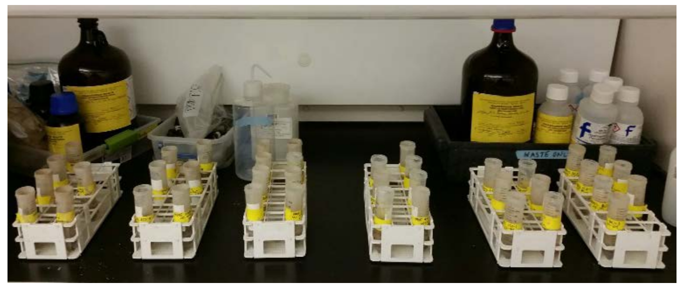


Figure 1-14: Sediment samples receiving hydrogen peroxide treatments in the chemical hood to remover organic carbon prior to measurement

- Oregon State University (Oregon State) consulted UT on microbiology analysis of depressurized core. During this quarter most of the work focused on completing a manuscript that describes the contaminant taxa that occur in low biomass core samples and also determining whether CT-scanning of geological cores alters the microbial community profiles in the cores. These issues are both important to optimize success of the microbiological component of the upcoming coring. Assuring that the communities examined in core samples are authentic, and not the result of contamination occurring due to sample handing, is key to our growing knowledge of life in hydrate-bearing sediments. Understanding the effect of CT scanning is important because geological cores, including those that have been collected for the GOM^2-1 and those that are planned to be collected for GOM^2-2, are routinely CT-scanned before samples are acquired. Microbiologists usually collect their samples after scanning and it is presently unknown whether the X-rays used in the scan alter the microbial communities in the cores.

  Additional discussions were held between Oregon State, ExxonMobil, and UT related to progress on the ExxonMobil biogeochemical analyses. Limited biomass has been extracted from the GOM^2-1 samples using a number of protocols. They have determined taxa that they believe to be contaminants and have started to remove these from the analysis. Oregon State will assist with the analysis of microbial communities, which appear to be mainly composed of highly alkaliphilic bacterial members.
  During this quarter we also started discussions with Bill Waite, Junbong Jang (both of USGS), and Sheng Dai (Georgia Tech) on the plans for using the BIO chamber to analyze pressure core from GOM^2-1.

Oregon State began the process of determining whether microbial communities are altered by the x-ray CT scanning that is routinely conducted during geological coring. A CT-scanned image of one of the cores is shown in Figure 1-15. A direct comparison of microbial communities present in non-CT-scanned (control) cores vs. CT scanned cores was made starting with the time of core collection every seven days for 21 days. Fifty-four subsamples were examined for microbial community characterization. While this is still preliminary data and we have a few additional sequencing runs to complete, it appears that CT scanning in a range typically used for examining geological cores does not have an effect on the DNA extraction and sequencing process.

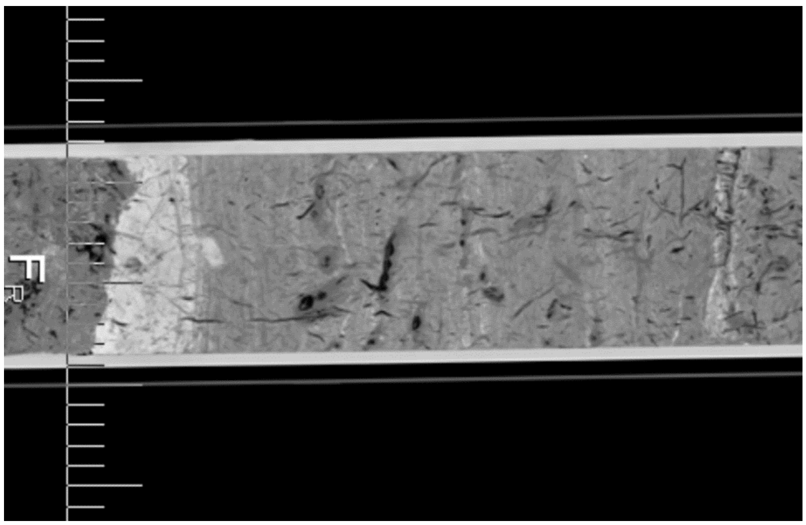


Figure 1-15: X-ray CT scan of geological core used for determining the effect of X-ray CT scanning on microbial communities. Organic-rich sediments are evident above and below bright sandy layer. (Photo obtained from Netarts Bay marsh).

Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis

- OSU is re-examining this data to see if it could be improved.

Subtask 10.6: Additional Core Analysis Capabilities

- Continued working with Geotek on delivery of the X-ray, P-wave attachment for Mini-PCATS from Geotek.
    - The UT Pressure Core Center with its Mini-PCATS facility has no way to image the cores within the pressure vessels, which is causing some issues for properly cutting distinct lithofacies from each other in Mini-PCATS. We have been relying on the images taken of the pressure cores when they were originally analyzed at sea or dockside. Unfortunately, the cores, especially compromised cores, have shifted somewhat and thus; we cannot locate exactly where we are in the section. To rectify that we have purchases an X-ray, p-wave attachment to image the cores inside mini-PCATS so that when we subsample our cores, we know exactly the sample we are taking.
- Continued conversation with Geotek concerning possible Pre-consolidation Chamber and or Plug micro-CT sampler (previously called a sidewall corer) purchase.

TASK 13.0 – MAINTENANCE AND REFINEMENT OF PRESSURE CORE TRANSPORT, STORAGE, & MANIPULATION

Status: Ongoing

Continued to store, stabilize, and perform tests on pressure core acquired from GOM^2-1 marine field test (May-June 2017). Performed weekly pressure checks on pressure chambers.

Subtask 13.1: Hydrate Core Manipulator and Cutter Tool

- Completed system maintenance of cutter, rotator, and viewing chamber.
- Received four NETL pressure chambers and cut four 30 cm pressure core samples from 3 cores (see *Subtask 10.4, A3 – Pressure Core Distribution* for further details).
- Cut one sample for K_0 from core 4FB-8.

Subtask 13.2: Hydrate Core Effective Stress Chamber

- Completed full K_0 system maintenance in August and September, 2018.
- One pressure core sample from core 4FB-8 was tested and degassed in the effective stress chamber.

Subtask 13.3: Hydrate Core Depressurization Chamber

- Ran two degassing tests during Q4.
    - H005-6FB-2, 0-21.5 cm was degassed in August, 2018.
    - K_0 sample from 4FB-8 was degassed in September, 2018.

Subtask 13.4: Hydrate Core Transport Capability for Field Program

- Future Task (GOM^2-2).

Subtask 13.5: Maintenance and Expansion of Pressure Core Storage Capability

- Continued to assess current capabilities and requirements for storing pressure cores that will be acquired in during GOM^2-2.

Subtask 13.6: Transportation of Hydrate Core (Field Program)

- Future Task (GOM^2-2).

Subtask 13.7: Storage of Hydrate Cores (Field Program)

- Future Task (GOM^2-2).

Subtask 13.8: Hydrate Core Distribution

- Future Task (GOM^2-2).

TASK 14.0 – PERFORMANCE ASSESSMENT, MODIFICATIONS, AND TESTING OF DOE PRESSURE CORING SYSTEM

Status: Ongoing

- UT coordinated with Geotek and Pettigrew Engineering to finalize the PCTB Testing Program Scope of Work and schedule.
- UT executed a Service Agreement with Geotek for PCTB Performance Assessment, Modifications and Testing (Task 14).
- UT coordinate with Pettigrew Engineering to develop a computational fluid dynamics (CFD) modeling scope of work.
- UT initiated a Service Agreement with Reaction Engineering International (Reaction) for CFD modeling of the PCTB.
- UT initiated monthly PCTB Development Team Meetings.

Subtask 14.1: PCTB Lab Testing and Analysis

- Geotek began developing a 3-dimensional model of the PCTB for CFD modeling.

Subtask 14.2 Pressure Coring System Modifications/Upgrades

- Future Task.

Subtask 14.3: PCTB Land-Based Testing and Analysis

- UT began preplanning activities for PCTB Land Test:
    - Contacted Schlumberger Cameron, Texas Testing Facility (CTTF) to discuss scope and estimated schedule
    - Contacted Texas A&M University to discuss use of drill pipe

TASK 15.0 – FIELD PROGRAM / RESEARCH EXPEDITION OPERATIONS

Status: In Progress

Subtask 15.1: Review and Complete NEPA Requirements

- Future Task.

Subtask 15.2: Finalize Detailed Operational Plan for Field Program

- As discussed above, a GOM^2 Workshop was held on September 24 and 25th. The second day focused on reviewing the existing GOM^2-2 plan, and identifying issues, gaps, and actions items to optimize the plan moving forward (Table 1-10). As shown in Table 1-11, five major tasks (identified as Tasks 3-7 in the workshop summary, **Appendix A**) and several administrative and logistical actions (Task 2) were identified. New working teams were identified to address all of action identified (Table 1-12). The teams have been asked to make recommendations back to the advisory group by December 1, 2018 in order to deliver a modification package to DOE with the most likely operational and scientific plan for GOM^2-2.

Table 1-10: GOM^2 Workshop Agenda Day 2

TIME (ET)	TOPIC	PRESENTER/LEAD
8:00 – 8:40	Science Goals/Hypothesis, Motivation for work	Flemings
8:40 – 9:10	GOM^2-2 Locations	Cook: Orca Flemings: Terrebonne
9:10 – 9:20	Logging While Drilling	Cook
9:20 – 9:40	In-Situ Testing	Flemings
10:00 – 10:30	Drilling/Coring Plan	Phillips
10:30 – 10:50	Operational Schedule	Pettigrew
10:50 – 11:20	Pressure Core Handling Plan	Thomas
11:20 – 12:00	Conventional Core Handling Plan	Phillips
12:30 – 1:00	Wrap up	Flemings, Thomas

Table 1-11: Identified Action items grouped by Task as identified during the GOM² Workshop Day 2. More details of the actions can be found in the workshop summary, Appendix A.

Task 2	'Nuts and Bolts' activities a. Summarize accurately and concisely Plan B-3. b. Terrebonne: Prepare one or several lithostratigraphic cross sections from 01 to 03 to 02. c. Determine science cost if there is a cut of two million dollars in budget from ESO cash contribution. d. Review original DOE proposal to review how strongly 'exploration' is emphasized (confirm commitment to exploration). e. Terrebonne: Prepare Log sections across key sand intervals for use in wireline testing and pressure coring planning f. Review and revise the compatibility of coring systems with other activities. g. Get Cost estimate for Cat-Scanning conventional core through Weatherford. h. Determine if ESO has officially stated that they will not contract vessel themselves. i. Determine if ESO cash can bypass UT and go directly to vessel. j. Develop timeline and budget for revised plan(s)
Task 3	Possible Macro-Scale Expedition Changes a. Expedition Timing will shift to calendar 2021 b. Consider changing when LWD is performed c. Revisit importance of updip (Tbone-02) well at Terrebonne d. Consider possibility of splitting LWD from coring effort.
Task 4	Revise Pressure Coring Program a. Review and revise the pressure coring program for the sands at Terrebonne. These sands are fundamentally different than those encountered at GC-955. b. Action Item: Pull up the logs on these sands and come up with a proposed coring program that captures the sands and the bounding seals above and below. c. Intermittent pressure cores are planned through the entire section. It is common for first pressure core to be partially filled with detritus from the bottom of the borehole. i. Action Item: Revise intermittent pressure coring to include at least two consecutive pressure cores to ensure recovery. Establish appropriate program that meets micro-biology needs. d. Establish relative importance of pressure core sampling for microbial factory, fractured interval, and intermediate sands. Link to DOE goals. e. Considerable momentum around pressure coring blue sand at 01B as updip analog to 03 (in original research proposal).
Task 5	Integrate 03B and 01B coring program at Terrebonne a. If our goal is to achieve complete sampling from top to bottom. Then, perhaps we can integrate measurements made in each hole to reach this goal. b. Considerable momentum around only pressure coring below Orange Sand (intermittently) in 01-B well. c. Considerable momentum to get pore water samples 50 m below BHSZ.
Task 6	Terrebonne: Revisit Plan to perform in-situ tests in Orange Sand in 01B well (H) a. Determine if it is physically reasonable to perform drawdown test on this horizon. Take into account that it is well above the base of the hydrate stability zone and thus may need more drawdown, which may exceed tool capability. b. Specify pipe depth for logging program. c. Get specifics of max diameter of wireline string and MDT to Pettigrew d. Can we deploy MDT as planned at the 1 well (H well) in the Orange Sand or are we too far from the stability zone.
Task 7	Refine and Revise Shipboard Core Analysis Program a. Water samples squeezed on board. Onboard analysis of alkalinity, pH, salinity, and H_2S. All other samples will be analyzed onshore with preserved samples b. Refine gas program c. Refine adjacent triplicate whole-round sampling (one cut for: phys pros/void space, pore water, microbio) d. Continuously sample mud program for characterizing microbial/chemical contamination. e. Use shipboard scanning to take whole core. Control # of samples. f. Take vane shear? g. Determine IR plan. If so, consider Geotek IR scanning equipment which is more mature.

Table 1-12: Matrix of Tasks and Teams identified at the GOM² Workshop

			UT	OPS Team	In-situ Wireline Test Team	Core Analysis Team	Due Date
	2	Nuts and bolts activities	X				11/1/18
	3	Macro-scale Expedition Changes		X			12/1/18
	4	Revise Pressure Coring Program		X			12/1/18
	5	Integrate 03B and 01B coring program at Terrebonne.		X			12/1/18
	6	Revisit plan to perform in-situ tests in Orange Sand in 01-B well (H).			X		12/1/18
	7	Refine and Revise Shipboard Core Analysis Program				X	12/1/18

Subtask 15.3: Permitting for Field Program

- Continued to refine G&G section of BOEM Exploration Plan for GOM²-2.
- In an effort to complete permitting documents, permitting meetings were moved to a once per week basis this quarter.
- OSU and UT continue to work on the Geological and Geophysical (G&G) sections of the BOEM Exploration Plan for Orca Basin and Terrebonne Basin.

Subtask 15.4: Assemble and Contract Pressure Coring Team Leads for Field Program

- UT finalized service agreement with Geotek for GOM²-2 PCTB deployment, shipboard pressure core analysis using PCATS, handling and transportation of pressure cores, and contingency services including conventional coring.

Subtask 15.5: Contract Project Scientists and Establish Project Science Team for Field Program

- Future Task.

1.3 WHAT DO YOU PLAN TO DO DURING THE NEXT REPORTING PERIOD TO ACCOMPLISH THE GOALS?

TASK 1.0: PROJECT MANAGEMENT AND PLANNING (CONT'D FROM PRIOR PHASE)

UT will continue to execute the project in accordance with the approved PMP, manage and control project activities in accordance with their established processes and procedures to ensure subtasks and tasks are completed within schedule and budget constraints defined by the PMP.

Key project management and planning goals for the next quarter include:

- Coordinate initiation of Task 14.1: PCTB Lab Testing and Analysis.
- Continue to coordinate assessment of a suitable vessel for GOM^2-2 by reviewing results of RFQ and preparing an RFP for potential vendors.
- Complete draft science and operational plan for GOM^2-2 based on final recommendations of the In-Situ/Wireline Team, Core Analysis Team, Operations Team, and Nuts & Bolts Team.
- Develop recommendations for clear path forward with GOM^2-2 based upon outcome of ECORD Council meeting in November.
- Develop optimized Science and Operational Plan and schedule for GOM^2-2.

TASK 6.0: TECHNICAL AND OPERATIONAL SUPPORT OF COMPLIMENTARY PROJECT PROPOSAL (CONT'D FROM PRIOR PHASE)

- UT will continue to coordinate with, and support IODP and ECORD, to the extent possible, to maximize the potential to mount GOM^2-2 as a Mission Specific Platform (MSP) Expedition through the European Consortium for Ocean Research Drilling (ECORD). If we can implement this program as an MSP in conjunction with ECORD, we will increase the amount of science done on the expedition through both direct and indirect financial support.
- We received an update from the ECORD Facility Board (EFB) on September 10, 2018, that the EFB has recommended that the European Science Operator (ESO) support an MSP Expedition based on GOM^2-2 Plan B3 for implementation in 2021.
- The ECORD Council and ECORD Science Support and Advisory Committee (ESSAC) will meet in November to plan operations and allocated budgets. We expect to receive a consensus statement from ECORD confirm their decision and funding commitment soon after this meeting.

TASK 10.0: PRESSURE CORE ANALYSIS (CONT'D FROM PRIOR PHASE)

Subtask 10.4: Continued Pressure Core Analysis

Pressure Core Analysis

A. Quantitative Degassing and Gas Analysis

- Quantitative depressurization of pressure core and gas analysis will continue

- We are beginning to analyze uncompromised, high quality core. Samples have been selected to fill in the gaps and increase resolution of estimated variation in hydrate saturation downhole.
- We will analyze samples with distinct lithologies: lithofacies 2 (sandy silt, high hydrate saturation) and 3 (clayey silt, low hydrate saturation)
- We will continue to collect additional gas samples and continue to improve gas sampling methods to minimize atmospheric contamination.

B. Steady-state Permeability Tests

- UT will continue the post-testing sample characterization of 4FB-8-1.
    - Residual sample of 4FB-8-1 will be subsampled for particle distribution analysis using laser diffraction method.
    - The rest sample of 4FB-8-1 will be packed and homogeneously mixed for steady-state permeability measurement.
- UT will continue steady-state permeability measurement of a new pressure core sample 4FB-8-2.

C. Pressure Core and Data Distribution

- UT will continue coordinating with other institutions on plans for transferring pressure core per the final distribution plan.

<u>Depressurized Core Analysis</u>

- Ohio State University will talk with the geochemistry lab about getting some organic matter concentrations and carbon isotopes of the organic matter from core subsamples from GC955.
- Ohio State University will work on the documentation/data report for Task 6.0
- Ohio State University will continue to review the XCT data collected by PCATS, and is testing if it is feasible to try to determine hydrate saturation using a combination of the PCSTS data and grain density.
- University of New Hampshire will continue working on the TOC and grain size experiments
- University of Washington will continue working on pore water analysis. UW will continue with the colorimetric analysis of pore water ammonium and silica concentrations, and report on the results.
- Oregon State University

  Discussions with will continue as we aim to 1) assess the microbial communities collected during the Gulf of Mexico coring, and 2) determine how best to prepare for the upcoming Gulf of Mexico coring in 2020 from a microbiological perspective. We will begin analysis of data and planning the manuscript to be submitted that describes these communities.

  In collaboration with ExxonMobil will begin analysis of microbiology sequence data and interpretation of results. Our plan is to analyze Exxon's metagenome data and assess functional attributes of microbes in samples acquired in May 2017. As the plan for coring in 2020 develops, we will enlist new microbiology investigators to participate in analysis of expedition samples.

Oregon State will continue experiments to determine the effect of X-ray computed tomography (CT) scans on microbial communities in core samples. Though microbes are known to be sensitive to x-rays few such investigations have been conducted and this work will help us to understand the implications of x-ray exposure on the microbial communities that we expect in Gulf of Mexico sediments

Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis

- OSU will continue work to see if there is significant lateral heterogeneity between holes especially to see if a tie can be done using compressional velocity measurements.

Subtask 10.6: Additional Core Analysis Capabilities

- UT will continue to coordinate with Geotek on the delivery of the X-ray computed tomography (CT) and P-wave velocity upgrade to Mini-PCATS.
- UT will continue to develop specs for Plug sampler.
- UT will continue conversation with Geotek concerning possible Pre-consolidation Chamber purchase to estimate its possible value to UT.

Other - AAGP Special Publication

- In support of the AAGP Special Publication Vol I and II, Cook and Flemings will continue to participate as Special Volume Editors.

TASK 13.0: MAINTENANCE AND REFINEMENT OF PRESSURE CORE TRANSPORT, STORAGE, & MANIPULATION

- Mini PCATS, the PMRS, and all storage chambers will undergo continued observation and maintenance at regularly scheduled intervals and on an as-needed basis.

TASK 14.0: PERFORMANCE ASSESSMENT, MODIFICATIONS, AND TESTING OF DOE PRESSURE CORING SYSTEM

- UT will coordinate with Geotek to complete 3-D drawings of the PCTB.
- UT will coordinate with Geotek to finalize and initiate the PCTB In-House Testing Program.
- UT will arrange for transport of required PCTB components that are currently stored at UT to Geotek Coring Inc. in Salt Lake City, Utah. Geotek will initiate Pressure Function Testing and Pressure Actuation Testing of the PCTB per the PCTB Testing Program.
- UT will coordinate with Reaction Engineering to initiate computational fluid dynamics (CFD) modeling of the PCTB.

TASK 15.0: FIELD PROGRAM PREPARATIONS

- As discussed above, a GOM^2 Workshop was held on September 24 and 25th. The second day focused on reviewing the existing GOM^2-2 plan, and identifying issues, gaps, and actions items to optimize the plan moving forward. Five major tasks and several administrative and logistical actions were identified (Table 1-11), and new working teams were identified (Table 1-12) to address these actions.
- In the next quarter, the teams will meet to work on assigned action items and prepare recommendations by December 1, 2018 in order to deliver a timely modification package to DOE with the most likely operational and scientific plan for GOM^2-2 (Figure 1-16).

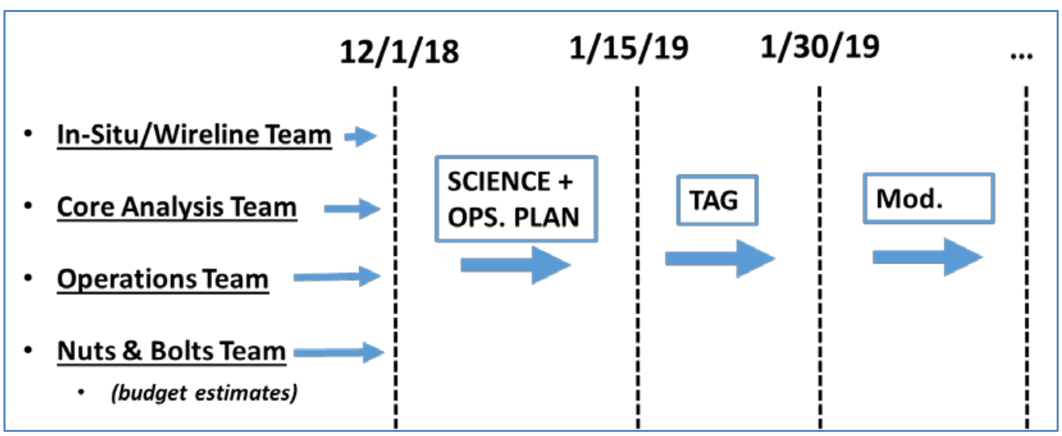


Figure 1-16: Envisioned timeline for team recommendations, plan write up and review and modification to the project)

- UT will continue to work with OSU, BOEM, DOE, and USGS to finalize drilling plans and locations
- UT will continue to provide support to ECORD in scoping GOM^2-2 as an ECORD MSP as required.
- UT will clarify path forward for executing GOM^2-2 as an ECORD MSP if such is deemed plausible by ECORD, UT, and DOE.
- OSU will continue working with IODP as needed for shallow hazard assessments in support of efforts to mount GOM^2-2 and an ECORD MSP.
- In recognition that GOM^2-2 may be pursued independently by the University of Texas (not with IODP), UT will complete a budget analysis to project how we would pursue GOM^2-2 through available commercial vessels. We will prioritize our science program and develop a series of options that included re-scoping the project to lower the total cost to the program.
- UT will evaluate RFQ submissions from vessel operators and begin to prepare request for proposals (RFP) to send to pre-qualified vessel operators.
- UT will continue to refine G&G section of Bureau of Ocean Energy Management (BOEM) Exploration Plan.

2 PRODUCTS

2.1 PUBLICATIONS, CONFERENCE PAPERS, AND PRESENTATIONS

Cook. A. E., and Waite, W. F., (2018). Archie's saturation exponent for natural gas hydrate in coarse-grained reservoirs. Journal of Geophysical Research. DOI: 10.1002/2017JB015138

Cook, A. E., & Sawyer, D. (2015). Methane migration in the Terrebonne Basin gas hydrate system, Gulf of Mexico. Presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Cook, A.E., & Sawyer, D. (2015). The mud-sand crossover on marine seismic data. Geophysics, v. 80, no. 6, A109-A114. 10.1190/geo2015-0291.1.

Cook, A.E., and Waite, B. (2016). Archie's saturation exponent for natural gas hydrate in coarse-grained reservoir. Presented at Gordon Research Conference, Galveston, TX.

Cook, A.E., Hillman, J., & Sawyer, D. (2015). Gas migration in the Terrebonne Basin gas hydrate system. Abstract OS23D-05 presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Cook, A.E., Hillman, J., Sawyer, D., Treiber, K., Yang, C., Frye, M., Shedd, W., Palmes, S. (2016). Prospecting for Natural Gas Hydrate in the Orca & Choctaw Basins in the Northern Gulf of Mexico. Poster presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Fang, Y., Flemings, P.B., Daigle, H., O'Connell, J., Polito, P., (2018). Measure permeability of natural hydrate-bearing sediments using K_0 permeameter. Presented at Gordon Research Conference on Gas Hydrate, Galveston, TX. Feb 24- Mar 02, 2018.

Flemings, P., Phillips, S., and the UT-GOM2-1 Expedition Scientists, (2018). Recent results of pressure coring hydrate-bearing sands in the deepwater Gulf of Mexico: Implications for formation and production. Talk presented at the 2018 Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX, February 24-March 2, 2018.

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists (2018). UT-GOM2-1 Hydrate Pressure Coring Expedition Summary. In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, UT-GOM2-1 Hydrate Pressure Coring Expedition Report. University of Texas at Austin Institute for Geophysics, Austin, TX. https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/reports/

Fortin, W. (2016). Properties from Seismic Data. Presented at IODP planning workshop, Southern Methodist University, Dallas, TX.

Fortin, W. (2018). Waveform Inversion and Well Log Examination at GC955 and WR313 in the Gulf of Mexico for Estimation of Methane Hydrate Concentrations. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Fortin, W., Goldberg, D.S., Holbrook, W.S., and Küçük, H.M. (2016). Velocity analysis of gas hydrate systems using prestack waveform inversion. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Fortin, W., Goldberg, D.S., Küçük, H.M. (2016). Methane Hydrate Concentrations at GC955 and WR313 Drilling Sites in the Gulf of Mexico Determined from Seismic Prestack Waveform Inversion. EOS Trans. American Geophysical Union, Fall Meeting, San Francisco, CA.

Fortin, W., Goldberg, D.S., Küçük, H. M. (2017). Prestack Waveform Inversion and Well Log Examination at GC955 and WR313 in the Gulf of Mexico for Estimation of Methane Hydrate Concentrations. EOS Trans. American Geophysical Union, Fall Meeting, New Orleans, LA.

Darnell, K., Flemings, P.B., DiCarlo, D.A. (2016). Nitrogen-assisted Three-phase Equilibrium in Hydrate Systems Composed of Water, Methane, Carbon Dioxide, and Nitrogen. Presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Goldberg, D., Küçük, H.M., Haines, S., Guerin, G. (2016). Reprocessing of high resolution multichannel seismic data in the Gulf of Mexico: implications for BSR character in the Walker Ridge and Green Canyon areas. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Hammon, H., Phillips, S., Flemings, P., and the UT-GOM2-1 Expedition Scientists, (2018). Drilling-induced disturbance within methane hydrate pressure cores in the northern Gulf of Mexico. Poster presented at the 2018 Gordon Research Conference and Seminar on Natural Gas Hydrate Systems, Galveston, TX, February 24-March 2, 2018.

Heber, R., Kinash, N., Cook, A., Sawyer, D., Sheets, J., and Johnson, J.E. (2017). Mineralogy of Gas Hydrate Bearing Sediment in Green Canyon Block 955 Northern Gulf of Mexico. Abstract OS53B-1206 presented at American Geophysical Union, Fall Meeting, New Orleans, LA.

Hillman, J., Cook, A. & Sawyer, D. (2016). Mapping and characterizing bottom-simulating reflectors in 2D and 3D seismic data to investigate connections to lithology and frequency dependence. Presented at Gordon Research Conference, Galveston, TX.

Hillman, J, Cook, A.E., Sawyer, D., Küçük, H.M., and Goldberg, D.S. (2017). The character and amplitude of bottom-simulating reflectors in marine seismic data. Earth & Planetary Science Letters, doi:http://dx.doi.org/10.1016/j.epsl.2016.10.058

Hillman, J.I.T., Cook, A.E., Daigle, H., Nole, M., Malinverno, A., Meazell, K. and Flemings, P.B. (2017). Gas hydrate reservoirs and gas migration mechanisms in the Terrebonne Basin, Gulf of Mexico. Marine and Petroleum Geology, doi:10.1016/j.marpetgeo.2017.07.029

Johnson, J. (2018). High Porosity and Permeability Gas Hydrate Reservoirs: A Sedimentary Perspective. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Kinash, N. Cook, A., Sawyer, D. and Heber, R. (2017). Recovery and Lithologic Analysis of Sediment from Hole UT-GOM2-1-H002, Green Canyon 955, Northern Gulf of Mexico. Abstract OS53B-1207 presented at American Geophysical Union, Fall Meeting, New Orleans, LA.

Küçük, H.M., Goldberg, D.S, Haines, S., Dondurur, D., Guerin, G., and Çifçi, G. (2016). Acoustic investigation of shallow gas and gas hydrates: comparison between the Black Sea and Gulf of Mexico. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Majumdar, U., Cook, A. E., Shedd, W., and Frye, M. (2016). The connection between natural gas hydrate and bottom-simulating reflectors. Geophysical Research Letters, DOI: 10.1002/2016GL069443

Malinverno, A. (2015). Monte Carlo inversion applied to reaction-transport modeling of methane hydrate in continental margin sediments. Abstract OS23B-2003 presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Malinverno, A. (2016). Modeling gas hydrate formation from microbial methane in the Terrebonne basin, Walker Ridge, Gulf of Mexico. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Malinverno, A., Cook, A. E., Daigle, H., Oryan, B. (2017). Methane Hydrate Formation from Enhanced Organic Carbon Burial During Glacial Lowstands: Examples from the Gulf of Mexico. EOS Trans. American Geophysical Union, Fall Meeting, New Orleans, LA.

Meazell, K., Flemings, P. B., Santra, M., and the UT-GOM2-01 Scientists (2018). Sedimentology of the clastic hydrate reservoir at GC 955, Gulf of Mexico. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Meazell, K., & Flemings, P.B. (2016). Heat Flux and Fluid Flow in the Terrebonne Basin, Northern Gulf of Mexico. Presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Meazell, K., & Flemings, P.B. (2016). New insights into hydrate-bearing clastic sediments in the Terrebonne basin, northern Gulf of Mexico. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Meazell, K., & Flemings, P.B. (2016). The depositional evolution of the Terrebonne basin, northern Gulf of Mexico. Presented at 5th Annual Jackson School Research Symposium, University of Texas at Austin, Austin, TX.

Meazell, K. (2015), Methane hydrate-bearing sediments in the Terrebonne basin, northern Gulf of Mexico. Abstract OS23B-2012 presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Moore, M., Darrah, T., Cook, A., Sawyer, D., Phillips, S., Whyte, C., Lary, B., and UT-GOM2-01 Scientists (2017). The genetic source and timing of hydrocarbon formation in gas hydrate reservoirs in Green Canyon, Block GC955. Abstract OS44A-03 presented at American Geophysical Union, Fall Meeting, New Orleans, LA.

Morrison, J., Flemings, P., and the UT-GOM2-1 Expedition Scientists (2018). Hydrate Coring in Deepwater Gulf of Mexico, USA. Poster presented at the 2018 Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Oryan, B., Malinverno, A., Goldberg, D., Fortin, W. (2017). Do Pleistocene glacial-interglacial cycles control methane hydrate formation? An example from Green Canyon, Gulf of Mexico. EOS Trans. American Geophysical Union, Fall Meeting, New Orleans, LA.

Oti, E., Cook, A. (2018). Non-Destructive X-ray Computed Tomography (XCT) of Previous Gas Hydrate Bearing Fractures in Marine Sediment. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Oti, E., Cook, A., Buchwalter, E., and Crandall, D. (2017). Non-Destructive X-ray Computed Tomography (XCT) of Gas Hydrate Bearing Fractures in Marine Sediment. Abstract OS44A-05 presented at American Geophysical Union, Fall Meeting, New Orleans, LA.

Phillips, S.C., Flemings, P.B., Holland, M.E., Schultheiss, P.J., Waite, W.F., Petrou, E.G., Jang, J., Polito, P.J., O'Connell, J., Dong, T., Meazell, K., and Expedition UT-GOM2-1 Scientists, (2017). Quantitative degassing of gas hydrate-bearing pressure cores from Green Canyon 955. Gulf of Mexico. Talk and poster presented at the 2018 Gordon Research Conference and Seminar on Natural Gas Hydrate Systems, Galveston, TX, February 24-March 2, 2018.

Phillips, S.C., Borgfedlt, T., You, K., Meyer, D., and Flemings, P. (2016). Dissociation of laboratory-synthesized methane hydrate by depressurization. Poster presented at Gordon Research Conference and Gordon Research Seminar on Natural Gas Hydrates, Galveston, TX.

Phillips, S.C., *You, K., Borgfeldt, T., *Meyer, D.W., *Dong, T., Flemings, P.B. (2016). Dissociation of Laboratory-Synthesized Methane Hydrate in Coarse-Grained Sediments by Slow Depressurization. Presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

Phillips, S.C., You, K., Flemings, P.B., Meyer, D.W., and Dong, T. (under review). Dissociation of Laboratory-Synthesized Methane Hydrate in Coarse-Grained Sediments By Slow Depressurization. Marine and Petroleum Geology.

Portnov, A., Cook, A., Heidari, M., Sawyer, D., Santra, M., Nikolinakou, M. (2018). Salt-driven Evolution of Gas Hydrate Reservoirs in the Deep-sea Gulf of Mexico. Presented at Gordon Research Conference on Natural Gas Hydrate Systems, Galveston, TX.

Santra, M., Flemings, P., Scott, E., Meazell, K. (2018). Evolution of Gas Hydrate Bearing Deepwater Channel-Levee System in Green Canyon Area in Northern Gulf of Mexico. Presented at Gordon Research Conference and Gordon Research Seminar on Natural Gas Hydrates, Galveston, TX.

Sheik, C., Reese, B., Twing, K., Sylvan, J., Grim, S., Schrenk, M., Sogin, M., and Colwell, F. (2018). Identification and removal of contaminant sequences from ribosomal gene databases: lessons from the census of deep life. Frontiers in Microbiology. doi: 10.3389/fmicb.2018.00840

Smart, K (2018) Modeling Well Log Responses in Hydrate Bearing Silts. Ohio State University. Undergraduate Thesis.

Treiber, K, Sawyer, D., & Cook, A. (2016). Geophysical interpretation of gas hydrates in Green Canyon Block 955, northern Gulf of Mexico, USA. Poster presented at Gordon Research Conference, Galveston, TX.

Worman, S. and, Flemings, P.B. (2016). Genesis of Methane Hydrate in Coarse-Grained Systems: Northern Gulf of Mexico Slope (GOM^2). Poster presented at The University of Texas at Austin, GeoFluids Consortia Meeting, Austin, TX.

Yang, C., Cook, A., & Sawyer, D. (2016). Geophysical interpretation of the gas hydrate reservoir system at the Perdido Site, northern Gulf of Mexico. Presented at Gordon Research Conference, Galveston, TX, United States.

You, K.Y., DiCarlo, D. & Flemings, P.B. (2015), Quantifying methane hydrate formation in gas-rich environments using the method of characteristics. Abstract OS23B-2005 presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

You, K., Flemings, P.B. (2016). Methane Hydrate Formation in Thick Sand Reservoirs: Long-range Gas Transport or Short-range Methane Diffusion?. Presented at American Geophysical Union, Fall Meeting, San Francisco, CA.

You, K., and Flemings, P. B. (2017). Methane Hydrate Formation In Thick Sand Reservoirs: 1. Short-Range Methane Diffusion, Marine and Petroleum Geology.

You, K.Y., Flemings, P.B., & DiCarlo, D. (2015). Quantifying methane hydrate formation in gas-rich environments using the method of characteristics. Poster presented at 2016 Gordon Research Conference and Gordon Research Seminar on Natural Gas Hydrates, Galveston, TX.

You, K., and Flemings, P. B. (2018). Methane Hydrate Formation in Thick Marine Sands by Free Gas Flow. Presented at Gordon Research Conference on Gas Hydrate, Galveston, TX. Feb 24- Mar 02, 2018.

2.2 WEBSITE(S) OR OTHER INTERNET SITE(S)

- Project Website: https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/
- GOM^2-1 Expedition Website: https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/
- Project SharePoint: https://sps.austin.utexas.edu/sites/GEOMech/doehd/teams/
- Methane Hydrate: Fire, Ice, and Huge Quantities of Potential Energy: https://www.youtube.com/watch?v=f1G302BBX9w
- Fueling the Future: The Search for Methane Hydrate: https://www.youtube.com/watch?v=z1dFc-fdah4
- Pressure Coring Tool Development Video: https://www.youtube.com/watch?v=DXseEbKp5Ak&t=154s

2.3 TECHNOLOGIES OR TECHNIQUES

Nothing to report.

2.4 INVENTIONS, PATENT APPLICATIONS, AND/OR LICENSES

Nothing to report.

3 CHANGES/PROBLEMS

3.1 CHANGES IN APPROACH AND REASONS FOR CHANGE

Nothing to report.

3.2 ACTUAL OR ANTICIPATED PROBLEMS OR DELAYS AND ACTIONS OR PLANS TO RESOLVE THEM

In May, 2018, the JRFB canceled IODP Expedition 386 and withdrew it from the *JR* schedule. This presents a significant challenge to the project due to the comparatively low cost of the *JR* to commercial drilling vessels. The JRFB, however, forwarded CPP2-887 to the EFB for consideration of the potential implementation of the project as an ECORD MSP.

UT and the GOM^2 team are actively pursuing two alternate paths forwarded in order to achieve the scientific objectives of GOM^2-2.

1. **ECORD MSP**: We continue to work with ECORD as they evaluate implementing CPP2-887 as an MSP expedition. UT presented the CPP2-887 program to the European Science Operator (ESO) in a teleconference on June 10, 2018. UT provided a presentation document of GOM^2-2 and GOM^2-2 Plan B options to ECORD Facility Board (EFB) on Sep. 7, 2018. In an EFB planning meeting on September 10, 2018, EFB recommended that ESO support an MSP based on Plan B3 for implementation in 2021. The ECORD Council will meet on November 7-8, 2018 to plan operations and allocate budgets. After this meeting we will receive a consensus statement from ECORD confirming their decision and funding commitment.

2. **UT-Led Expedition**: Another possibility is that UT executes GOM^2-2 independently, as we did with GOM^2-1 in Green Canyon 955. We are working with UT administration to prequalify drilling vessel vendors and develop rigorous cost estimates. We have developed an approach and budget required to achieve the full science program and have also developed contingency plans with reduced scope and reduced budget.

After UT receives the consensus statement from ECORD in November we anticipate that the GOM^2-2 Expedition will be illuminated. We intend to have an optimized Operational and Science Plan to present to the Technical Advisory Group (TAG) for review by January 15, 2019. The TAG will in turn make recommendations by January 30, 2018.

3.3 CHANGES THAT HAVE A SIGNIFICANT IMPACT ON EXPENDITURES

The cost estimate for the GOM^2-2 drilling expedition was developed during the GOM^2 Phase 2/Phase 3 budget period transition, based on the assumption that a 56-day expedition would be executed using the *JR* for a pre-negotiated lump sum. It is now clear that GOM^2-2 will no longer be executed using the *JR*.

UT conducted a preliminary estimate of the costs associated with executing the 56-day expedition as originally planned if UT must contract all expedition-related activities, subcontractors, and vendors independently, as was done during the 2017 GOM^2-1 Marine Test. It is anticipated that expedition costs would increase significantly.

As discussed above, we are pursuing two approaches to meet our scientific goals.

1) We will continue to work with ECORD to support mounting GOM^2-2 as a mission specific drilling program. By doing so, a significant part of the increased costs will be covered by the IODP.
2) We are planning to execute GOM^2-2 independently. As part of this preparation, we are developing a scaled approach wherein we will budget to achieve the full science program and also develop plans with reduced scope and reduced budget that still achieve our critical science objectives.

3.4 CHANGE OF PRIMARY PERFORMANCE SITE LOCATION FROM THAT ORIGINALLY PROPOSED

Nothing to report.

4 SPECIAL REPORTING REQUIREMENTS

4.1 CURRENT: PHASE 3

Task 1.0 – Revised Project Management Plan

Subtask 14.3 – PCTB Land Test Report

Subtask 15.2 – Final Research Expedition Operational Plan

4.2 FUTURE – PHASE 4

Task 1.0 – Revised Project Management Plan

Subtask 17.1 – Project Sample and Data Distribution Plan

Subtask 17.3 – IODP Proceedings Expedition Volume

Subtask 17.4 – Expedition Scientific Results Volume

5 BUDGETARY INFORMATION

Phase 3 (Budget Period 3) cost summary is outlined below (Table 5-1). Note: Y4 in the table is Y5 of the overall project including BP1.

Table 5-1: Phase 3 (Budget Period 3) Cost Profile

Baseline Reporting Quarter		Budget Period 3					
		Y4Q2		Y4Q3		Y4Q4	
		01/01/18-03/31/18		04/01/18-06/30/18		07/01/18-09/30/18	
		Y4Q2	Cumulative Total	Y4Q3	Cumulative Total	Y4Q4	Cumulative Total
Baseline Cost Plan	Phase 2 Extension						
Federal Share		$ 1,066,233	$ 1,066,233	$ 788,190	$ 1,854,423	$ 1,270,466	$ 3,124,889
Non-Federal Share		$ 358,558	$ 358,558	$ 358,558	$ 717,116	$ 358,558	$ 1,075,674
Total Planned		$ 1,424,791	$ 1,424,791	$ 1,146,748	$ 2,571,539	$ 1,629,024	$ 4,200,563
Actual Incurred Cost							
Federal Share		$ 394,532	$ 394,532	$ 433,578	$ 828,110	$ 518,480	$ 1,346,590
Non-Federal Share		$ 211,985	$ 211,985	$ 207,161	$ 419,146	$ 155,856	$ 575,002
Total Incurred Cost		$ 606,517	$ 606,517	$ 640,739	$ 1,247,256	$ 674,336	$ 1,921,592
Variance							
Federal Share		$ (671,701)	$ (671,701)	$ (354,612)	$ (1,026,313)	$ (751,986)	$ (1,778,299)
Non-Federal Share		$ (146,573)	$ (146,573)	$ (151,397)	$ (297,970)	$ (202,702)	$ (500,672)
Total Variance		$ (818,274)	$ (818,274)	$ (506,009)	$ (1,324,283)	$ (954,688)	$ (2,278,971)

Baseline Reporting Quarter	Budget Period 3							
	Y5Q1		Y5Q2		Y5Q3		Y5Q4	
	10/01/18-12/31/18		01/01/19-03/31/19		04/01/19-06/30/19		07/01/19-09/30/19	
	Y5Q1	Cumulative Total	Y5Q2	Cumulative Total	Y5Q3	Cumulative Total	Y5Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 5,665,774	$ 8,790,663	$ 458,336	$ 9,248,999	$ 6,464,836	$ 15,713,835	$ 458,336	$ 16,172,171
Non-Federal Share	$ 496,980	$ 1,572,654	$ 496,980	$ 2,069,634	$ 496,980	$ 2,566,613	$ 496,980	$ 3,063,593
Total Planned	$ 6,162,754	$ 10,363,317	$ 955,316	$ 11,318,633	$ 6,961,816	$ 18,280,448	$ 955,316	$ 19,235,764
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

*Note: Year reflects that of overall project

6 REFERENCES

Flemings, P. B., 2016a, Y2Q1 Quarterly Research Performance Progress Report (Period ending 12/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

Flemings, P. B., 2016b, Y2Q2 Quarterly Research Performance Progress Report (Period ending 3/31/2015), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

7 ACRONYMS

Table 7-1: List of Acronyms

ACRONYM	DEFINITION
AAPG	American Association of Petroleum Geologists
AIST	National Institute of Advanced Industrial Science and Technology
ASW	Air-Saturated Water
BET	Brunauer-Emmett-Teller
BGS	British Geological Survey
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulation
CNPL	Calcareous Nannofossil Plio-Pleistocene
CPP	Complimentary Project Proposal
CT	Computed Tomography
DOE	U.S. Department of Energy
ECORD	European Consortium for Ocean Research Drilling
EFB	ECORD Facility Board
EPSP	Environmental Protection and Safety Panel
ESSAC	ECORD Science Support and Advisory Committee
ESO	European Science Operator
GHSZ	Gas Hydrate Stability Zone
HPTC	High Pressure Temperature Corer
IMO	International Maritime Organization
IODP	International Ocean Discovery Program
JOGMEC	Japanese Oil, Gas, and Metals National Corporation
JR	JOIDES Resolution
JRFB	JOIDES Resolution Facility Board
JRSO	JOIDES Resolution Science Operator
mbsf	meters below sea floor
MODU	Mobile Offshore Drilling Unit
MS	Mass Spectrometry
MSP	Mission Specific Platform
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
OCS	Outer Continental Shelf
ORCAB	Orca Basin
OSU	Ohio State University
PCATS	Pressure Core Analysis and Transfer System
PCC	Pressure Core Center
PCS	Pressure Coring System

ACRONYM	DEFINITION
PCTB	Pressure Core Tool with Ball Valve
PM	Project Manager
PMP	Project Management Plan
PMRS	Pressure Maintenance and Relief System
QRPPR	Quarterly Research Performance and Progress Report
RFP	Request for Proposal
RFQ	Request for Qualifications
RPPR	Research Performance and Progress Report
SEP	Site Evaluation Panel
SOPO	Scope of Project Objectives
SSDB	Site Survey Data Bank
TBONE	Terrebonne Basin
UNH	University of New Hampshire
USCG	United States Coast Guard
USGS	U.S. Geological Survey
USIO	United States Implementing Organization
UT	University of Texas at Austin
UW	University of Washington
XCT	X-ray Computed Tomography
XRD	X-ray Diffraction

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

DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report Period Ending 09/31/2018

Deepwater Methane Hydrate Characterization and Scientific Assessment

APPENDIX A

GOM^2 Workshop Summary

Action Items from Ohio State GOM2 Workshop
(Held 9/24/2018-9/25/2018)

TASKS:

Task 1: Refine our science goals and approach

a. Gain a better understanding of the microbial factory and the origin of water and methane in the system.
    i. At GC 955: Location of Previous coring (GOM2-1)
        1. Traditional δ13C and C1/C2 analysis suggests microbial origin (Whiticar et al., 1999). However, we have no consensus on whether this is microbial degradation of thermogenic reservoir or biogenic sourced.
        2. Identify action items to understand the origin of methane:
            a. Develop a science plan with clear tasks that will illuminate a path forward
            b. is it microbially altered thermogenics (i.e. a deep source)
            c. Is it microbially generated from carbon burial (i.e. a shallow source)
        3. Things that came up:
            a. Need follow-up meetings on geo and microbiology (Steve, Evan, Tim, Myles)
            b. Need to get going on the BIO chamber (Junbong, Bill, Carla, Sheng Dai, Rick C, and Jen Glass)
            c. Need pore water samples from pressure cores so we can measure δ13C isotopes of dissolved inorganic carbon to identify signatures methane oxidation (Steve, Evan)
            d. Need better measurements/procedures/planning to capture the full carbon story: CO2, carbon isotopes, ripening
    ii. Develop a statement of actions we need to take for design of experimental program for GOM2-2, the next drilling program, to drive this question forwards.
b. We need to refine/build a better Physical Pore Model: micromechanical and pore liquid model, look at pore size not necessarily grain size
    i. Inconsistent stories on how hydrate fills the pores, cementing or not, framework support, etc?
    ii. Issue that hydrate saturation may not be a good prediction of effective permeability – if not what is?
    iii. Better connection of core and pore scale behavior; need better integration

Task 2: Nuts and bolts activities

a. Summarize accurately and concisely Plan B-3.
    i. Summarize assumptions made.
b. Terrebonne: Prepare one or several lithostratigraphic cross sections from 01 to 03 to 02 well to help inform possible changes in operational plan.
c. Determine science cost if there is a cut of two million dollars in budget from ESO cash contribution.

        i. Report to ESO this impact.
d. Review original DOE proposal to review how strongly 'exploration' is emphasized (confirm commitment to exploration).
e. Terrebonne: Prepare Log sections across key sand intervals for use in wireline testing and pressure coring planning
f. Review and revise the compatibility of coring systems with other activities.
    i. Example: can we run t2P in RCB BHA?
    ii. Example: can we run PCTB_CS in RCB BHA?
    iii. Are there other examples of what we can do that we have not taken into account?
g. Get Cost estimate for Cat-Scanning conventional core through Weatherford.
h. Determine if ESO has officially stated that they will not contract vessel themselves and thus it is UT's responsibility.
i. Determine if ESO cash can bypass UT and go directly to vessel.
j. Develop timeline and budget for revised plan(s)

Task 3: Possible Macro-Scale Expedition Changes

a. Expedition Timing will shift to calendar 2021
    i. ESO has committed to calendar 2021
        1. It is possible ESO could do late calendar 2020.
        2. DOE has pointed out that late 2021 (i.e. after 10/1/21) is most preferable from a budget perspective. It maximizes the ability to build a budget for the program.
        3. The most likely planning scenario is 2021
b. Consider changing when LWD is performed
    i. If coring is not predicated on LWD results, then LWD could be at end of expedition as easily as beginning of expedition.
        1. Consider whether (and where) to do large diameter wireline logging & in-situ testing between drilling of holes at 1 and 3.
        2. Consider that this will lower the prioritization of LWD holes (i.e. exploration at Orca).
c. Revisit importance of updip (Tbone-02) well at Terrebonne
    i. Consider science motivation.
d. Consider possibility of splitting LWD from coring effort.
    i. Develop approximate budget to split off LWD
    ii. Produce justification for this decision:
        1. The LWD and coring really have separate objectives. The LWD component exists to explore, and works best when you can change or tweak your plans based on what you've found. The goals of the coring are really to get as much pressure and conventional core as possible (as well as the MDT test). If we do run both components together and in a single cruise there are certainly pitfalls. For example, if we run LWD first, we surely will not try to change the time or the number of holes we drill because we have to preserve all of the time we planned for coring. If we run LWD second (after coring), there could be a chance

that we would have extra time for LWD, but there could also be no time for LWD because of coring problems.

2. If we run the LWD leg early, we get another major accomplishment in the project (exploration).
3. An LWD cruise would require significantly less personnel than GOM-01 or a coring cruise. I think you would need about 6 scientists (3 on each shift), 1 company man, cementers, mud engineers and LWD Schlumberger engineers. I estimate ~13-15 people total (contractors + scientists), outside the staff on whatever boat is hired.
4. Removing LWD from the coring cruise means we will maximize the amount of core recovered on a later coring cruise meaning we also maximize the ECORD contribution.
5. Drilling at Orca is planned; we are ready to go now.
6. There could be cost savings to running things sooner; we don't know what the cost of the boat or Schlumberger will be in 3 years.
7. LWD does not leverage ESO because their expertise is in coring. A lot of people are standing around while we are LWD'ing.
8. Consider implication to pressure coring program if LWD is separated (little time to prep. PCATS).

Task 4: Revise Pressure Coring Program

a. Review and revise the pressure coring program for the sands at Terrebonne. These sands are fundamentally different than those encountered at GC-955.
b. Action Item: Pull up the logs on these sands and come up with a proposed coring program that captures the sands and the bounding seals above and below.
c. Intermittent pressure cores are planned through the entire section. It is common for first pressure core to be partially filled with detritus from the bottom of the borehole.
    i. Action Item: Revise intermittent pressure coring to include at least two consecutive pressure cores to ensure recovery. Establish appropriate program that meets micro-biology needs.
d. Establish relative importance of pressure core sampling for microbial factory, fractured interval, and intermediate sands. Link to DOE goals.
e. Considerable momentum around pressure coring blue sand at 01B as updip analog to 03 (in original research proposal).

Task 5: Integrate 03B and 01B coring program at Terrebonne

a. If our goal is to achieve complete sampling from top to bottom. Then, perhaps we can integrate measurements made in each hole to reach this goal.
b. Considerable momentum around only pressure coring below Orange Sand (intermittently) in 01-B well.
c. Considerable momentum to get pore water samples 50 m below BHSZ.

Task 6: Terrebonne: Revisit plan to perform in-situ tests in Orange Sand in 01-B well (H)

a. Determine if it is physically reasonable to perform drawdown test on this horizon. Take into account that it is well above the base of the hydrate stability zone and thus may need more drawdown, which may exceed tool capability.

i. Should we perform in-situ test instead in Orange Sand in 03B (G) well?
ii. Should we instead perform in-situ test in Blue Sand?

b. Specify pipe depth for logging program.
c. Get specifics of max diameter of wireline string and MDT to Pettigrew
d. Can we deploy MDT as planned at the 1 well (H well) in the Orange Sand or are we too far from the stability zone.

<u>Task 7:Refine and Revise Shipboard Core Analysis Program</u>

a. Water samples squeezed on board. Onboard analysis of alkalinity, pH, salinity, and H2S. All other samples will be analyzed onshore with preserved samples
b. Refine gas program
    i. determine safety protocol for headspace
    ii. determine IODP protocol
    iii. refine gas sampling plan to avoid contamination (*e.g. like UT system before bubbling chamber)
c. Refine adjacent triplicate whole-round sampling (one cut for: phys pros/void space, pore water, microbio)
d. Continuously sample mud program for characterizing microbial/chemical contamination.
e. Use shipboard scanning to take whole core. Control # of samples.
f. Take vane shear?
g. Determine IR plan. If so, consider Geotek IR scanning equipment which is more mature.

TEAMS:

Team 1. Nuts and Bolts Team (UT) (Task 2)

a. Charged with
    1) Addressing the logistical and administrative actions
b. Team Members
    1) Lead: Flemings
    2) Jesse Houghton
    3) Jamie Morrison
    4) Carla Thomas
    5) Steve Phillips
    6) Lynda Miller
    7) etc.

Team 2. UT-GOM2-2 Operational (including Coring Points) Planning Team (Tasks 3,4, & 5):

a. Charged with
    1) Determining the best coring plan options
    2) Determining the trade-offs offs between those options
    3) Making a recommendation(s) on UT-GOM2-2 coring/logging/testing plan
b. Team Members
    1) Lead: Flemings
    2) Joel Johnson
    3) Ann Cook
    4) Tim Collett
    5) Ray Boswell
    6) Carla Thomas
    7) Manasij Santra
    8) Jesse Houghton
    9) Tom Pettigrew

Team 3. UT-GOM2-2 In-situ Testing / Wireline Logging (Wireline) Team (Task 6):

a. Charged with
    1) Determining what is really possible with the different versions of MDT available
    2) Determining where (what hole and Horizon) different version of the MDT could be used
    3) Making a final recommendation on test plan
b. Team Members
    1) Lead: Tim Collett
    2) Lead: Peter Polito
    3) Logging Team, plus
    4) Bill Waite
    5) Tim Collett
    6) David Goldberg
    7) Ray Boswell
    8) Kehua You
    9) Li Wei
    10) Yi Fang

11) Evan Solomon

Team 4. UT-GOM2-2 Core Analysis Team (Task 7)

a. Charged with
   1) Determine what analysis we really need to try to get on-board vessel
   2) Determine the Prioritization of that list for cost, space, and berth considerations
   3) Determine what analysis should be done immediately after the expedition (dockside or somewhere close)
   4) Determine what analyses we should push to be done at Bremen/Marum
b. Team Members
   1) Lead: Carla Thomas
   2) Steve Phillips
   3) Joel Johnson
   4) Rick Colwell
   5) Evan Solomon
   6) Junbong Jang
   7) Derek Sawyer
   8) Tim Collet
   9) Yi Fang
   10) Myles Moore

Team 5. Biogeochemical Processes Team (Task 1a):

a. Charged with:
   1) Refine science program around methane source
b. Team Members
   1) Evan as the GOM2 Geochemistry Technical Lead and Rick Colwell as the GOM2 Microbiology Technical Lead are tasked with this as an outcome of the discussions under coring team and core analysis teams.
   2) Steve Phillips
   3) Tom Darrah
   4) Myles Moore
   5) ExxonMobil
   6) Georgia Tech

Team 6. Rock Physics Team (Task 1b)

a. Charged with:
   1) Refine science program around rock physics
b. Team Members
   1) Lead: Bill Waite
   2) Yi Fang
   3) Yongkoo Seol
   4) Jun Yoneda
   5) Junbong Jang
   6) Sheng Dai
   7) Liang Lei
   8) Choi Jeong

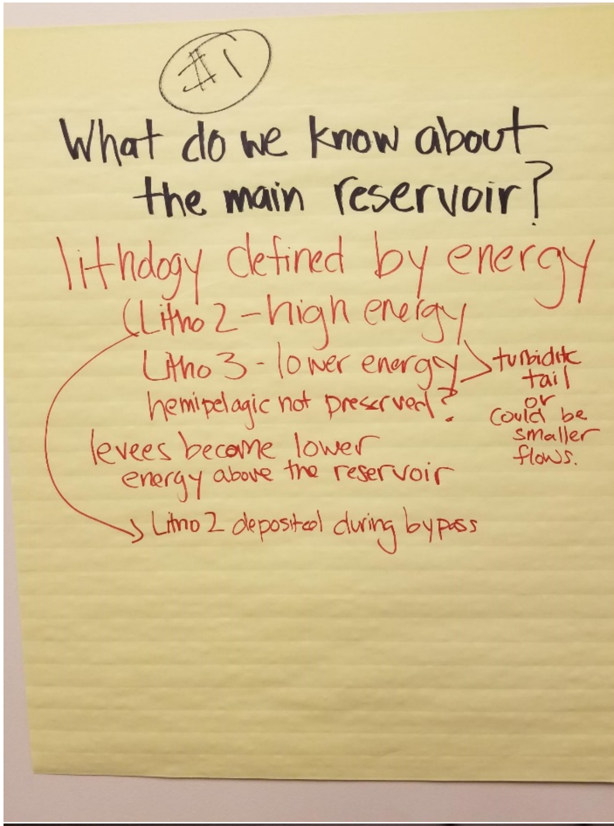
Other Existing or Pre-existing Teams
Team 7. TAG—Final Review board for science plan.
Team 8. Mapping/Permitting Team: Will continue to complete permitting.

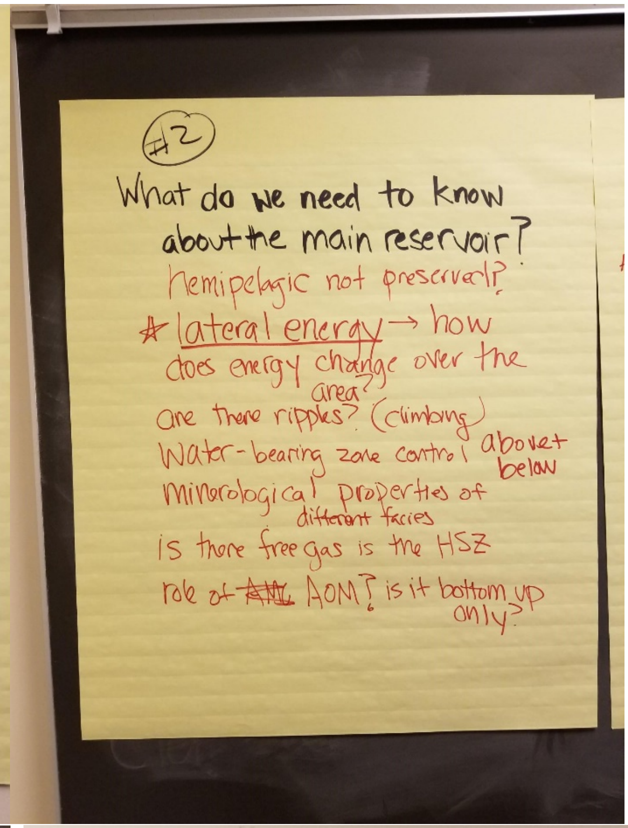
MATRIX of TASKS and TEAMS

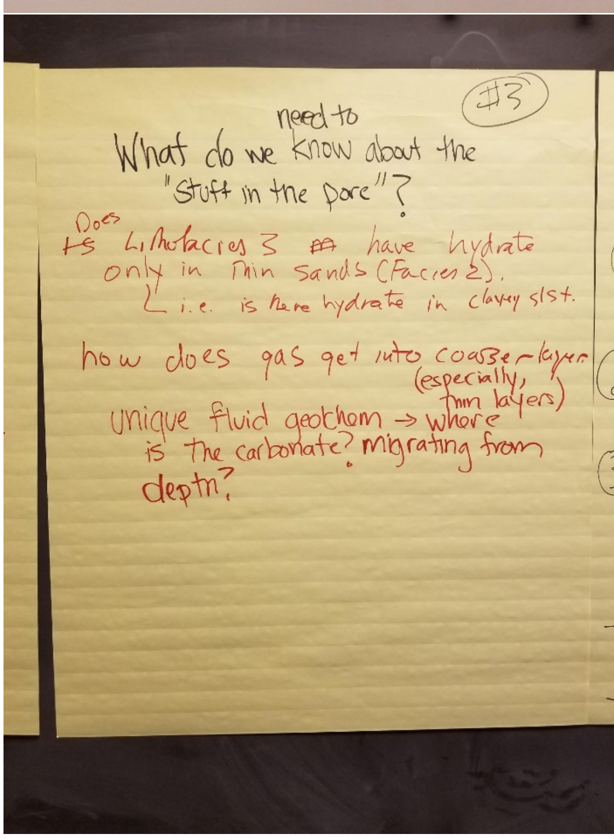
			TEAMS						Due Date
			UT	OPS Team	In-situ Wireline Test Team	Core Analysis Team	Bio-geochemical Processes Team	Rock Physics Team	
TASKS	1a	Outstanding Science: Origin of Methane and water					X		
	1b	Outstanding Science: Pore Model						X	
	2	Nuts and bolts activities	X						11/1/18
	3	Macro-scale Expedition Changes		X					12/1/18
	4	Revise Pressure Coring Program		X					12/1/18
	5	Integrate 03B and 01B coring program at Terrebonne.		X					12/1/18
	6	Revisit plan to perform in-situ tests in Orange Sand in 01-B well (H).			X				12/1/18
	7	Refine and Revise Shipboard Core Analysis Program				X			12/1/18

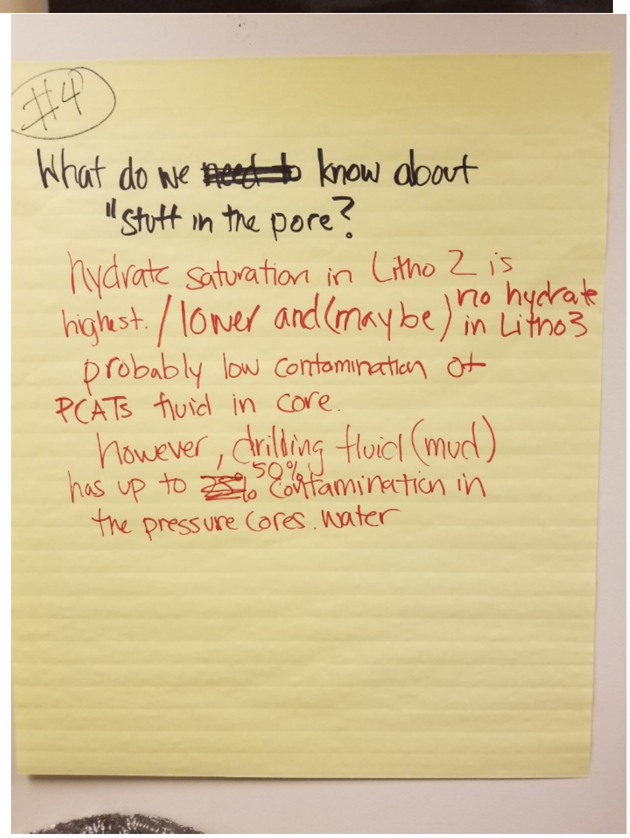
GROUP NOTES

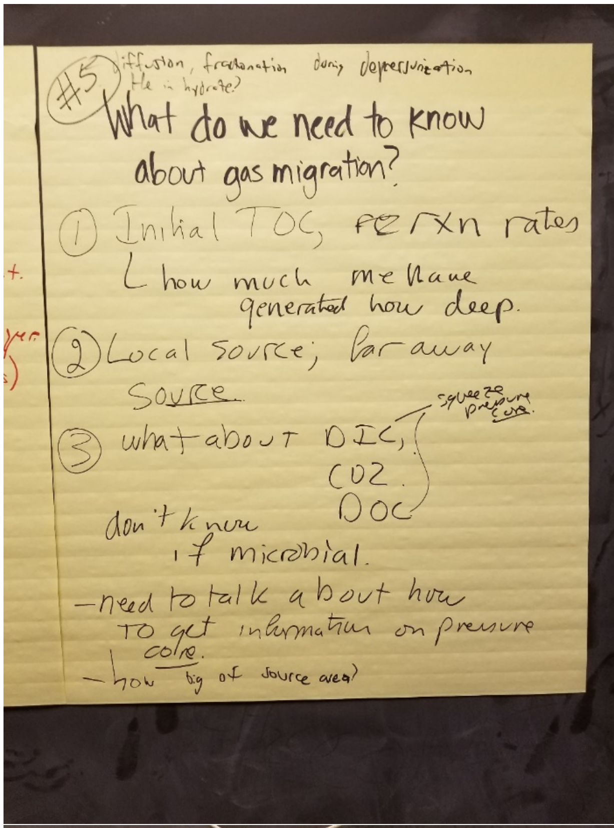
Day 1

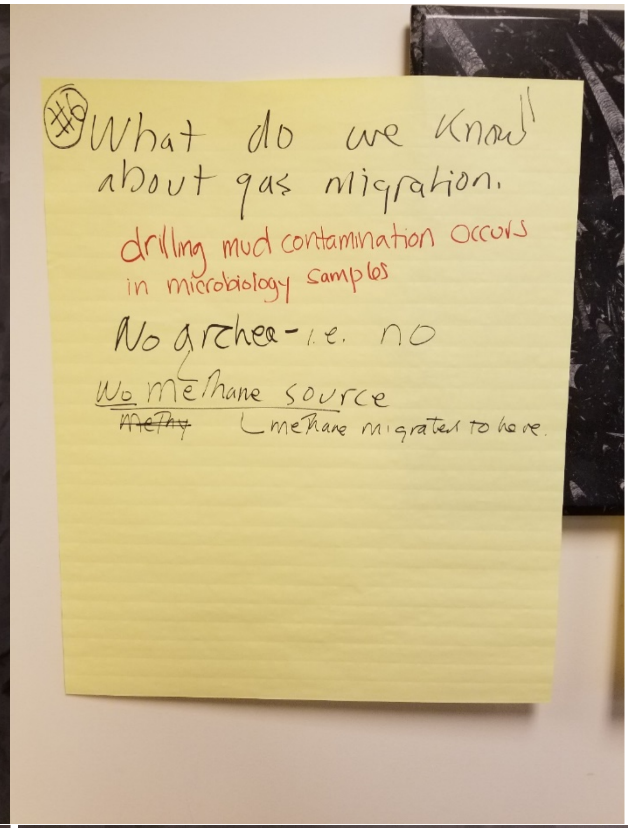


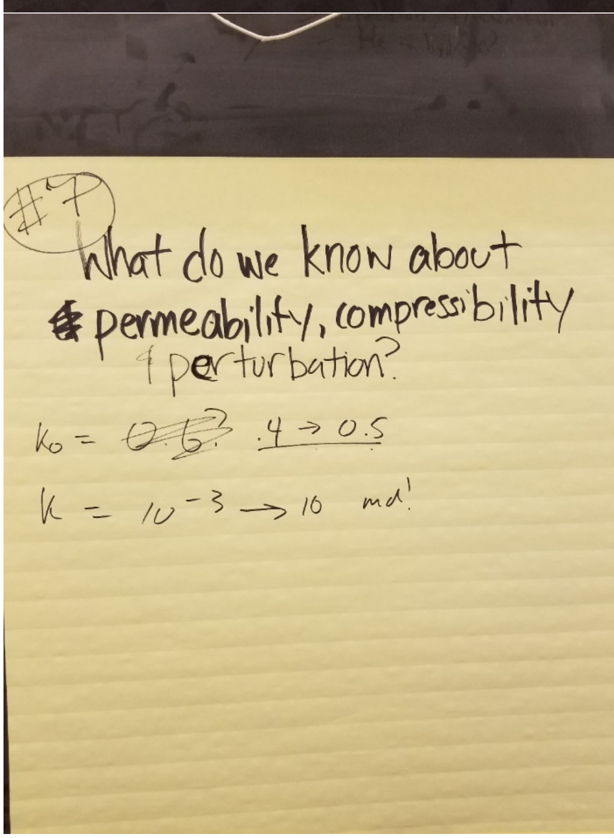


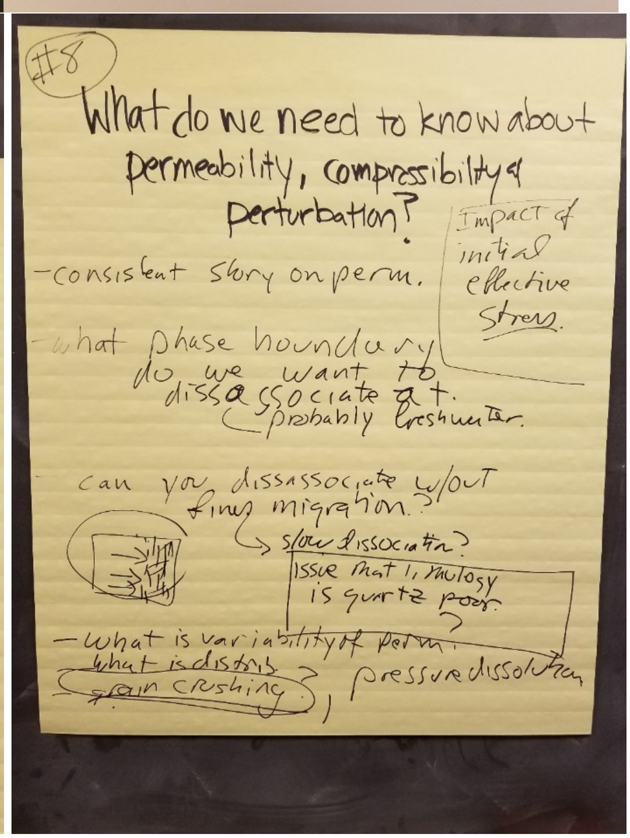


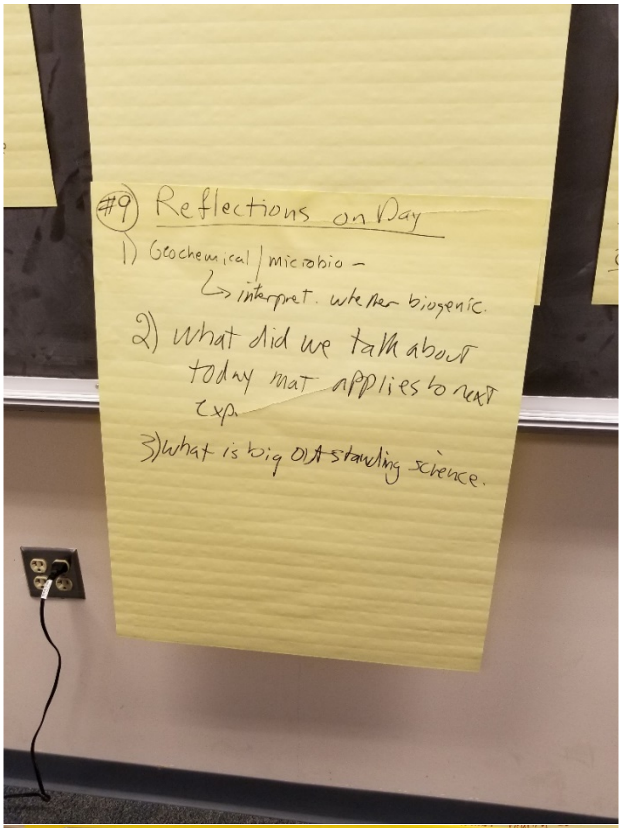


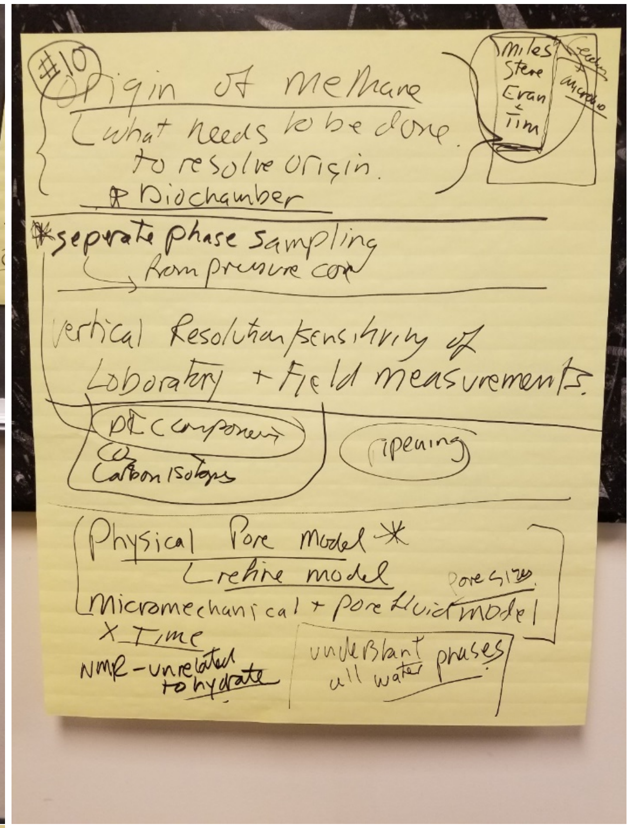

#5
Diffusion, fractionation during depressurization
He in hydrate?
What do we need to know about gas migration?
① Initial TOC, rxn rates
how much methane generated how deep.
② Local source; far away source
squeeze pressure core.
③ what about DIC, CO2, DOC
don't know if microbial.
-need to talk about how to get information on pressure core.
- how big of source area?

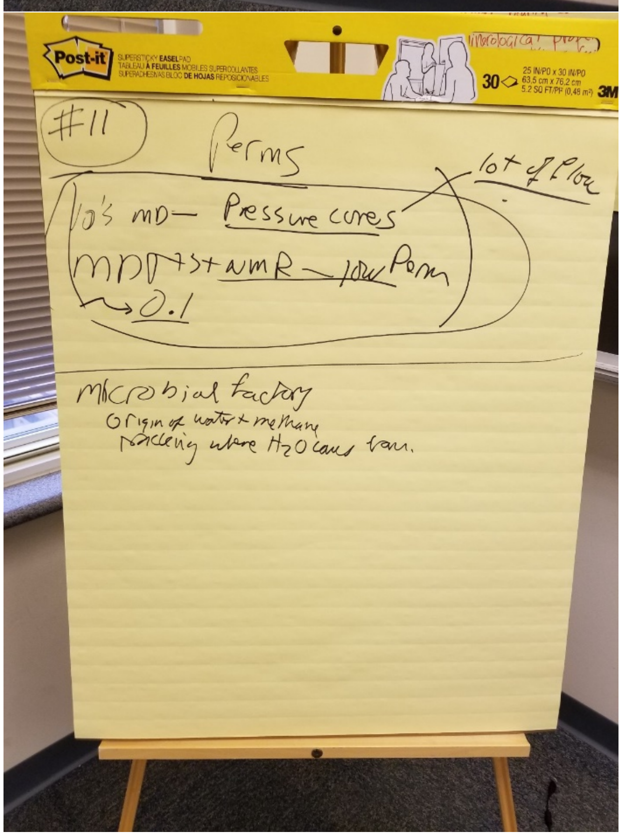

#6
What do we know about gas migration.
drilling mud contamination occurs in microbiology samples
No archea - i.e. no
No methane source
methane migrated to here.


#7
What do we know about permeability, compressibility & perturbation?
k0 = .4 → 0.5
k = 10^-3 → 10 md!

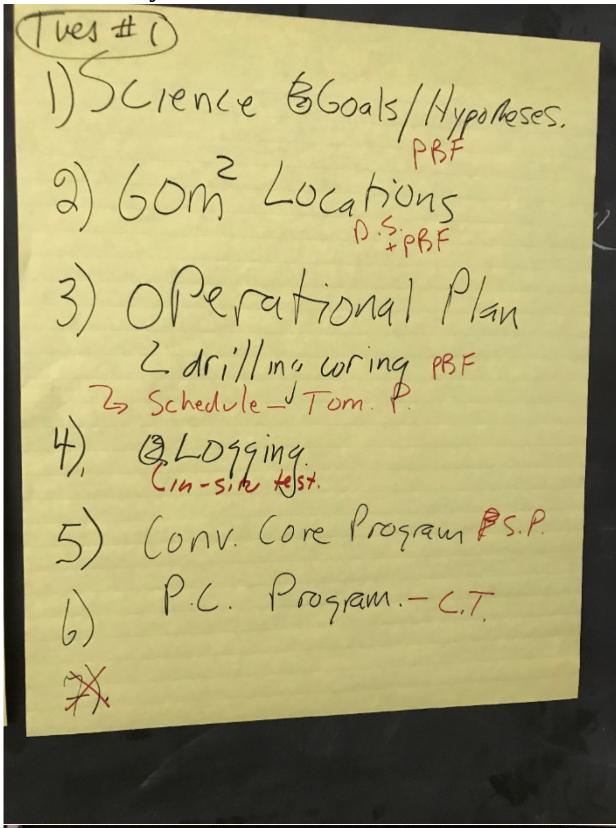

#8
What do we need to know about permeability, compressibility & perturbation?
Impact of initial effective stress.
-consistent story on perm.
what phase boundary do we want to dissassociate at.
probably freshwater.
can you dissassociate w/out fines migration?
slow dissociation?
Issue that lithology is quartz poor.
-what is variability of perm.
what is distrib
grain crushing, pressure dissolution

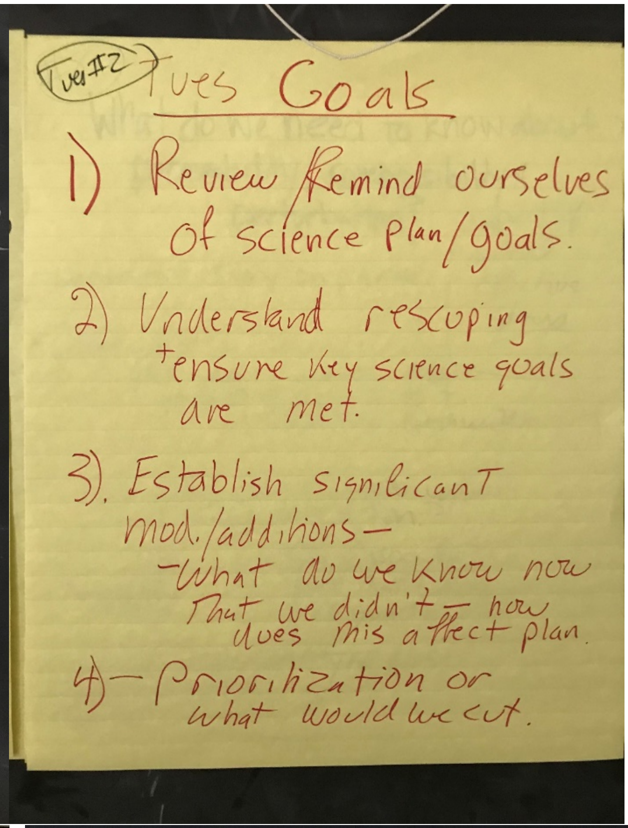

#9 Reflections on Day
1) Geochemical / microbio –
interpret. whether biogenic.
2) what did we talk about today that applies to next exp.
3) what is big outstanding science.

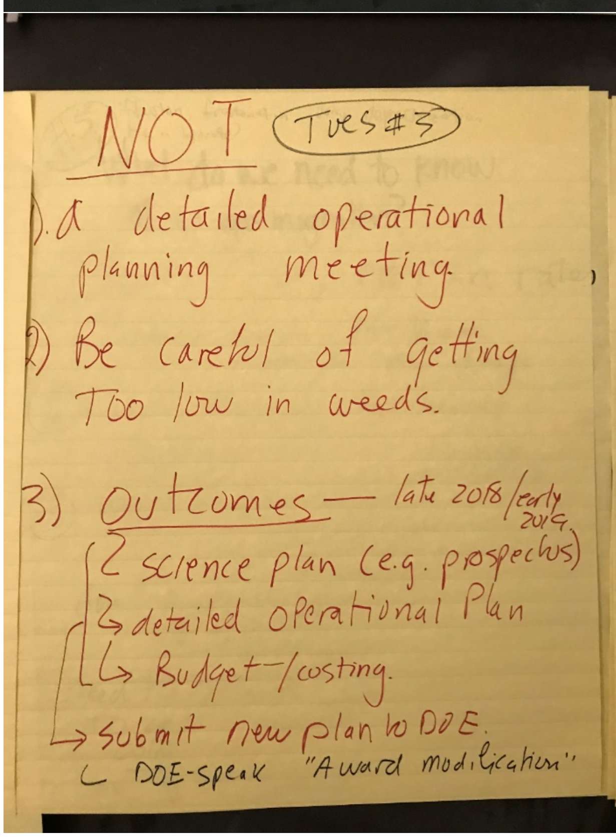

#10 Origin of methane
What needs to be done to resolve origin.
Biochamber
Miles
Steve
Evan
Tim
separate phase sampling from pressure core
vertical Resolution/sensitivity of Laboratory + Field measurements.
Carbon Isotopes
opening
Physical Pore Model
refine model
Pore size
Micromechanical + pore fluid model
x Time
NMR - unrelated to hydrate
all water phases

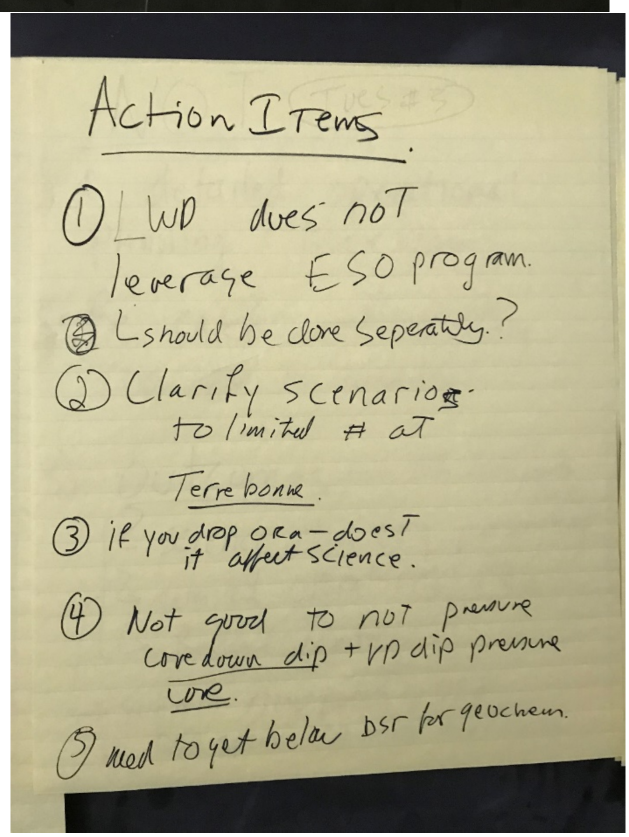

Post-it
#11
Perms
lot of flow
Pressure cores
NMR
0.1
Microbial factory
Origin of water + methane

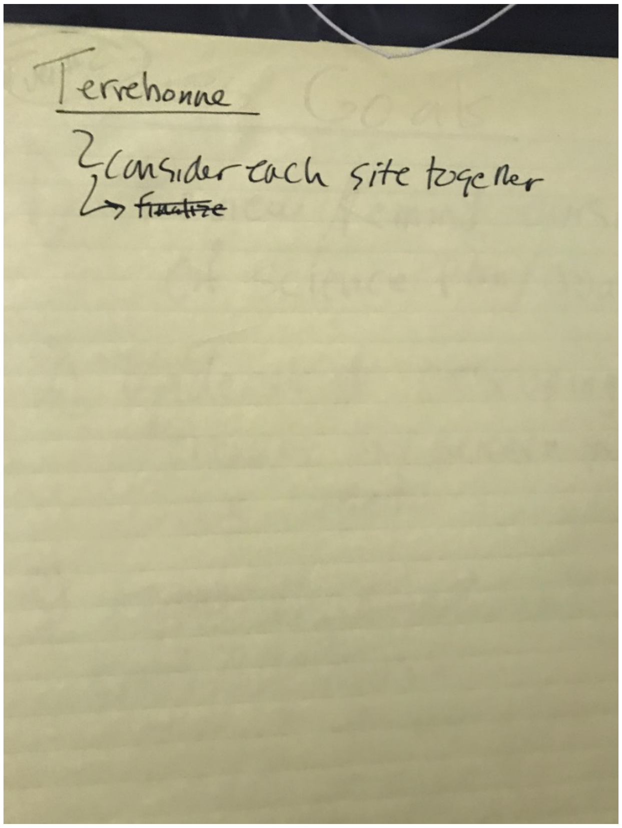
Boards: Day 2

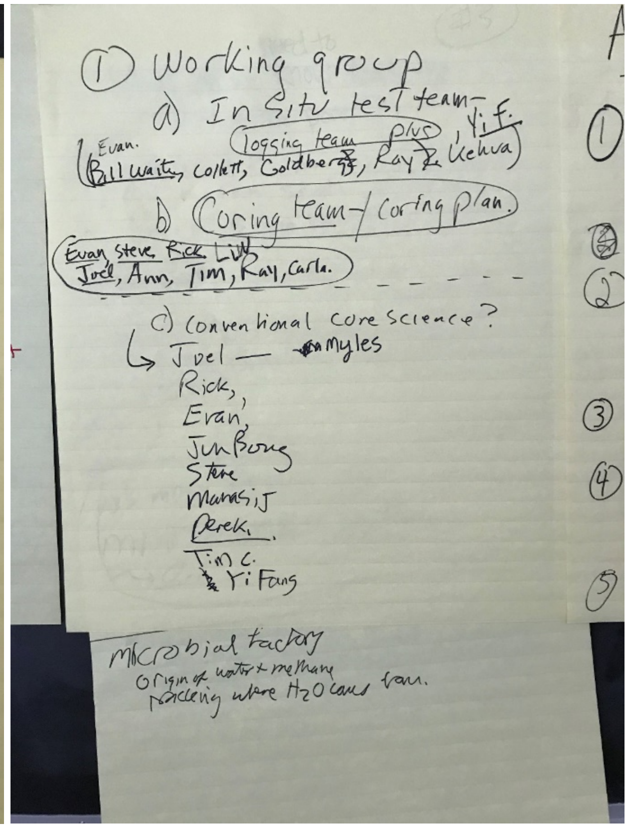

Tues #1
1) Science Goals/Hypotheses. PBF
2) GOM2 Locations D.S. + PBF
3) Operational Plan
drilling coring PBF
Schedule – Tom. P.
4) Logging
5) Conv. Core Program PS.P.
6) P.C. Program. – C.T.


Tues #2
Tues Goals
1) Review /Remind ourselves of science plan/goals.
2) Understand rescoping + ensure key science goals are met.
3). Establish significant mod./additions –
– What do we know now that we didn't – how does this affect plan.
4) – Prioritization or what would we cut.


NOT Tues #3
1). a detailed operational planning meeting
2) Be careful of getting too low in weeds.
3) Outcomes — late 2018/early 2019.
science plan (e.g. prospectus)
detailed operational plan
Budget/costing.
submit new plan to DOE.
DOE-speak "Award modification"


Action Items.
1) LWD does not leverage ESO program.
should be done seperately?
2) Clarify scenarios to limited # at Terrebonne.
3) if you drop ... – doesn't it affect science.
4) Not good to not pressure core down dip + up dip pressure core.
5) need to get below BSR for geochem.


Terrehonne
consider each site together
finalize


① Working group
a) In Situ test team - Yi F.
(logging team plus)
Evan.
Bill waite, Collett, Goldberg, Ray, Kehua
b) Coring team / coring plan
Evan, Steve, Rick, Lin
Joel, Ann, Tim, Ray, Carla.
c) conventional core science?
Joel — Myles
Rick,
Evan,
Steve
Derek,
Tim C.
Yi Fang
①
②
③
④
⑤
Microbial factory
origin of water + methane
where H2O came from.