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Quarterly Research Performance Progress Report

Period Ending 3/31/2019

Deepwater Methane Hydrate Characterization and Scientific Assessment

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

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1 ACCOMPLISHMENTS

<u>What was done? What was learned?</u>

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

- **UT-GOM2-2 Path Forward:** In Y5Q2, UT worked with the GOM2 planning teams, the GOM2 Advisory Team and technical experts from Oregon State, UNH, and UW to prioritize science objectives and develop a new science and operational plan that maximizes science and minimizes risk within the original budget. The GOM2 Advisory Team and technical experts came to a consensus recommendation for the program. UT is currently developing the revised operational plan and will propose the plan to DOE in the next quarter.

- **Core Analysis**: UT installed an X-ray CT system with integrated P-wave measurement capability. The system is now being using to scan UT-GOM2-1 pressure core for higher precision cutting of the samples under pressure.

- **Products**: Two additional papers were submitted to a special volume of the American Association of Petroleum Geologists Bulleting on the UT-GOM2-1 expedition.

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	03/2015	03/2015	Project Mgmt. Plan
	M1B	1.0	Project Kick-off Meeting	01/2015	12/2014	Presentation
	M1C	2.0	Site Location and Ranking Report	09/2015	09/2015	Phase 1 Report
	M1D	3.0	Preliminary Field Program Operational Plan Report	09/2015	09/2015	Phase 1 Report
	M1E	4.0	Updated CPP Proposal Submitted	05/2015	10/2015	Phase 1 Report
	M1F	2.0	Demonstration of a viable PCS Tool: Lab Test	09/2015	09/2015	Phase 1 Report
	M1G	--	Document results of BP1/Phase 1 Activities	12/2015	01/2016	Phase 1 Report
Phase 2	M2A	6.0	Complete Updated CPP Proposal Submitted	11/2015	11/2015	QRPPR
	M2B	6.0	Scheduling of Hydrate Drilling Leg by IODP	05/2016	05/2017	Report status to DOE PM
	M2C	7.0	Demonstration of a viable PCS tool for hydrate drilling through completion of land-based testing	12/2015	12/2015	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	01/2017	05/2017	QRPPR
	M2E	11.0	Update Field Program Operational Plan	02/2018	04/2018	Phase 2 Report
	M2F	--	Document results of BP2/Phase 2 Activities	04/2018	04/2018	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	12/2018	--	PCTB Lab Test Report (in QRPPR)
	M3B	14.0	Demonstration of a viable PCS tool for hydrate drilling: Land Test	03/2019	--	PCTB Land Test Report (in QRPPR)
	M3C	15.0	Complete Refined Field Program Operational Plan Report	12/2018	--	QRPPR
	M3D	15.0	Completion of required Field Program Permit(s)	12/2018	--	QRPPR
	M3E	--	Document results of BP3/Phase 3 Activities	12/2019	--	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	03/2020	--	QRPPR
	M4B	17.0	Complete Preliminary Expedition Summary	09/2020	--	Report directly to DOE PM
	M4C	17.0	Complete Project Sample and Data Distribution Plan	05/2020	--	Report directly to DOE PM
	M4D	17.0	Contribute to IODP Proceedings Volume	09/2021	--	Report directly to DOE PM
	M4E	17.0	Initiate comprehensive Scientific Results Volume with appropriate scientific journal	09/2021	--	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 *Subtask 2.1* *Subtask 2.2*	**Site Analysis and Selection** *Site Analysis* *Site Ranking / Recommendation*	Y1Q1 - Y1Q4
	Task 3.0	**Develop Pre-Expedition Operational Plan**	Y1Q3 - Y1Q4
	Task 4.0	**Complete IODP CPP Proposal**	Y1Q2 - Y1Q4
	Task 5.0 *Subtask 5.1* *Subtask 5.2* *Subtask 5.3*	**Pressure Coring and Core Analysis System Modifications and Testing** *Pressure Coring Tool with Ball Scientific Planning Workshop* *Pressure Coring Tool with Ball Lab Test* *Pressure Coring Tool with Ball Land Test Prep*	Y1Q2 - Y1Q4
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 *Subtask 7.1* *Subtask 7.2* *Subtask 7.3* *Subtask 7.4*	**Cont'd. Pressure Coring and Core Analysis System Mods. and Testing** *Review and Complete NEPA Requirements (PCTB Land Test)* *Pressure Coring Tool with Ball Land Test* *PCTB Land Test Report* *PCTB Tool Modification*	Y2Q1 - Y3Q2
	Task 8.0 *Subtask 8.1* *Subtask 8.2* *Subtask 8.3* *Subtask 8.4* *Subtask 8.5*	**Pressure Coring Tool with Ball Marine Field Test** *Review and Complete NEPA Requirements* *Marine Field Test Operational Plan* *Marine Field Test Documentation and Permitting* *Marine Field Test of Pressure Coring System* *Marine Field Test Report*	Y2Q1 - Y4Q1
	Task 9.0 *Subtask 9.1* *Subtask 9.2* *Subtask 9.3* *Subtask 9.4* *Subtask 9.5* *Subtask 9.6* *Subtask 9.7*	**Pressure Core Transport, Storage, and Manipulation** *Review and Complete NEPA Requirements* *Hydrate Core Transport* *Storage of Hydrate Pressure Cores* *Refrigerated Container for Storage of Hydrate Pressure Cores* *Hydrate Core Manipulator and Cutter Tool* *Hydrate Core Effective Stress Chamber* *Hydrate Core Depressurization Chamber*	Y2Q2 - Y3Q3

	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.
- Continued planning alternate path forward for the UT-GOM2-2 expedition after ECORD declined to participate in UT-GOM2-2.
- Held a focus-group workshop January 8-11, 2019 to develop multiple UT-GOM2-2 operational plans that meet science objectives to varying degrees.

Objective 3: Communicate with project team and sponsors.

- Organized and coordinated regular project team meetings:
  - Monthly sponsor meetings
  - GOM2-2 Advisory Team meetings
  - PCTB development team meetings
- Communicated development of a new expedition plan to the Sponsors, sub awards, and project team
- Managed SharePoint sites, email lists, and archive/website.

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.
- Monitored progress and schedule of Geotek preparations for PCTB bench test.
- Initiated contract discussions with Schlumberger Cameron Test Training Facility (CTTF) for PCTB land test.
- Monitored progress and schedule of Reaction Engineering International (Reaction Engineering) work scope of computation fluid dynamics (CFD) modeling of the Pressure Coring Tool with Ball-valve (PCTB).

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.

<u>**TASK 6.0 - TECHNICAL AND OPERATIONAL SUPPORT OF COMPLIMENTARY PROJECT PROPOSAL**</u>

Status: Closed (See *Task 15: Field Program / Research Expedition Preparation* for UT-GOM2-2 plan forward).

A timeline of tasks associated with 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
November 7-8, 2018	ECORD Council and ESSAC determine that it is not possible to implement CPP2-887 as an MSP.

<u>TASK 9.0 - PRESSURE CORE TRANSPORT, STORAGE, AND MANIPULATION</u>

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

<u>TASK 10.0 - PRESSURE CORE ANALYSIS</u>

Status: Ongoing

Subtask 10.4 - Continued Pressure Core Analysis

A. Pressurized Core Analysis

<u>A.1. Quantitative Degassing and Gas Analysis</u>

- UT continued quantitative depressurization of pressure core and analysis of the resultant gases. Samples were selected to fill in the gaps and increase the resolution of estimated variation in hydrate saturation downhole. During this quarter, we degassed an interval from core section UT-GOM2-1-H005-13FB-1. This is the first degassing of a core from the lower high-resistivity interval cored at H005. The gases collected from these experiments will be analyzed next quarter.
- UT submitted four samples from various previous degassing experiments for C and H isotopic analysis at Isotech Laboratories with results expected early next quarter.
- UT and Ohio State performed more detailed gas collection during the quantitative degassing experiment on a section of core from H005-013FB to collect gas samples in evacuated copper and steel tubes prior to the bubbling chamber (the PBC: pre-bubbling chamber samples) and then later expanded through the bubbling chamber to test the ABC (after bubbling chamber) method. Figure 1-1 shows some pictures of the experimental set-up. Sixteen copper tube samples were collected prior to the bubbling (PBC samples, 11 duplicates were also taken in steel canisters), 12 copper tube samples were collected ABC, and 5 additional copper tube samples were collected of PCAT waters and bubbling chamber waters. Thus, there is a total number of 33 copper tube samples and 11 steel canister samples collected during this sampling trip. These samples will provide gases with less atmospheric contamination for noble gas analysis and allow for characterization of possible fractionation of gases during bubble chamber sampling.

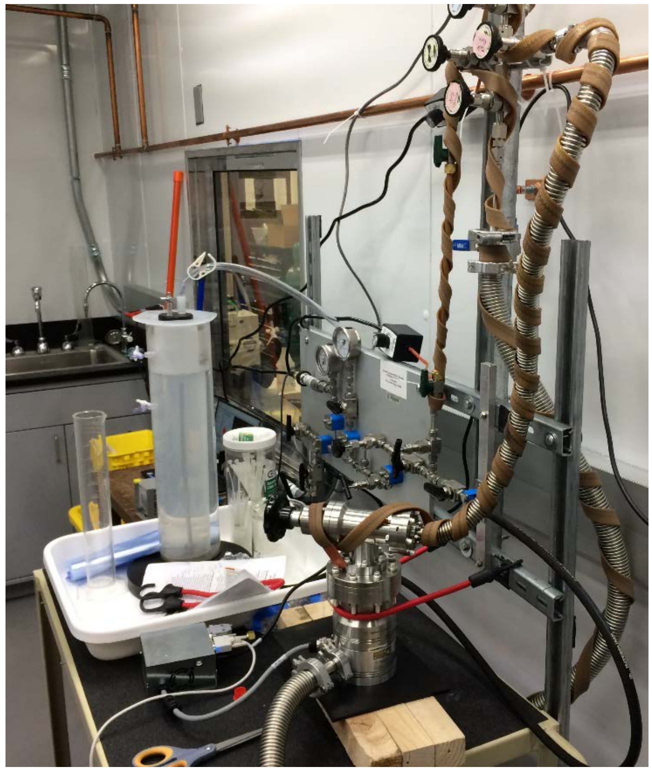

Figure 1-1. The degassing system with the heating tapes throughout the additional vacuum system and copper tube (used to collect the Pre-Bubbling Chamber (PBC) samples). The heating tapes help to pump away vapor prior to sample collection and between sample collection periods during the degassing.

A2. Index properties, permeability and compressibility of GC 995 lithofacies

- UT continued studying the index properties, permeability, and compressibility of the reconstituted lithofacies in the UT-GOM2-1 pressure cores. Specifically, we used a resedimentation method and made new specimen of lithofacies 3 (a clayey silt lithofacies) from dissociated pressure core UT-GOM2-1-H005-11FB-1. We then measured the index properties, particle size and intrinsic permeability, compressibility and capillary behavior. The intrinsic permeability and compressibility were measured by CRS test and capillary behavior was measured by MICP test.
  - Lithofacies 2 has a liquid limit (w_L) of 23 % and plastic Index (I_p) of 3.5%. Lithofacies 3 has a w_L = 49.8%, and I_p = 28%. Lithofacies 2 (4FB-8) sediments are inorganic silts and lithofacies 3 (11FB-1) are classified as lean clay (CL) (Figure 1-2), confirming that the index properties of GOM2 lithofacies 2 and 3 sediments are accurately measured and fit the characteristic index properties of the Gulf of Mexico sediment.
  - Lithofacies 2 sediments are sandy silts and well-sorted, with median grain size D_{50} = 48 μm (Figure 1-3, red symbols,). In contrast, lithofacies 3 sediments are clayey silts and more poorly sorted, with median grain size D_{50} = 2.8 μm (Figure 1-3, green symbols).
  - The permeability of lithofacies 3 varies from 2.7×10^{-2} mD to 3.84×10^{-4} mD over a porosity range from 0.516 (0.02 MPa) to 0.306 (3.8 MPa). These data also follow a log linear trend with γ = 8.38 and β = -

21 (Figure 1-4). The permeability at the in-situ porosity (n = 0.4) is 2.2×10^{-3} mD whereas the permeability at the predicted in-situ effective stress (σ'_v = 3.8 MPa) is 3.84 ×10^{-4} mD.

- Lithofacies 3 is more compressible than lithofacies 2 over an effective stress range of 0.1 to 3.8 MPa, but its compressibility increases with the effective stress over 3.8 MPa (Figure 1-5).
- The capillary pressures for lithofacies 3 are approximately 100 times greater than that of lithofacies 2 over water saturations that range from 50 to 100% (Figure 1-6).

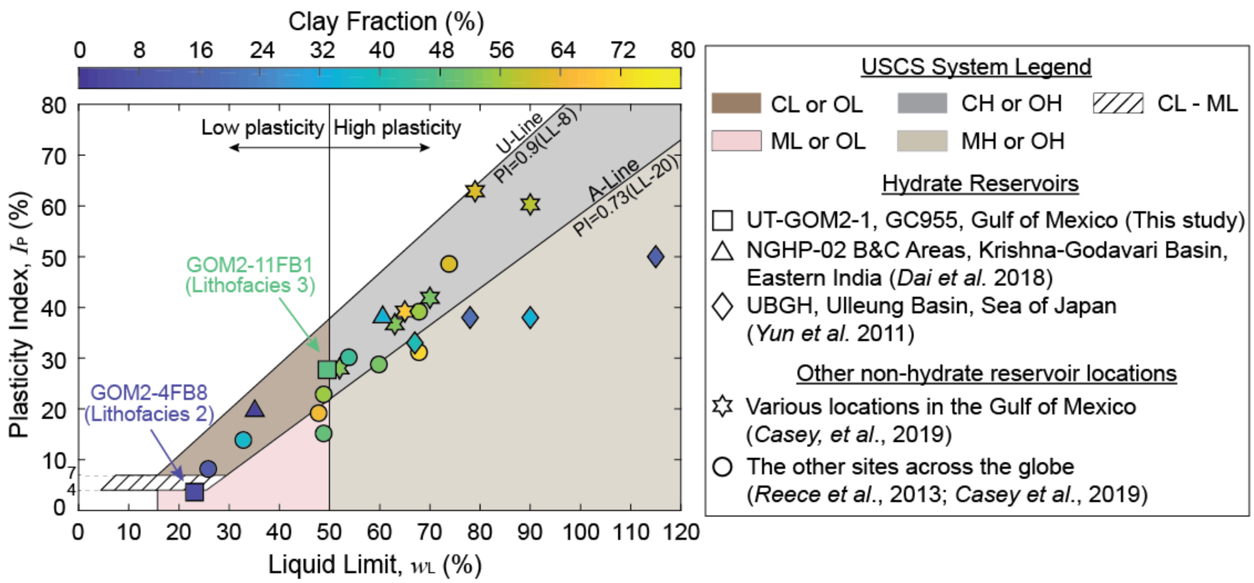

Figure 1-2: Casagrande plasticity chart of core sediments. The clay fraction of each sample is color coded. The bright yellow indicates the highest clay content and the dark blue shows the lowest clay content. The region background colors denote the Unified Soil Classification System (USCS) symbols (i.e., CL, OL, CH, OH, ML, A-Line, U-Line), which are defined and interpreted in ASTM D2487 (2017). Sample 4FB-8 (lithofacies 2) falls within the ML or OL zone and is close to the lower boundary of CL-ML zone. Sample 11FB-1 (lithofacies 3) is within the CL or OL zone and is near the left boundary of the CH or OH zone. Atterberg limits of our samples are compared to other gas hydrate reservoirs (Dai et al., 2018; Yun et al., 2011) and non-hydrate reservoir locations (Casey et al., 2019; Reece et al., 2013)

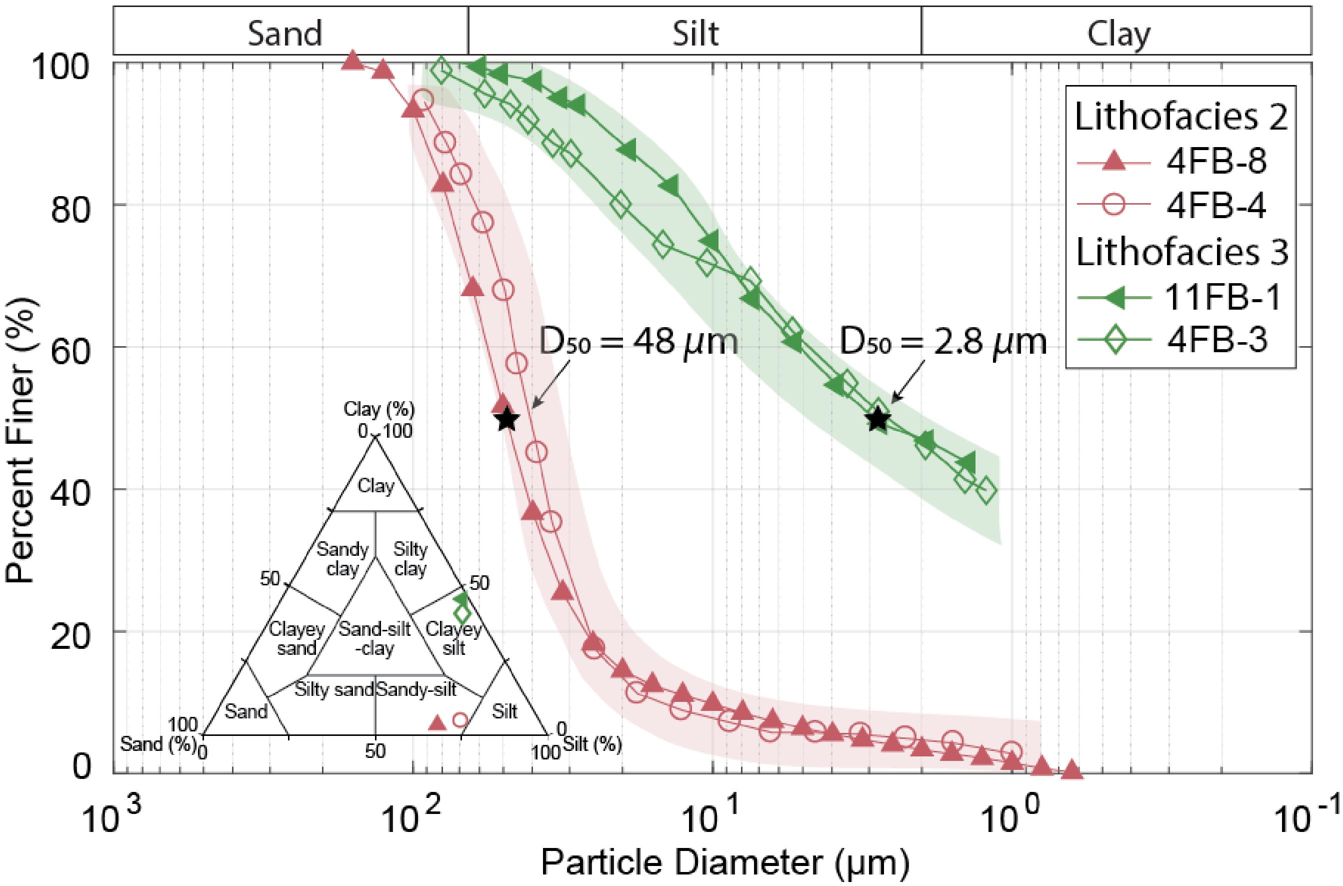

Figure 1-3: Grain size distribution plots on a semi-log scale. Data points of 4FB-4, 11FB-1, 4FB-3 represent hydrometer readings. Data of 4FB-8 were obtained from analysis by laser diffraction. Sand/silt boundary is defined at 62.5 μm, and silt/clay boundary is defined at 2 μm. Characteristic grain size distribution of lithofacies 2 is obtained from core 4FB-2 and 4FB-8. Characteristic grain size distribution of lithofacies 3 is obtained from core 4FB-3 and 11FB-1. Each lithofacies shows consistent fractions of sands, silts and clay. Sediments of 4FB-8 and 11FB-1 were used for reconstituting artificial samples for permeability and CRS experiments. Sedimentological classification of the lithofacies based on the Shepard scale indicates that lithofacies 2 is sandy silt and lithofacies 3 is clayey silt.

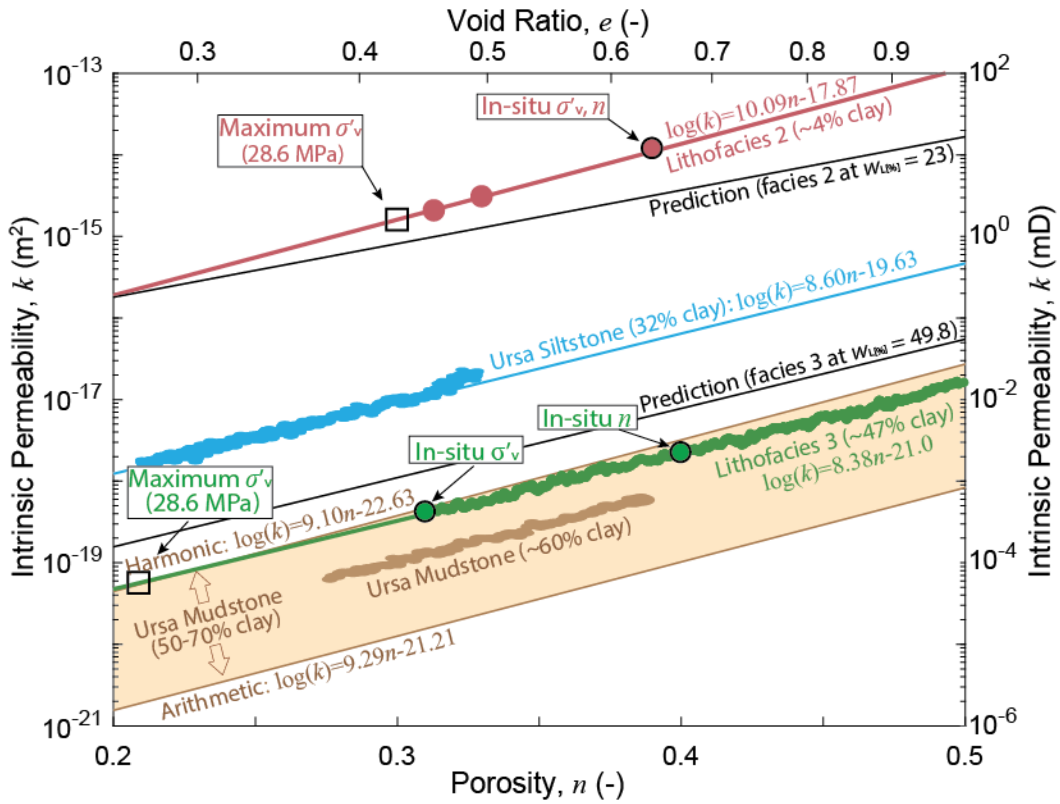

Figure 1-4. The permeabilities of reconstituted 4FB-8 and 11FB-1 samples. Results of lithofacies 2 were obtained by flow tests (red dots) and results of lithofacies 3 were measured by the CRS experiment (green dots). Log-linear porosity-permeability of Ursa Siltstone is marked in blue line and Ursa mudstones with clay from 50% to 79% is marked in the yellow zone (Reece et al., 2012). The black lines are the predicted intrinsic permeabilities using k - w_L[%] correlations (w_L[%] = 23 for lithofacies 2 and w_L[%] = 49.8 for lithofacies 3) summarized from all mudrocks in Casey et al. (2013)

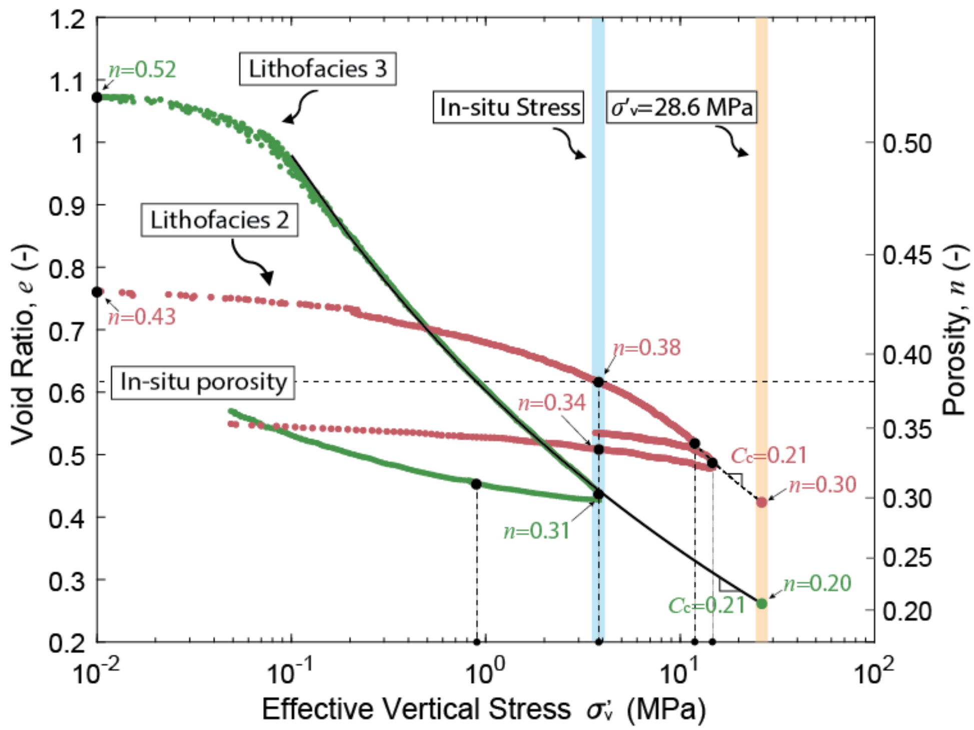

Figure 1-5. Evolution of void ratio under vertical effective stress. (a) Result of reconstituted lithofacies 2 sediments (4FB-8) during the loading under a constant rate of 2.5%/hr. The black solid line of lithofacies 2 is speculated based on the constant compression index (C_c = 0.21) over 10 MPa (Casey et al., 2019). (b) Result of a resedimented specimen of lithofacies 3 sediments (11FB-1) during the loading under a constant rate of 0.4%/hr. The black solid line of lithofacies 3 is a fitting curve described by log-linear relationship between n and σ'v (i.e., $n - n_{ref} = -C_{Cn} log_{10}(\sigma'_v/\sigma'_{vref})$) in Casey et al. (2019). For this sample, n_{ref} = 0.3759, σ'_v=1 MPa, C_{cn} = 0.1188, and R_2 = 0.9992.

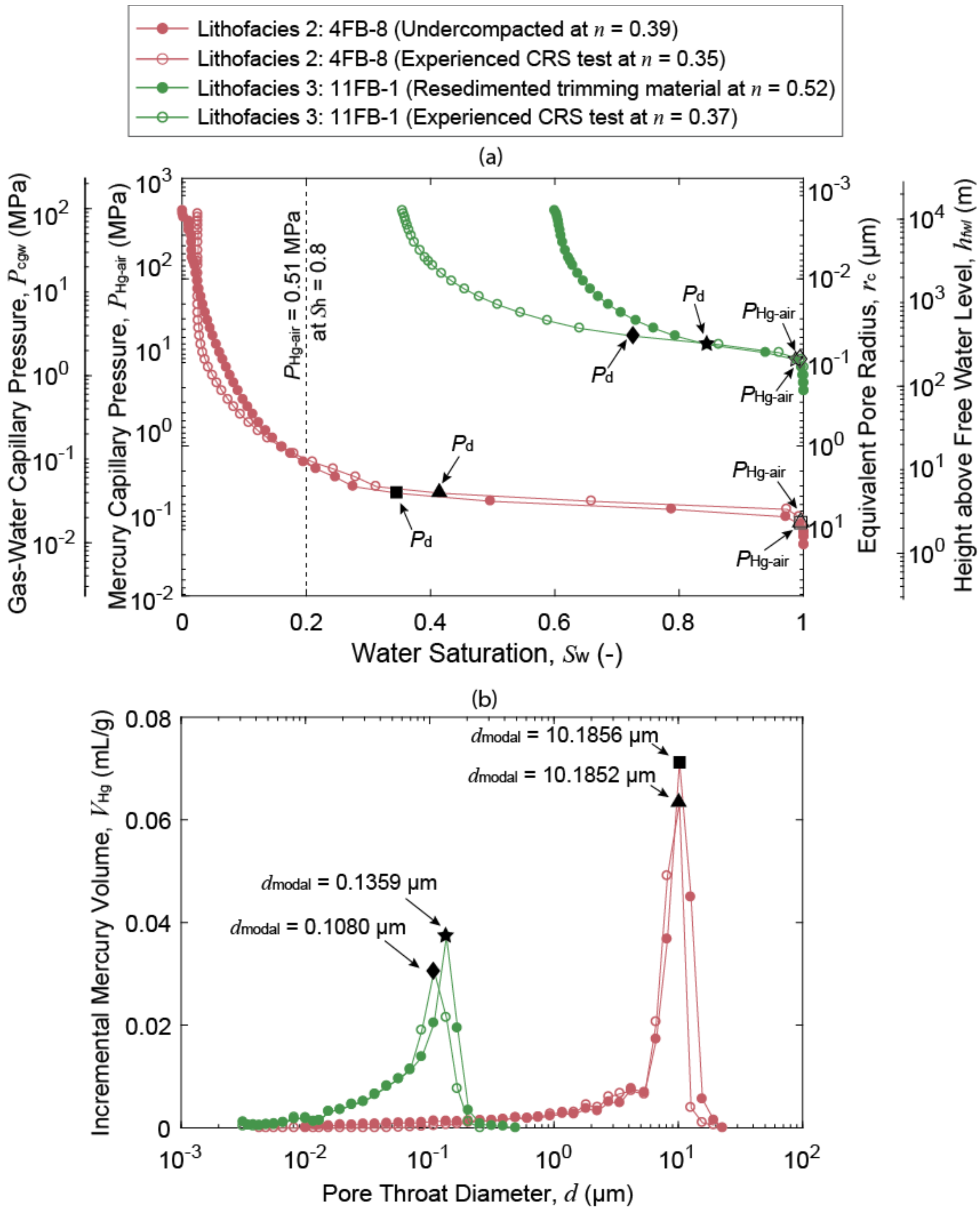

Figure 1-6. Results of Mercury injection capillary pressure measurement of reconstituted lithofacies 2 and 3 sediments. (a) Hg-air entry pressure curves. (b) Incremental Mercury injection volume with pore throat diameter.

- UT submitted manuscript to the AAPG Bulletin special issue summarizing the UT-GOM2-1 Expedition Results. *Flemings et al. (in review) Concentrated hydrate in a deepwater Gulf of Mexico turbidite reservoir: initial results from the UT-GOM2-1 Hydrate Pressure Coring Expedition, American Association of Petroleum Geologist Bulletin.*

- UT submitted manuscript to the AAPG Bulletin special issue summarizing the pressure coring results and core quality of the main reservoir at GC 955 based on pressure coring data, core recovery, and core CT images. *Thomas, et al. (in review) Pressure-coring operations during Expedition UT-GOM2-1 in Green Canyon Block 955, northern Gulf of Mexico, American Association of Petroleum Geologist Bulletin*

- Ohio State University began working on a paper outlining how to determine gas hydrate saturation from the expedition X-ray image data of the pressure cores to compare to quantitative degassing results. However, after reviewing our methods during writing the paper, they have made a change to the method and need to modify and recalculate the work as previously reported.

- Oregon State, with UT, is helping prepare for the microbial analysis of the UT-GOM2-1 pressure cores at UT, collaborating with Zara Summers (ExxonMobil), Bill Waite, Junbong Jang (both of USGS), and Jenn Glass and Sheng Dai (both of Georgia Tech). Experiments continue to be planned that can be conducted with the preserved cores to determine which microbial communities are stimulated as a result of depressurization in a lab study that would be somewhat analogous to a depressurization in the field aimed at producing methane from hydrates. Among the few samples that are still at pressure is one that is close to a reference sample taken at the time that the cores were collected in 2017. The microbial community in this reference sample has been characterized at ExxonMobil Research by Zara Summers and Ian Drake and will be a useful comparison for the communities derived from the pressure core. After consulting with Zara Summers (ExxonMobil) and Brandi Kiel Reese (TAMU-Corpus Christi) we have developed the following plan:
    - Depressurize the core then freeze at -80 C so that the same sample can be used for both DNA and RNA extractions. Then:
    - Option 1: Extract both nucleic acids (RNA and DNA) simultaneously using the RNA PowerSoil kit with DNA elution accessory kit. This has maximized yield in similar samples possessing low biomass, or
    - Option 2: Split the extraction mid-way through the phenol-chloroform extraction in order to get both RNA and DNA so that we can conduct both a metagenome and a metatranscriptome study.
    - We may need to pool multiple separate extractions to get a reasonable set of amplicons.
    - If the cells are active, there should be more RNA than DNA. The main concern is the sampling time and preservation of RNA. If the cells experience changing conditions during depressurization we may lose some of the RNA signal and possibly see evidence of a stress response. A possible approach is to use an RNA preservation cocktail quickly upon depressurization to preserve a viable signal. Even with low biomass, it may be possible to create cDNA (without doing a rRNA cleanup step) from the extract and then amplify with 16S primers. To avoid liquid water in the presence of the RNA we will flood the sample with RNA protectant immediately.

New methods for DNA extraction have been obtained from Ian Drake (Exxon). After trying multiple methods, the FastDNA kit for soil was the most effective as it allowed high throughput and better yields and purity than other kits or approaches. Drake includes a number of modifications that optimize the DNA yield:

- Limit freeze thaw cycles before sampling
- Get samples into a phosphate buffer before any lysis so that the PO4 sources (PolyA) binds to the sediment before your genomic DNA has a chance to.
- Sample only the middle of the core and scrape away a layer before sampling for extraction, to avoid drill mud. Multiple samples throughout the center of the core is best as this increases your chances in yielding DNA from these low biomass samples
- Microbes appear too patchy in their distribution (scattered pockets of communities). Apparent replicates of the same samples may yield dramatically different concentrations of DNA even though it appeared to be the same sample.
- Extract many of these "biological replicates" from each core sample, as the FastDNA soil kit only handles 0.5g at a time. Each 0.5g "replicate" subsample should be sequenced to avoid losing DNA by trying to combine and concentrate samples.
- Linear poly acrylamide (LPA) may be used as a co-precipitant as necessary with low biomass samples.
- For the samples that never really yielded a large enough amount of DNA, a Sygnis Whole Genome Amplification kit works well, especially on low concentrations of DNA, possibly because it uses primase to generate primers in situ instead of using random hexamers.

In summary, there are approaches that we can use to capture DNA from ultra-low biomass samples and they may be modified in order to also collect samples for RNA determinations. The respective analyses allow the chance to determine genetic diversity and identity (DNA) and specific activity (RNA) of microbes in the sediments. We are presently developing a plan for how these analyses will be made on UT-GOM2-1 samples maintained in pressure vessels since May 2017. Current plans with the team would be to initiate these studies by collecting samples in late July 2019 at UT.

A3. Pressure Core Distribution

- UT 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-GOM2-1-3FB-5 and 5FB-3. The execution of the agreement should begin once AIST has secured funding.

B. Depressurized Pressure Core Analysis

- Washington University (UW)

  Status of Sediment and Pore Water Samples

  UW has extracted the pore water from all whole-round samples received; and is characterizing the geochemistry of all pore water samples received from the UT-GOM2-1 Hydrate Pressure Coring Expedition to date. UW contributed pore water chemistry data to the Expedition report. UW is still expecting to receive water samples from UT-GOM2-1 Pressure Cores collected during degassing and/or permeability studies at UT and shipped to UW.

  When pore water samples are limited by volume, sample allocation for specific analyses must be prioritized. **Appendix A**, Table 1, shows the sample subdivision priority used for the UT-GOM2-1 pore water samples. As a result of low pore water recovery from some whole-rounds, some samples were only analyzed for select solutes and isotope ratios. As shown in **Appendix A**, Tables 2-4, we have finished the salinity, Cl, Br, SO_4, Ca, Mg, K, Na, B, Li, Sr, Ba, Fe, and Mn concentration analyses, as well as $\delta^{18}O$ and δD stable isotope ratios analyses. We have finished the analyses of pore water samples for PCATS contamination, tracked by Cs tracer concentrations. In addition, pore water subsamples per sediment sample received have been preserved for a range of analyses, and are available to the science party. Sub-samples include 1-2 ml in sealed glass ampoules, 1-2 ml frozen in amber bottles, 1-2 ml in glass vials, 1-4 ml acidified to pH <2 and stored in acid-cleaned plastic bottles, and 1-4 ml un-acidified samples stored in plastic bottles. Likewise, squeezed sediment whole-round cores have been sectioned into three sub-samples and 1) stored at room-temperature and are available to the science party, 2) frozen and are available to the science party, and 3) sent to UNH for analysis of grain size, TC, TN, TS, TOC, and derived $CaCO_3$.

  PCATS Water Contamination

  These analyses were completed this reporting period. Onboard GOM2-1, 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 GOM2-1 expedition, pore water samples exhibited very low contamination ranging from <0.003-0.02% contamination.

  Drilling Fluid Contamination

  We corrected the pore water major and minor element concentration data, as well as the oxygen and hydrogen isotope ratios for drill water contamination based on the measured sulfate concentrations in drilling fluid and pore water samples.

Below the sulfate-methane transition zone, sulfate is depleted in the pore fluids, and any sulfate present in a sample is a result of contamination with drill water that was pumped down the hole while drilling. Drilling fluid was sampled during coring at both Sites H002 and H005 and analyzed as at the University of Washington. Based on the sulfate concentration of each pore water sample, we used the chemical composition of the drilling water to correct each analysis for contamination using the following equations:

$F_{DW} = [SO_4]_{meas}/[SO_4]_{DW}$

$f_{Pf} = 1 - f_{DW}$

$[X]_{corr} = [[X]_{meas} - (f_{DW} \times [X]_{DW})]/f_{Pf}$

Where f_{DW} is the fraction of a pore fluid sample that is contaminated with drilling fluid and f_{PW} is the fraction of uncontaminated pore water in a sample. The subscripts DW, PF, and meas denote drill water, pore fluid, and measured, respectively. $[X]_{corr}$ is the corrected value of a solute (e.g., Cl, Ca, Sr, etc.), $[X]_{meas}$ is the measured concentration of that solute, and $[X]_{DW}$ is the concentration of the solute in the drilling fluid.

The uncorrected geochemical data are shown in **Appendix A**, Table 1, and the corrected data based on the composition of the drill water collected during coring at Sites H002 and H005 are presented in **Appendix A**, Table 2. There is large variability in the drill water composition in drilling fluid samples collected between the two sites, and it was significantly altered with respect to surface seawater composition. Typically, surface seawater is used as a drilling fluid. As such, I also provide corrected data in **Appendix A**, Table 3, assuming the drilling fluid had a composition of average seawater.

Ammonium and Silica Concentration

There was not enough pore water recovered from the whole-round samples for DOC concentration analyses.

Dissolved Organic Carbon Concentrations

There was not enough pore water recovered from the whole-round samples for DOC concentration analyses.

Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis

- No update

Subtask 10.6: Additional Core Analysis Capabilities

- UT, with Geotek, installed the X-ray CT system with P-wave attachment for Mini-PCATS in January 2019 (Figure 1-7) which will aid in the proper identification and cutting of specific lithofacies.

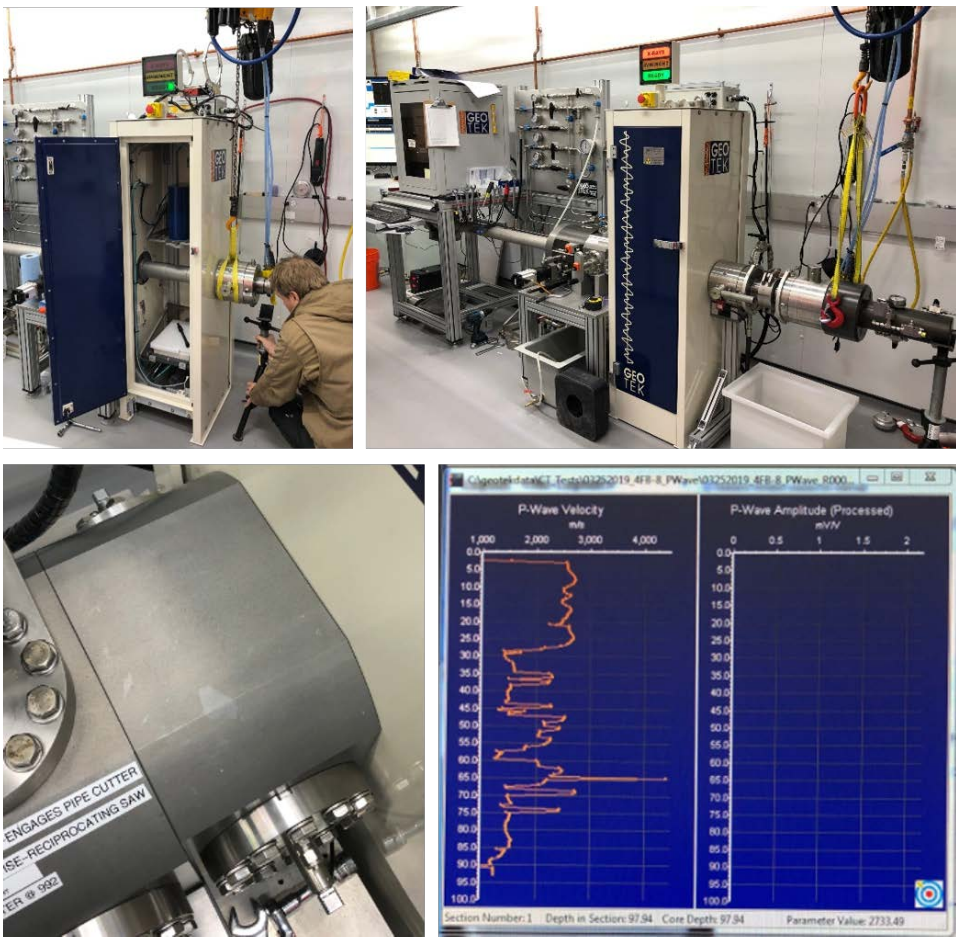

Figure 1-7. Top: Images of the new CT scanning attachment installed on the UT Mini-PCATS system, bottom: Images of the P-Wave attachment and initial data.

- The first core to undergo scanning with the Mini-PCATS XCT was Core UT-H005-09FB-3 (compromised core). New core scans of this pressure core revealed that the pressure core had undergone changes in core diameter while in storage. We believe this is a result of the core being compromised during the expedition. Subsequent scans of uncompromised core confirmed that they had not undergone significant changes.

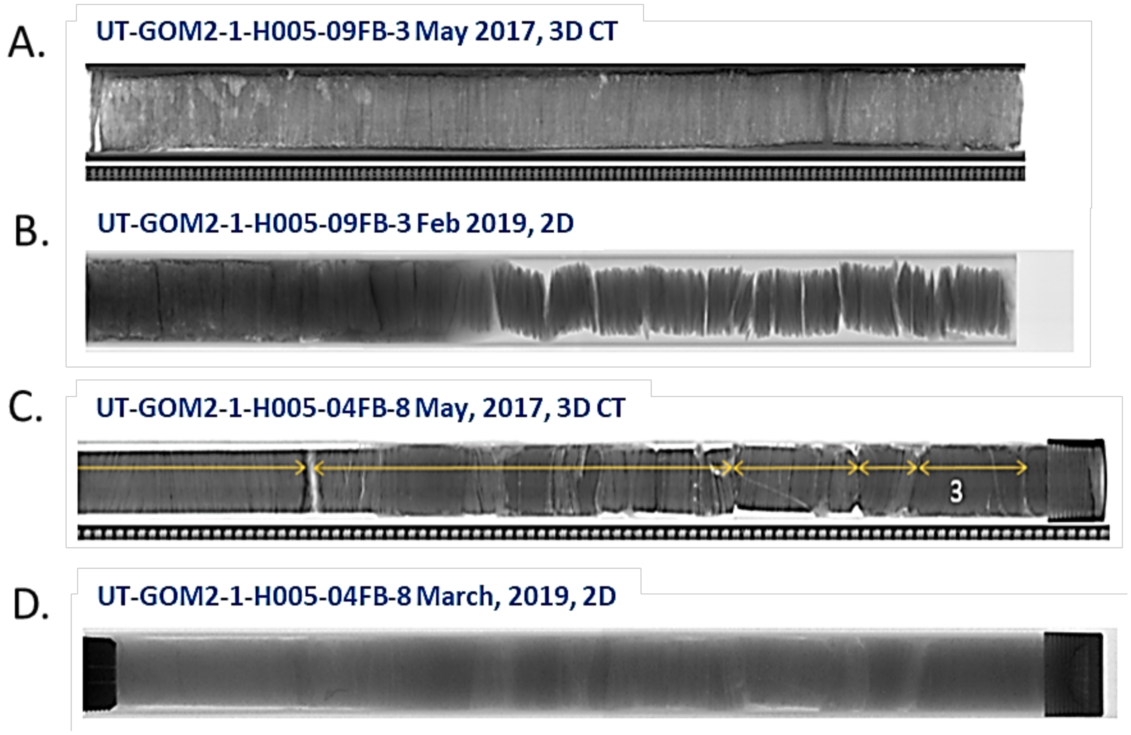

Figure 1-8. A comparison of pressure core images before and after storage A. Full 3D CT scan of compromised Core UT-GOM2-1-H005-09FB-3 during the expedition, B. Quick 2D scan of compromised Core UT-GOM2-1-H005-09FB-3 after almost 2 years of storage showing degradation of the core, C. Full 3D CT scan of uncompromised Core UT-GOM2-1-H005-04FB-8 during the expedition, D. Quick 2D scan of uncompromised Core UT-GOM2-1-H005-04FB-8 after almost 2 years of storage showing no significant degradation of the core.

- UT ordered a Geotek Pre-consolidation System. The system would at a minimum all for multiple K0 permeameter samples to be cut, stored, and prepared for analysis saving time and the amount of core we need to allocate and discard to the PCATS grabber. With the current equipment we can only cut one sample at a time. UT reviewed design options with Geotek.

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 UT-GOM2-1 marine field test (May-June 2017). Performed weekly pressure checks on pressure chambers.

Subtask 13.1: Hydrate Core Manipulator and Cutter Tool

- Installation of the Mini-PCATS 3D X-ray CT system.
- X-ray system underwent critical inspection by UT EHS and Geotek.
  - No adverse radiation leakage detected. All limits within normal.
- Three cores scanned and subsampled with the aid of the new CT scanner system
  - Core H005-6FB-1 – K0, Degas samples
  - Core H005-13FB-1 – Degassed and sampled w/ Ohio State
  - Core H005-4FB-8 – K0, Degas samples
- One core scanned and degassed
  - Core H005-9FB-3 – Fully degassed
- System cleaned and cutter blades replaced after each sampling.

Subtask 13.2: Hydrate Core Effective Stress Chamber

- One pressure core sample from core H005-6FB-1 was tested and dissociated in the effective stress chamber in Late February-March, 2019. Sediments from sample collected for additional analysis.
- Completed K0 system maintenance in March, 2019.
- One pressure core sample from core H005-4FB-8 was tested and dissociated in the effective stress chamber in Late March-April, 2019. Sediments from sample collected for additional analysis.
- Consult with Ingersoll-Rand and upgraded PCC compressed air system has reduced moisture in air lines.

Subtask 13.3: Hydrate Core Depressurization Chamber

- Ran three degassing tests during Q1. The results of these experiments are discussed above in Subtask 10.4
  - H005-09FB-3, was degassed in February, 2019
  - H005-06FB-1, was degassed in Late February, 2019
  - H005-13FB-1, was degassed in Early March, 2019
  - H005-04FB-8 undergoing degassing currently

Subtask 13.4: Hydrate Core Transport Capability for Field Program

- Future Task (UT-GOM2-2).

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 UT-GOM2-2.

Subtask 13.6: Transportation of Hydrate Core (Field Program)

- Future Task (UT-GOM2-2).

Subtask 13.7: Storage of Hydrate Cores (Field Program)

- Future Task (UT-GOM2-2).

Subtask 13.8: Hydrate Core Distribution

- Future Task (UT-GOM2-2).

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

Status: Ongoing

Subtask 14.1: PCTB Lab Testing and Analysis

PCTB Bench Testing Program

- UT and Geotek, completed NEPA requirements for installing a vertical in-house testing capability at the Geotek Coring Inc. facility in Salt Lake City, Utah.
- Geotek completed a vertical testing capability at the Geotek Coring Inc. facility in Salt Lake City, Utah. This capability will allow the PCTB to be fully assembled in the optimal configuration, suspended vertically in the test hole, and undergo pressure testing.
- In February, 2019, UT shipped the PCTB to Geotek in Salt Lake City, Utah for the Bench Testing program.
- Geotek developed a detailed plan for the PCTB bench testing program.
- Geotek developed an experimental single-trigger ball valve closure mechanism for the PCTB.
- Geotek is currently building up the first pressure function test (PFT) of the PCTB, which will use the exact configurations deployed during UT-GOM2-1. Geotek will then adapt in the single trigger mechanism for testing.

Computational Fluid Dynamics (CFD) Analysis

- Geotek completed 3-dimensional CAD model of PCTB
- Reaction Engineering (REI) completed the first phase of the CFD scope of work:
    - Developed a CFD model to simulate flow of sea water through PCTB
    - Verified CFD model after some minor configurations
    - Conducted baseline simulations to assess flow and pressure fields in PCTB at lower and middle range of typical PCTB coring parameters
- The CFD analysis verified that the PCTB flow diverter is performing as designed (eliminates high pressure differentials from forming across core liner and inner tube walls, eliminating collapse of core liner). It also provided magnitudes for various pressure drops throughout the tool during coring operations.

These results were used to more accurately define the overall pressure drop throughout the PCTB, leading to more accurate predictions of pump pressures while coring.

Subtask 14.2 Pressure Coring System Modifications/Upgrades

- Geotek has initiated a test design for a single-trigger mechanism to close the ball valve and fire the pressure boost in the PCTB. This is currently experimental, but will be tested and may inform a figure modification to the tool to optimize sealing of the autoclave.

Subtask 14.3: PCTB Land-Based Testing and Analysis

- UT and Pettigrew Engineering continued planning activities for PCTB Land Test:
    - Negotiated tentative schedule at Schlumberger CTTF for 10-12 days in late September, 2019.
    - UT and Pettigrew Engineering initiated scope of work and cost discussions with Schlumberger.
    - UT initiated contracting discussions with Schlumberger.

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

UT will conduct the UT-GOM2-2 expedition independently as was done for UT-GOM2-1.

Given this new scenario, in late 2018 UT began to develop a new UT-GOM2-2 operational and science plan to maximize scientific objectives within the existing budget. At the OSU Workshop in September, 2018, the UT-GOM2-2 planning teams were charged with specific tasks to develop the new expedition program. Based on the recommendations of the planning teams, UT compiled a recommended plan. The GOM2 Advisory Team then provided feedback. After several iterations (Figure 1-9), a final plan was developed. This plan will be presented to DOE in the next quarter with the vision that this process will be completed by the end of the fiscal year (Figure 1-9). The details of this process are described below.

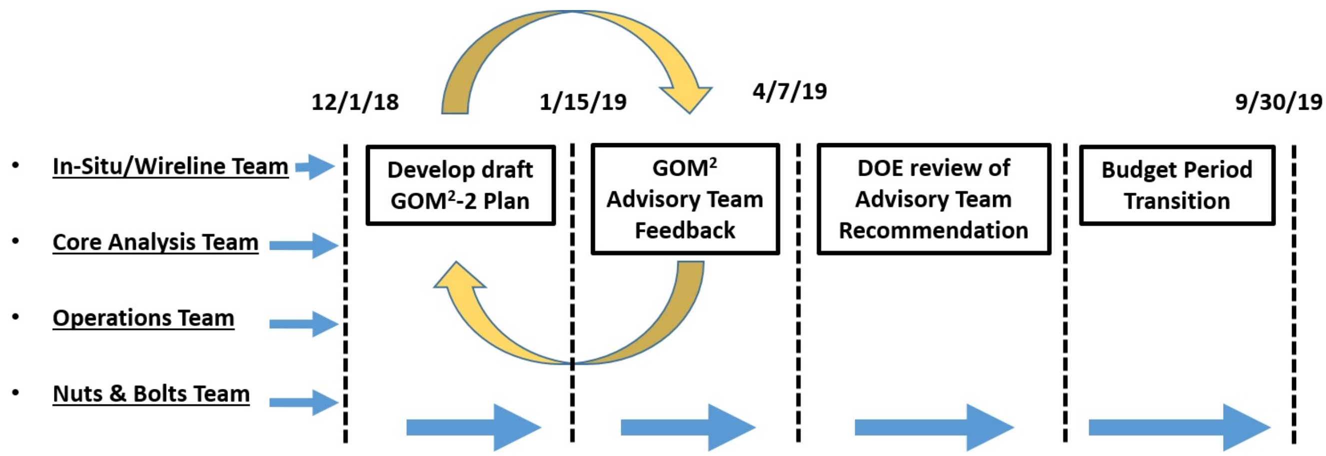

Figure 1-9. Envisioned process and timeline for team recommendations, plan development, and modification to the project.

A focus group of GOM2 science leads and team members from UT and OSU met in Marble Falls, Texas from January 8-11 to integrate recommendations from the GOM2-2 working teams and develop possible GOM2-2 operational plans. Recommendations provided by the various GOM2-2 Planning Teams (including the Operational Team, the Wireline Team, and the Core Analysis Team) were condensed into a list of eight possible UT-GOM2-2 science objectives (Table 1-6). Five possible operational plans were then outlined, budgeted, and evaluated against the current UT-GOM2-2 budget to assess what is feasible with the current funding. The focus group also evaluated what of the original science plan could accomplished with additional incremental funds.

Table 1-6: Possible UT-GOM2-2 scientific objectives

Objective 1	Characterization of the Orange Sand hydrate reservoir through pressure coring
Objective 2	Reservoir characterization through in situ testing and wireline logging across the Orange Sand at TBONE-01B
Objective 3	Reservoir characterization and in situ measurements through LWD in TBONE-02A
Objective 4	Measurement of the thermal gradient – temperature profile (1640 fbsf)
Objective 5	Characterization of the dissolved methane concentration and the hydrocarbon composition depth profile
Objective 6	High resolution geochemical and sedimentary profiles – moving towards an exploration model
Objective 7	Reservoir characterization of other Targets
Objective 8	Characterizing hydrate reservoirs at different thermodynamic states within a dipping sand (up-dip, down-dip)

UT presented the eight possible science objectives, and five possible operational plans to the GOM2 Advisory Team, composed of members of UT, Ohio State, LDEO, DOE, BOEM, and USGS, and a panel of technical experts from Oregon State, UNH, and UW, in a web conference on January 24, 2019.

Advisory Team feedback from the January 24 meeting:

1. Agreed that the highest priority is reservoir characterization of the main target: the TBONE-01B (WR3213H) hydrate-bearing Orange Sand.
2. Requested more discussion on the MDT and wireline logging goals and asked for us to separate the goals.
3. Agreed that measurement of the thermal gradient – temperature profile was important, but asked if there was another/better way to obtain the profile.
4. Agreed with the possibility of obtaining spot pressure cores to gain information on the dissolved methane profile and a limited amount of geochemical and microbiology data. Confirmed that the dissolved methane could only be calculated from pressure cores, but when acquired by conventional cores, could be used to confirm the diffusion model of hydrate formation if sufficient samples were taken in mudstones bounding hydrate-bearing sandstone.
5. Agreed that high resolution geochemical and sedimentary profiles provided important science.
6. Generally agreed with the possibility of obtaining reservoir characterization of other targets, but questioned the ability to obtain cores from these intervals.
7. Questioned the de-prioritization of the science from understanding lateral connectivity within a dipping sand, which was an important component of the original plan proposed to IODP (CPP-887). Requested science and budget analysis of replace the downdip hole at WR313-G with LWD and coring of the updip Terrebonne-02A location.

UT addressed the feedback from the January 24 meeting then met again with the Advisory Team and Technical Experts on February 7, 2019. UT presented revisions to the science objectives, possible operational plans & budgets, and presented a sixth possible operational plan. As a result of this meeting, a seventh possible plan was also introduced.

On March 4, 2019 UT provided the GOM2 Advisory Team and Technical Experts with a Decision Document for the UT-GOM2-2 Gulf of Mexico Hydrate Coring Expedition. The Decision Document defined the eight science objectives for UT-GOM2-2, and presented four possible in-budget plans to meet the science objectives. The document addressed, in detail, the scientific benefits of each plan, identified risks of each plan, and cost of each plan. UT requested a decision as to which plan to proceed with based on 1) the relative importance of each science objective, 2) the degree to which any plans meets the objectives, and 3) the risk of not meeting the objectives.

On March 18, 2019, UT met with the Advisory Team and Technical Experts to discuss the Decision Document. It was agreed that maximizing the potential for scientific achievement within the funding originally allocated for the coring expedition could best be accomplished by combining two of the existing plans. This plan is currently being developed based on the GOM2 Advisory Team recommendations listed below. UT will propose this plan to NETL and DOE headquarters in Y5Q3.

The UT-GOM2-2 plan will be based on the following Advisory Team recommendations:
Recommendation 1: TBONE-01B (WR 313-H) should be drilled first with the face-bit bottom hole assembly (BHA) to provide maximum time and budget to reach and acquire pressure core samples in the Orange Sand (Objective 1) and within overlying hydrate reservoirs (Objective 7). This maximizes the probability of meeting the primary objectives (Objective 1 and 7).
Recommendation 2: Meet Objective 8 by comparing the Blue Sand at TBONE-01B and at TBONE-03B. This is not as desirable as comparing the Orange Sand at up-dip and down-dip locations. However, the costs of drilling the LWD hole and the associated core hole (Objective 3) in order to penetrate the up-dip location for the Orange Sand, was felt to exceed the scientific opportunity.
Recommendation 3: Acquire pressure cores intermittently to obtain dissolved methane concentrations (Objective 5) in both holes (TBONE-01B and TBONE-03B). These data will complement T2P data (Objective 4) and conventional coring (Objective 6) in the second hole (TBONE-03B). It is understood that the number of pressure and conventional core is contingent on field conditions and budget. Enough dissolved methane samples should be acquired in the first hole to provide guidance on the expected dissolved methane profile in the second hole.
Recommendation 4: Do not perform in-situ measurements by large diameter wireline logging and Modular Dynamics Testing (MDT) over the Orange Sand. This objective (Objective 2) is of high scientific value. However, there is considerable risk that deployment of the MDT will not successfully measure permeability, or take fluid samples within the hydrate reservoir. The elevated scientific risk lead to the decision not to pursue this objective.

Subtask 15.3: Permitting for Field Program

- OSU and UT G&G permitting has been put on hold pending input from the GOM2 Advisory Team and DOE concerning UT- UT-GOM2-2. All files have been archived on the GOM2 SharePoint site

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

- No activity this period.

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:

- UT will continue to coordinate and manage Task 14.1: PCTB Lab Testing and Analysis.
- UT will continue to coordinate and plan Task 14.3: PCTB Land-Based Testing and Analysis.
- UT will document the prioritized GOM2-2 science priorities and revised UT-GOM2-2 Operational Plan based on recommendations from GOM2 Advisory Team.
- UT will propose the GOM2-2 science priorities and revised UT-GOM2-2 Operational Plan to DOE, in preparation for the BP3/BP3 budget period transition. UT has begun to prepare documents and tables for budget period transition, and will continue to do so in Y5Q3.
- UT will continue to coordinate development of technical requirements and scope of work for a drilling vessel.

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

- UT will continue to plan and prepare for the UT-GOM2-2 expedition independently. Technical and operational support of the UT-led UT-GOM2-2 field program will be conducted under Task 15 – Field Program Preparation.

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

- We will continue the quantitative depressurization of pressure core and gas analysis:
  - We are now analyzing uncompromised, high quality core, targeting gaps to 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), particularly improving the number of lithofacies 3 samples.
  - 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 k0 permeability measurement of pressure core sample 4FB-8-3.
    - Sample 4FB-8-3 will be scanned by PCTAS X-CT and cut for K0 permeability measurement. We will perform the pressure core analysis of 4FB-8-3. This analysis will include (1) measure the effective permeability of pressure core at in-situ stress; (2) measure the intrinsic permeability at in-situ stress; (3) CT-scan of the core after core is taken out of the Ko system; (4) laser grain size distribution; (5) Hg-porosity measurement; (6) Mercury injection capillary measurement.

C. *Microbiology of Pressure Cores*

- Oregon State will continue planning for the microbiological analysis of pressure cores. One of the pressure-preserved cores for microbiology was collected within centimeters of the location of one of the cores sent to ExxonMobil for microbiology study and so we will have a key reference sample to compare to. Current expectations are that these experiments will occur during the summer of 2019 based on the availability of the cores.

D. *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 continue to work on the XCT data and publication; we are making several tweaks to the estimates and plan to add some sections that were collected while drilling mud was used.
- Ohio State University will continue to measure the $\delta^{13}C$ and δD composition of methane and continue working on noble gas geochemistry results. OSU will make additional gas chromatography measurements to assist current interpretation. Ohio State is working on two noble gas and gas chemistry papers. The first is planned for the AAPG volume and will be on gas sampling. The second will be on gas source (and depending on timing and availability may not make it into the volume).
- Ohio State will measure the new noble gas samples collected in the reported quarter. These include: major gases (N2, CO2, H2), hydrocarbon (C1-C5) gas composition, stable isotopes of hydrocarbons and N2, and noble elemental and isotopic abundance measurements.
- Ohio State University will continue work on preparing manuscripts reporting on the gas source at GC 955.
- University of New Hampshire will continue working on the Bulk sediment CHNS elemental analysis, Bulk sediment TOC, N, and S isotopes
    - We will complete the remaining CHNS analyses, and C, N, and S isotopes from holes H002 and H005 prepared and start to quantify the bulk compositional trends for import gas and gas hydrate related sediment components (TOC and C/N =organic matter quantity and type, CaCO3

tracks authigenic and biogenic carbonate variations, TS tracks variations in pyrite and other Fe sulfides produced during sulfate reduction and AOM).

  - For TOC measurements, we acidified bulk sediment samples with sulfurous acid in silver capsules to remove any CaCO33 (biogenic or authigenic). The treated samples are then measured with an elemental analyzer and reflect the true TOC. We also will measure equivalent untreated samples in tin capsules to determine the TC (total carbon), and total N. The difference in TC and TOC represents the carbonate fraction in the samples. The acidification process can add sulfur and/or nitrogen; thus we use the untreated samples for TS and TN measurement. Isotopes of TOC are measured on the acidified sample and isotopes for TS and TN are measured on the un-acidified samples using a mass spectrometer.
- University of New Hampshire will continue working on the Grain size analysis using a laser particle size analyzer
  - We will complete the bulk sediment grain size measurements of the 40 prepared samples using a Malvern Mastersizer laser particle size analyzer. We will start to determine the grain size effects on the gas hydrate distribution. These measurements will be also be compared to measurements of grain size taken at UT and other locations.
- University of New Hampshire will start working Data Reports and an AAPG Special Volume submission.
- Oregon State University will continue discussions with Colwell, Klasek, Summers, and Phillips with the 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.
- Oregon State University will continue working with ExxonMobil to obtain the best DNA extraction protocols, we will make the plans needed to conduct experiments with pressurized samples that are allocated for microbial analysis. These studies will also be coordinated with researchers at USGS and Georgia Tech as noted above. As the plan for coring in 2020 develops, we will enlist new microbiology investigators to participate in analysis of expedition samples.
- Oregon State will work with UT and ExxonMobil to produce a UT-GOM2-1 Biogeochemical Report including:
  - Biogeochemical Data
  - Biogeochemical Data Analysis
  - Identification of challenges associated with preliminary studies

- UW started preparing a formal data report summarizing the UT-GOM2-1 pore water geochemical data and results
- UW will work with UT-Austin and the other project members to develop the pore water and gas sampling plan for the research expedition through a series of in-person meetings and teleconferences.

This effort will ensure the sampling and analytical plan is appropriate to fully address the expedition objectives.

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 finalize the design of the ordered Pre-consolidation System with Geotek and Geotek will start manufacturing. .
- UT will work with Geotek to identify possible critical replacement parts that UT needs to have on hand to avoid long Mini-PCATS shut down time.

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 execute the PCTB In-House Testing Program. In Q3, Geotek will complete the pressure function tests (PFT), and will initiate the pressure actuation tests (PAT).
- UT will continue to coordinate with Schlumberger regarding scope, schedule, and cost of PCTB Land Testing Program at CTTF.
- UT will continue contracting discussions with Schlumberger for PCTB land test.

TASK 15.0: FIELD PROGRAM PREPARATIONS

- Based on feedback from the GOM2 Advisory Team, UT will develop a detailed cost profile and operational plan for the revised UT-GOM2-2 coring program. UT will propose this program to NETL and DOE headquarters in preparation for the BP3/BP4 budget period transition.
- Once the UT-GOM2-2 science and operational plan has been developed, we will develop vessel requirements and scope of services that will be used as the basis for vessel acquisition.

- OSU and UT will continue to working to fulfill permitting requirements for Orca Basin and Terrebonne locations (see Subtask 15.3 for additional information).
- OSU and UT will resume G&G permitting once the revised UT-GOM2-2 field program has been developed and once we have received feedback from DOE on if/how to proceed.

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., Waite, W. F., Spangenberg, E., and Heeschen, K.U. (2018). Petrophysics in the lab and the field: how can we understand gas hydrate pore morphology and saturation? Invited talk presented at the American Geophysical Union Fall Meeting, Washington D.C.

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., 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.

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., & 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.

Erica Ewton et al. (2018). The effects of X-ray CT scanning on microbial communities in sediment cores. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS23D-1657

Yi Fang, et al. (2018). Permeability, compression behavior, and lateral stress ration of hydrate-bearing siltstone from UT-GOM2-1 pressure core (GC-955 – northern Gulf of Mexico): Initial Results. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS23D-1650

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. (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., 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.

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

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.

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

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- UT-GOM2-1 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
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- 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 presented a significant challenge to the project due to substantial in-kind contribution from IODP resulting in a comparatively low cost of the *JR* to commercial drilling vessels. The JRFB forwarded CPP2-887 to the EFB for consideration of the potential implementation of the project as an ECORD MSP.

In Fall, 2018, UT and the GOM² team began actively pursuing two alternate paths in order to achieve the scientific objectives of UT-GOM2-2:

1. **<u>ECORD MSP</u>**: Work with ECORD in their evaluation of implementing CPP2-887 as an MSP expedition.

2. **<u>UT-Led Expedition</u>**: Begin preparations to execute UT-GOM2-2 independently, as was done for UT-GOM2-1 in Green Canyon 955.

The EFB met on September 10, 2018 to review CPP2-887 and evaluate implementing UT-GOM2-2 as an MSP. As a meeting outcome, EFB recommended that the ESO support an abridged CPP2-887 expedition as an MSP for implementation in 2021. The ECORD Council and ECORD Science Support and Advisory Committee met in November met on November 7-8, 2018 to plan operations and allocate budgets. ECORD Council determined that previously-postponed Arctic and Antarctic expeditions would be prioritized for implementation in 2021-2022. Therefore ECORD Council determined it was not possible to implement CPP2-887 as an MSP.

The clear path forward for UT-GOM2-2 is for UT to contract a vessel independently as was done for UT-GOM2-1. UT has already begun this process. In Fall 2018, we began working with UT administration to prequalify drilling vessel vendors. In August, 2018, a request for qualifications (RFQ) was posted publicly and sent to targeted vessel contracts, with the intent to follow up with a Request for Proposal (RFP). However, UT canceled the RFQ in December, 2018 due to uncertainties in the expedition schedule, and the need to re-evaluate field program so that it fits within originally envisioned budget. Until we determine and commit to a plan, we are unable to cost-effectively contract a fit-for purpose vessel. Given then now-anticipated delay to 2021, the RFP will most likely be delayed until spring 2019.

As discussed above, UT has worked extensively with the GOM2 planning teams, the GOM2 Advisory Team and technical experts from Ohio State, UNH, LDEO, UW, and Oregon State to prioritize science objectives and develop a revised operational plan that can be accomplished within the existing expedition budget. We will present the proposed UT-GOM2-2 plan to DOE in Y5Q3. If approved, we will then develop a detailed vessel scope of work and evaluate the optimal path forward for vessel acquisition.

3.3 CHANGES THAT HAVE A SIGNIFICANT IMPACT ON EXPENDITURES

The budget for the UT-GOM2-2 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, with substantial in-kind contribution. It is now clear that UT-GOM2-2 will be executed independently using a commercial vessel that is privately contracted by UT, and without additional financial backing from the IODP or ECORD.

UT has analyzed the costs associated with executing the 56-day expedition originally planned in CPP2-886. If UT contracts all expedition-related activities, subcontractors, and vendors independently, as was done for the 2017 UT-GOM2-1 Marine Test, costs would increase significantly. Therefore, we are working with the UT-GOM2-2 planning teams and the GOM^2 Advisory Group to develop an expedition plan with reduced scope and reduced budget that still achieves 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	$ 22,778,167	$ 788,190	$ 23,566,357	$ 1,270,466	$ 24,836,823
Non-Federal Share		$ 358,558	$ 20,625,085	$ 358,558	$ 20,983,643	$ 358,558	$ 21,342,201
Total Planned		$ 1,424,791	$ 43,403,252	$ 1,146,748	$ 44,550,000	$ 1,629,024	$ 46,179,024
Actual Incurred Cost							
Federal Share		$ 394,532	$ 21,967,474	$ 433,578	$ 22,401,052	$ 518,480	$ 22,919,532
Non-Federal Share		$ 211,985	$ 20,999,161	$ 207,161	$ 21,206,322	$ 155,856	$ 21,362,178
Total Incurred Cost		$ 606,517	$ 42,966,635	$ 640,739	$ 43,607,374	$ 674,336	$ 44,281,710
Variance							
Federal Share		$ (671,701)	$ (810,693)	$ (354,612)	$ (1,165,305)	$ (751,986)	$ (1,917,291)
Non-Federal Share		$ (146,573)	$ 374,076	$ (151,397)	$ 222,679	$ (202,702)	$ 19,977
Total Variance		$ (818,274)	$ (436,617)	$ (506,009)	$ (942,626)	$ (954,688)	$ (1,897,314)

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	$ 30,502,597	$ 458,336	$ 30,960,933	$ 6,464,836	$ 37,425,769	$ 458,336	$ 37,884,105
Non-Federal Share	$ 496,980	$ 21,839,181	$ 496,980	$ 22,336,161	$ 496,980	$ 22,833,140	$ 496,980	$ 23,330,120
Total Planned	$ 6,162,754	$ 52,341,778	$ 955,316	$ 53,297,094	$ 6,961,816	$ 60,258,909	$ 955,316	$ 61,214,225
Actual Incurred Cost								
Federal Share	$ 1,094,173	$ 24,013,705	$ 524,054	$ 24,537,759				
Non-Federal Share	$ 351,676	$ 21,713,855	$ 116,074	$ 21,829,929				
Total Incurred Cost	$ 1,445,849	$ 45,727,560	$ 640,128	$ 46,367,688				
Variance								
Federal Share	$ (4,571,601)	$ (6,488,892)	$ 65,718	$ (6,423,174)				
Non-Federal Share	$ (145,303)	$ (125,326)	$ (380,906)	$ (506,232)				
Total Variance	$ (4,716,905)	$ (6,614,218)	$ (315,188)	$ (6,929,406)				

*Note: Cumulative totals reflect those of overall project

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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
CTTF	Cameron Test Testing Facility
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

ACRONYM	DEFINITION
PCS	Pressure Coring System
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
TOC	Total Organic Carbon
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

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Quarterly Research Performance Progress Report Period Ending 03/31/2018

Deepwater Methane Hydrate Characterization and Scientific Assessment

APPENDIX A

Washington University Tables

Table 1. Distribution of pore water samples

	glass			plastic				
	O/H	DOC	Halogens and NH4	SO4	Cations	B and Si	Residue	
								total
code	GOMOH	GOMDOC	GOMHAL	GOMSO4	GOMCAT	GOMBSi	GOMIW	
subsample container	1-2 ml ampoule	1.5 ml amber screw top	2ml screw top	10 ml Corning Cent. Tube; 0.1 ml sample from hal bottle to 9.9 ml Zn-acetate solution	4 ml acid-cleaned bottles	4 ml acid-cleaned bottles	5 ml acid-cleaned cryo-tubes	
treatment	No Treatment	Frozen	No Treatment	Zn-acetate	acidify with 10 ul HNO3	No Treatment	acidify with 10 ul HNO3	
20 ml	2	2	2	0.1	4	4	5	19.1
15 ml	2	2	2	0.1	4	4	1	15.1
10 ml	1	0	2	0.1	4	3	0	10.1
5 ml	1	0	1	0.1	2	1	0	5.1
4 ml	1	0	1	0.1	2	0	0	4.1
3 ml	1	0	0	0.1	2	0	0	3.1
2 ml	1	0	0	0.1	1	0	0	2.1
1 ml	1	0	0	0	0	0	0	1

Table 2. Pore water geochemical data not corrected for drill water contamination

Expedition	Hole	Core	Type	Section	Volume Recovered (ml)	Salinity	Cl (mM) $AgNO_3$ Titration	Cl (mM)	Br (mM)	SO_4 (mM)	$\delta^{18}O$ (‰)	δD (‰)	Ca (mM)	Mg (mM)	K (mM)	Na (mM)	B (µM)	Li (µM)	Sr (µM)	Ba (µM)	Fe (µM)	Mn (µM)
UT-GOM2-1	H002	1	CS	1	8	8	150	148	0.746	6.67	-	-	2.21	6.06	2.17	156	217	15.4	12.55	1.99	0.916	2.02
UT-GOM2-1	H002	2	CS	2	1	3	-	-	-	-	0.71	13.98	-	-	-	-	-	-	-	-	-	-
UT-GOM2-1	H002	6	CS	4	2	14	-	279	0.484	5.41	-	-	4.94	15.01	3.62	255	272	25.1	28.93	5.68	1.07	3.83
UT-GOM2-1	H002	8	CS	1	11	19	344	350	2.24	9.11	-0.38	6.09	6.15	20.59	3.20	308	224	21.6	34.33	3.89	0.919	2.91
UT-GOM2-1	H002	8	CS	4	4.5	6	161	163	0.291	5.37	0.11	10.81	2.38	7.78	2.37	159	239	16.9	14.61	2.47	0.928	3.14
UT-GOM2-1	H005	1	FB	3	11	28	493	500	0.925	0.495	-1.90	-3.36	5.75	36.60	3.88	435	195	14.4	69.48	5.44	0.904	1.44
UT-GOM2-1	H005	4	FB	5	9	18.5	331	339	0.588	6.59	-1.01	-1.17	5.47	18.25	3.10	290	185	16.3	39.03	5.74	0.916	1.37
UT-GOM2-1	H005	7	FB	2	8	5.5	111	107	0.219	3.11	-0.11	3.32	1.48	4.11	2.20	108	185	8.0	8.512	1.47	0.895	0.609
UT-GOM2-1	H005	12	FB	2	1	13	-	-	-	-	0.20	8.21	-	-	-	-	-	-	-	-	-	-
UT-GOM2-1	H005	12	FB	3	7	16	273	281	0.516	11.9	-0.26	6.59	5.33	17.27	3.17	256	251	23.1	22.58	1.16	8.99	5.37
UT-GOM2-1	H002	1	CS	Drill Water	-	-	474	483	-	27.7	-0.43	-1.99	16.19	44.79	9.57	458	335	23.6	20.15	BDL	1.09	96.7
UT-GOM2-1	H005	1	FB	Drill Water	-	-	-	590	0.977	30.4	0.95	7.98	11.23	56.61	12.00	506	439	30.2	82.37	BDL	BDL	0.322
UT-GOM2-1	H005	2	FB	Drill Water	-	-	580	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UT-GOM2-1	H005	2	FB	PCATS	-	-	-	33.5	0.142	1.72	0.86	8.67	0.89	3.44	2.12	33.2	32.1	2.11	BDL	BDL	BDL	2.49
UT-GOM2-1	H005	4	FB	PCATS	-	-	-	5.49	0.018	0.743	-5.34	-32.46	1.07	0.89	1.61	8.83	97.3	3.22	5.671	BDL	BDL	1.99
UT-GOM2-1	H005	7	FB	PCATS	-	-	-	26.6	0.114	1.27	0.89	9.06	0.87	2.31	1.69	26.8	88.4	3.15	3.745	BDL	BDL	2.44

Note:

(1) Salinity (analyzed by Reichert temperature-compensated handheld refractometer and a conductivity meter) Salinity is a routine measurement of dissolved salt content. It is used as an initial assessment of gas hydrate distribution and concentration. Salinity governs the physical properties of the pore water (e.g. density), and is important for determining the limits of the gas hydrate stability field.

(2) Cl, Chloride Concentrations (determined via determined via titration with $AgNO_3$ and by ion chromatography): Chloride concentrations are affected by evaporite dissolution, and also tracks the addition or uptake of H_2O. Background Cl profiles provide information on authigenic clay formation and clay dehydration (e.g. the smectite-illite transition) at depth. Negative Cl anomalies are used to estimate in situ gas hydrate concentrations.

(3) SO_4, Sulfate Concentrations (determined on a Metrohm 882 Compact ion chromatograph): SO_4 is consumed during organic matter degradation and the anaerobic oxidation of methane. Below the sulfate-methane transition zone, SO_4 is a valuable, quantitative tracer for drill water contamination.

(4) Br, Bromide (determined on a Metrohm 882 Compact ion chromatograph) is a product of the decomposition of organic matter that is used to track microbial metabolic reactions in marine sediments. Once released from organic matter, it behaves conservatively within the temperature and pressure conditions anticipated at these sites.

(5) δ18O and δD Pore Water (determined on a Picarro cavity ring-down spectrometer water analyzer): These are important tracers, when coupled with dissolved Cl profiles, for documenting the presence of gas hydrates and estimating in situ concentrations. Background profiles provide information on fluid/rock reactions and water sources (i.e. clay dehydration at depth, meteoric water), and are also commonly used in chemical geothermometry.

(6) Calcium, Magnesium, Sodium, and Potassium Concentrations (analyzed on a Perkin-Elmer 8300 inductively coupled plasma – optical emission spectrometer): These are the major cations in seawater. They are involved in a wide-range of in situ and deeper fluid-rock reactions. They are used to constrain carbon sinks, diagenetic reactions, deeper-sourced fluids, and fluid flow pathways.

(7) Lithium, Boron, Strontium, Barium, Iron, Manganese, and Si Concentrations (analyzed on a Perkin-Elmer 8300 inductively coupled plasma – optical emission spectrometer): Each tracks a different component of the system ranging from redox reactions important in the early diagenesis of organic matter to fluid-sediment interactions over a wide range of temperatures and depths. The alkali metals and B in particular are useful tracers of fluid rock interaction and geothermometers, and dissolved Si concentrations provide information on fluid-rock equilibria and fluid sources.

Table 3. Pore water geochemical data corrected for drill water contamination

Hole	Core	Type	Section	Cl (mM) $AgNO_3$ Titration	Cl (mM)	Br (mM)	SO4 (mM)	δ18O (‰)	δD (‰)	Ca (mM)	Mg (mM)	K (mM)	Na (mM)	B (mM)	Li (∝M)	Sr (∝M)	Fe (∝M)	Mn (∝M)	f_{dw}	f_{pf}
H002	1	CS	1	47.1	41.6	-	0	-	-	BDL	BDL	BDL	60.4	180	12.8	10.13	0.86	BDL	0.24	0.76
H002	2	CS	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H002	6	CS	4	-	229	-	0	-	-	2.21	7.78	2.18	206	256	25.5	31.06	1.07	BDL	0.20	0.80
H002	8	CS	1	280	285	-	0	-0.35	10.1	1.23	8.72	0.08	234	170	20.6	41.28	0.83	BDL	0.33	0.67
H002	8	CS	4	85.7	86.2	-	0	0.24	13.9	BDL	BDL	0.64	87.3	216	15.2	13.28	0.89	BDL	0.19	0.81
H005	1	FB	3	492	498	0.924	0	-1.94	-3.55	5.66	36.27	3.75	434	191	14.1	69.27	-	1.4617285	0.02	0.98
H005	4	FB	5	262	269	0.480	0	-1.56	-3.70	3.88	7.63	0.64	230	115	12.5	27.03	-	1.6631926	0.22	0.78
H005	7	FB	2	57.6	51.7	0.133	0	-0.23	2.79	0.37	BDL	1.08	63.0	156	5.5	0.10	-	0.6415131	0.10	0.90
H005	12	FB	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H005	12	FB	3	74.1	81.1	0.219	0	-1.04	5.69	1.52	BDL	BDL	94.1	130	18.5	BDL	-	8.627347	0.39	0.61

- indicates not corrected for drill water contamination

f_{dw} = fraction of pore water sample that is contaminated with drill water

f_{pw} = fraction of uncontaminated pore water in a sample

BDL = below detection limit

Table 4. Pore water geochemical data corrected for contamination assuming drilling fluid had composition of average seawater

Hole	Core	Type	Section	Cl (mM) $AgNO_3$ Titration	Cl (mM)	Br (mM)	SO4 (mM)	$\delta^{18}O$ (‰)	δD (‰)	Ca (mM)	Mg (mM)	K (mM)	Na (mM)	B (mM)	Li (∝M)	Sr (∝M)	Ba (∝M)	Fe (∝M)	Mn (∝M)	f_{SW}	f_{pw}
H002	1	CS	1	27.2	24.6	0.712	0	-	-	BDL	BDL	BDL	59.1	155	12.2	BDL	2.56	1.19	2.63	0.23	0.77
H002	2	CS	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H002	6	CS	4	-	214	0.398	0	-	-	3.65	6.04	2.06	203	237	24.9	15.6	6.96	1.32	4.72	0.19	0.81
H002	8	CS	1	245	254	2.87	0	-0.55	8.90	4.12	5.20	BDL	228	132	19.5	10.1	5.63	1.34	4.25	0.32	0.68
H002	8	CS	4	70.2	72.8	0.161	0	0.13	13.28	0.51	BDL	0.53	86.0	197	14.8	BDL	3.01	1.14	3.86	0.19	0.81
H005	1	FB	3	492	499	0.926	0	-1.93	-3.42	5.67	36.30	3.77	435	191	14.2	69.2	5.54	0.92	1.47	0.02	0.98
H005	4	FB	5	264	274	0.508	0	-1.31	-1.51	3.97	7.68	0.94	234	114	13.5	24.9	7.40	1.19	1.78	0.23	0.77
H005	7	FB	2	57.0	52.2	0.142	0	-0.13	3.72	0.39	BDL	1.20	63.5	156	5.9	BDL	1.63	1.00	0.68	0.11	0.89
H005	12	FB	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H005	12	FB	3	71.2	85.1	0.275	0	-0.44	11.22	1.66	BDL	BDL	98.0	129	21.0	BDL	1.90	15.31	9.14	0.41	0.59

- indicates not corrected for drill water contamination

f_{sw} = fraction of pore water sample that is contaminated with drill water

f_{pw} = fraction of uncontaminated pore water in a sample

BDL = below detection limit