DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report

Period Ending 06/31/2018

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:

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

Office of Fossil Energy

DISCLAIMER

1 ACCOMPLISHMENTS

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.
- Updated Field Program Operational Plan (Milestone *M2E*) and submitted to DOE on 13 April, 2018.
- Documented results of BP2/Phase 2 activities (Milestone *M2F*) and submitted to DOE on 14 April, 2018.
- Coordinated submission of GOM^2-1 Paleontological Report to Bureau of Safety and Environmental Enforcement (BSEE), fulfilling final GOM^2-1 permit submission.
- Coordinated with *JOIDES Resolution* (*JR*) Science Operator (JRSO) to develop plan to assess requirements for the *JR* to meet 1989 International Maritime Organization (IMO) Mobile Offshore Drilling Unit (MODU) Code or 46 Code of Federal Regulation (CFR) Part 108 Requirements.
- Initiated cost analysis and planning of GOM^2-2 contingency scenarios once it was recognized that the *JR* may not meet regulatory requirements to conduct drilling in the Gulf of Mexico.
- Initiated discussions with IODP and European Consortium for Ocean Research Drilling (ECORD) regarding possibility of executing GOM^2-2 as a Mission Specific Platform (MSP).
- Presented the CPP2-886 science and operational plan to the European Science Operator (ESO) in a teleconference on 8 June, 2018. UT followed up by transferring detailed Operational Plan and vessel requirements to the ESO for assessment.
- Coordinated the technical evaluation of the High Temperature/Pressure Corer (HTPC) as an alternative to the Pressure Coring Tool with Ball-Valve (PCTB) for GOM^2-2 deployment.
- Initiated plans for a scientific workshop to summarize results from GOM^2-1 and refine scientific plan for GOM^2-2.
- Managed ongoing experimental analysis of pressure cores.

Objective 3: Communicate with project team and sponsors.

- Organized 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 DOE sponsors regarding developments of IODP Expedition 386, ability of the *JR* to comply with regulatory requirements for drilling in the U.S. outer continental shelf (OCS), alternative contingency plans for executing the drilling expedition, and corresponding cost estimates.

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.
- Coordinated with Geotek Coring Inc. and Ltd. (Geotek) to develop comprehensive scope of work for continued services throughout BP3 and BP4 in accordance with the GOM^2 Scope of Project Objectives (SOPO).
- Initiated service agreement between UT and Geotek for BP3 and BP4.

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 and as needed reported to project team and stakeholders.
  - Identified possibility that *JR* may not meet regulatory requirements to drill in U.S. OCS.
  - Identified possibility that JRSO and *JR* ship owner (ODL-SIEMS) may choose to not pursue vessel upgrades enabling continued planning and execution of IODP Expedition 386.
  - Proactively communicated developments of evaluation of *JR*'s ability to comply with regulatory requirements with DOE and project sponsors on a monthly, bi-monthly basis, or more regular basis, as warranted.
  - Developed risk mitigation strategies for GOM^2-2 expedition and took preliminary steps including:
    - Expressing UT's willingness to pursue a review of potentially inappropriate vessel regulations imposed upon JR, and/or seek alternative regulations,
    - Reevaluating minimum-viable GOM^2-2 scientific objectives,
    - Defining and developing cost estimates for alternative GOM^2-2 expedition scenarios,
    - Interfacing with ECORD to pursue possibility of mounting Expedition 386 as an MSP,
    - Taking preliminary steps towards executing GOM^2-2 independent of IODP/ECORD in the event that collaborating IODP/ECORD should prove infeasible, and
    - Communicating all strategies to DOE on a regular basis.

TASK 6.0 - TECHNICAL AND OPERATIONAL SUPPORT OF COMPLIMENTARY PROJECT PROPOSAL

Status: Ongoing

- Held in-person and teleconference meetings with IODP to discuss implementation of Expedition 386, vessel requirements, and vessel permitting.
- Was informed that that JRFB had canceled IODP Expedition 386 and removed it from the *JR*'s 2020 schedule, citing high costs and insufficient available time for ship upgrades required for the *JR* to meet MODU 1989 Standards mandated by the United States Coast Guard (USCG). This information as well as a discussion of possible paths forward for the GOM^2-2 research expedition was distributed to the GOM^2 project team in a Memo from Dr. Flemings (**Appendix A**). Official notification of JRFB's decision is provided as **Appendix B**.
- Was informed that the JRFB would forward proposal CPP2-887 to the ECORD Facility Board (EFB) for consideration of the potential implementation of this project as an MSP.
- Held a conference call with ESO on 14, June, 2016 to provide a technical and operational overview of GOM^2-2 expedition and provide information required for ESO to scope to assess potential for mounting expedition as an MSP. Attendees included Peter Flemings, Carla Thomas, and Jesse Houghton of UT, Timothy Collett of United States Geological Survey (USGS), Richard Baker and Ray Boswell of DOE, Dave McInroy, Dave Smith, and Graham Tulloch of British Geological Survey (BGS) , Ursula Rohl of MARUM, Sally Morgan of University of Leicester, Gilbert Camoin of Cerege, and others.
- Provided ESO with GOM^2-2 detailed Operational Plan and vessel requirements.
- Ohio State (lead by Portnov) continued to work on permitting requirements for the Orca Basin locations. The pore pressure and mud plan in Geology and Geophysics (Chapter C) of the Exportation Plan was edited based on feedback from Dr. Flemings. The only section remaining for editing in the Orca document is related to site hazards.

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

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

Subtask 10.4 - Continued Pressure Core Analysis

A. Pressurized Core Analysis

A.1. Quantitative Degassing and Gas Analysis

- UT improved its approach to calculating hydrate saturation from the amount of gas released during depressurization by: 1) using better estimates of core volume from computed tomography (CT) images rather than a single estimate based on core liner inner diameter (Fig. 1-1); and 2) directly measuring grain density in the laboratory. These more refined approaches slightly increased our estimate of hydrate saturations.

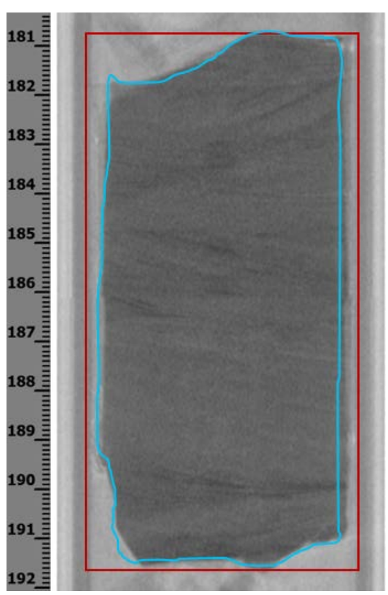

Figure 1-1: Image comparing old (red) and new (blue) estimates of Core volume used in the calculation of hydrate saturation.

- UT, with Ohio State University (OSU), improved the method of collecting gas samples during depressurization of degassing of GOM[2] Pressure cores to reduce atmospheric contamination by adding a built a turbo vacuum line to collect gas samples before they move through the bubbling chamber (Fig. 1-2).
    - OSU showed that the new experimental set up dramatically reduced the concentrations of N2 and other atmospheric gases (Ar).
        - Three samples acquired using the new sampling technique were run on OSU's Stanford Research System RGA 300 Quadrupole mass spectrometer (MS). All three contained less than 0.026 ccSTP/cc of nitrogen
        - Samples from the old set up contained 0.12 ccSTP/cc to 0.79 ccSTP/cc of nitrogen.
- OSU continued working to determine the C1 to C5, N2, 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).
    - Initial measurements of the methane/ethane (C1/C2) ratio as a function of when the gas was released from the core sample show a drop in the C1/C2 ratio as more gas trapped in the methane hydrate cage is released indicating a potential fractionation effect during degassing (Fig. 1-3). We need to determine if fractionation in the C1/C2 ratio seen in all degassing experiments is caused by sampling artifacts or solely due to hydrate dissociation.
    - Analyses of all samples is completed. Data processing planned for August 2018.
    - Final results will be compared to the gas measurements made on the Geotek system on board as at the dock.
- 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. 1-4). However, as mentioned above these samples had very high nitrogen content, making the age estimates questionable.
    - Analyses of 16 samples was completed. Data processing planned for August 2018.
- UT began work on estimating downhole in-situ salinity from depressurization curves.

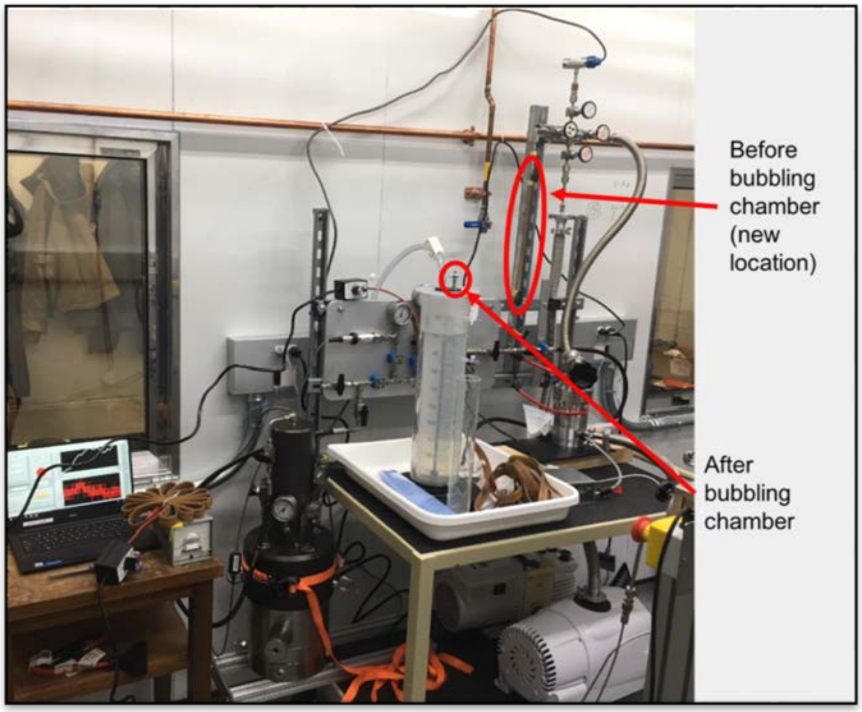

Figure 1-2: Degassing chamber in the PCC showing old and new location for collecting gas samples for gas analysis

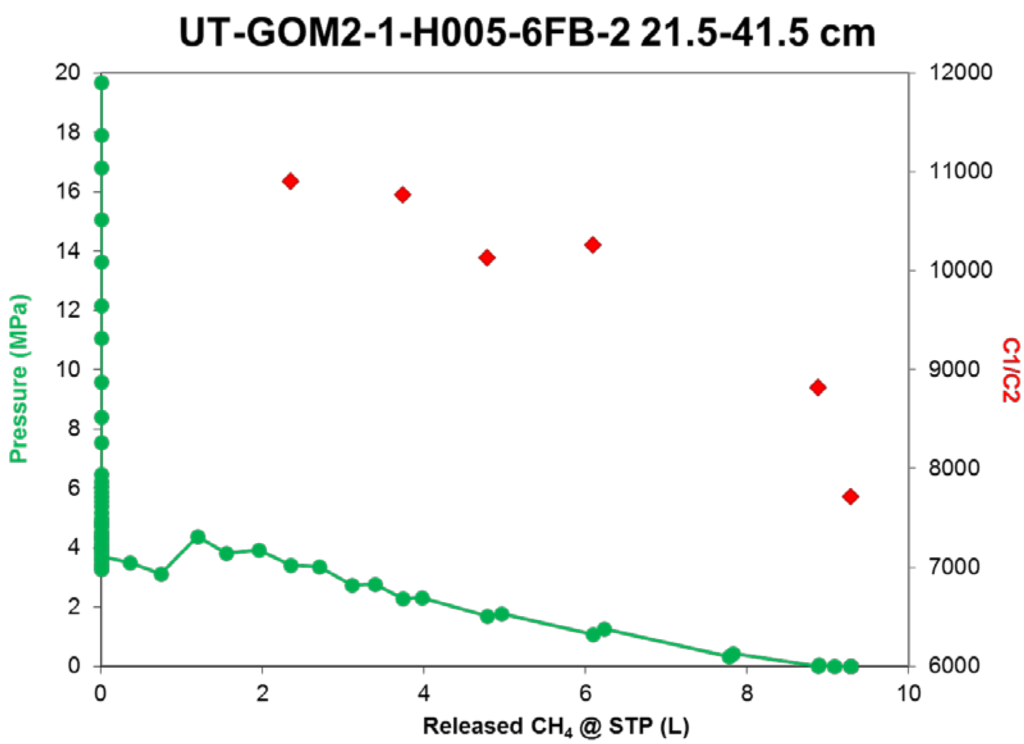

Figure 1-3: Results from a recent degassing experiment in the UT Pressure Core Center. During progressive degassing a decrease in the C1/C2 ratio is observed. We are currently analyzing samples collected before and after the bubbling chamber to determine if C1/C2 fractionation is a result of hydrate dissociation or a sampling artifact from the bubbling chamber.

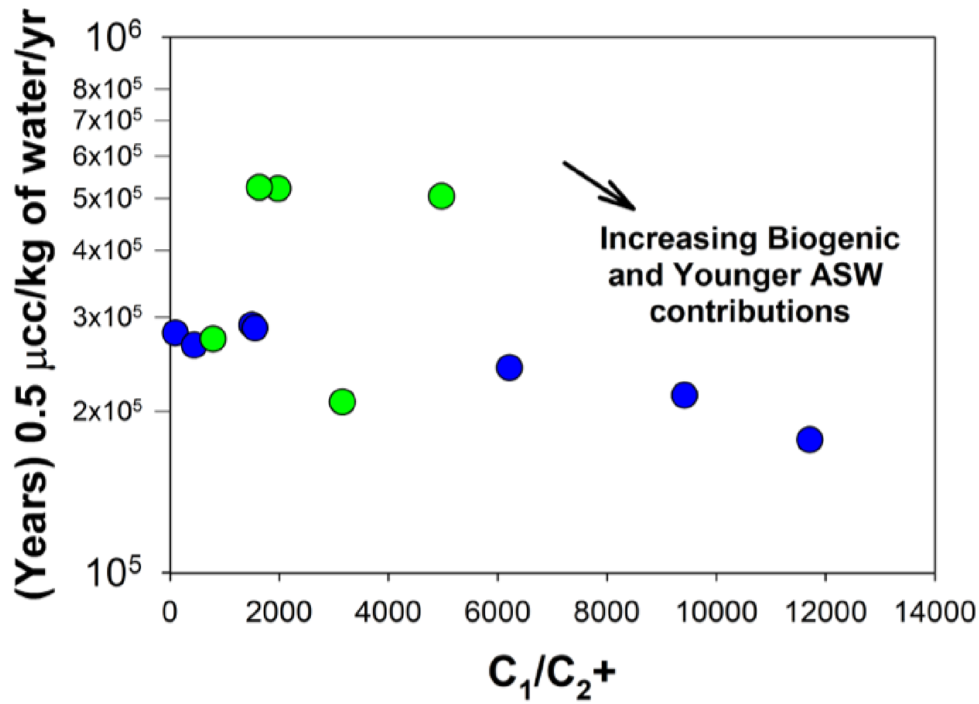

Figure 1-4: Predicted residence time range of 150,000 to 525,000 years methane gas from noble gas measurements versus methane/ethane and larger hydrocarbons (C1/C2+). Green dots represent Hole H002 and blue dots Hole H005. Air-saturated water (ASW) is the expected atmospheric gases in crustal fluids (waters) as determined by Henry's Law equilibrium between the atmosphere and water (assumed to be seawater in this case).

A2. Steady-state Permeability Tests

- UT completed additional multiple steady-state permeability tests on 6FB2:
    - Completed 22 consolidation tests (hydrostatic and K_0) to date.
    - Completed 61 permeability tests over a stress range of 1 to 5 MPa (vertical stress) to date.
    - Tested and improved procedures for hydrostatic compression, K0 compression, and permeability.
    - Developing procedure for quantitative degassing from the K0 chamber.
    - Testing and improving procedures to characterize the K0 /permeability sample post-testing using X-ray computed tomography (XCT) scanning.

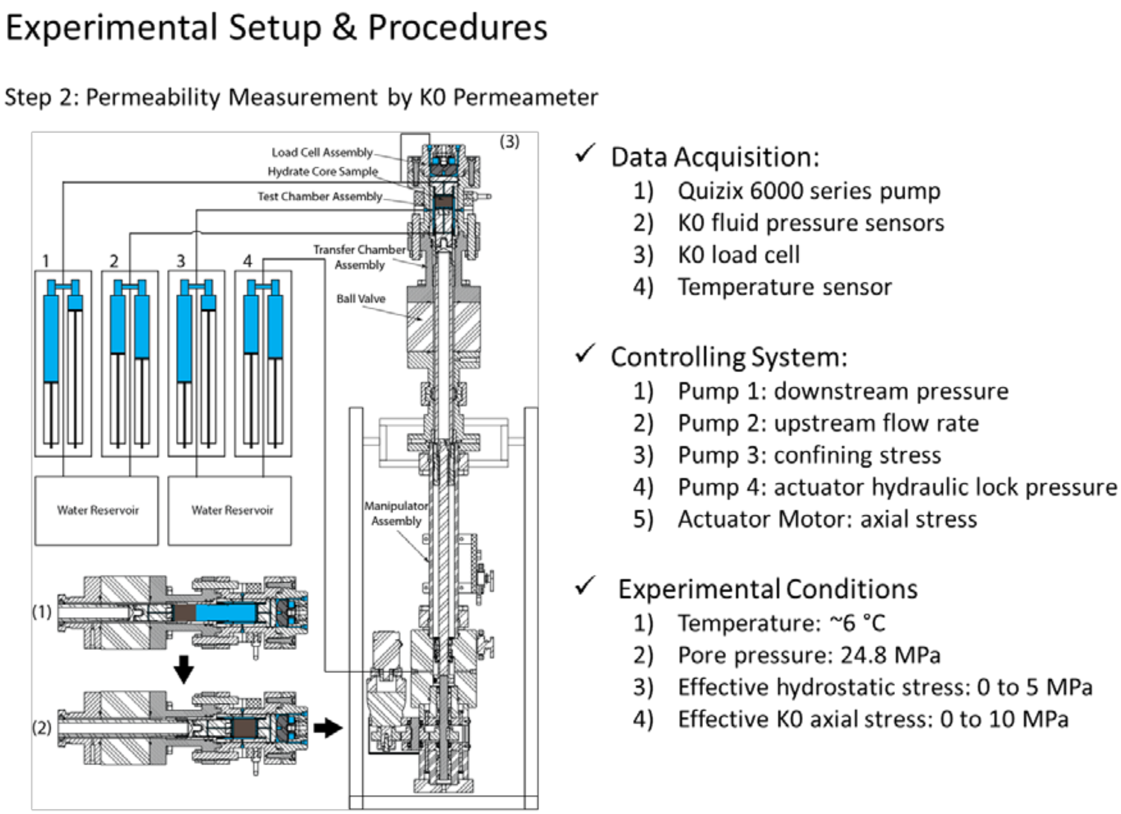

Figure 1-5: Experimental configuration for measurement of permeability of pressure core samples.

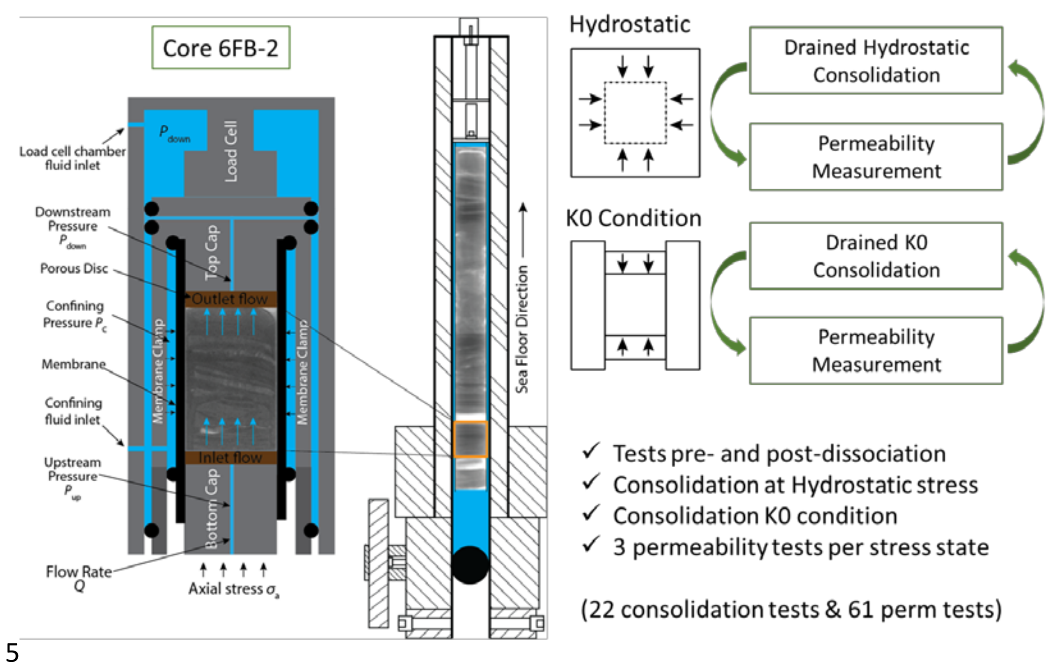

Figure 1-6: Expanded view of permeability measurement apparatus and summary of measurement program.

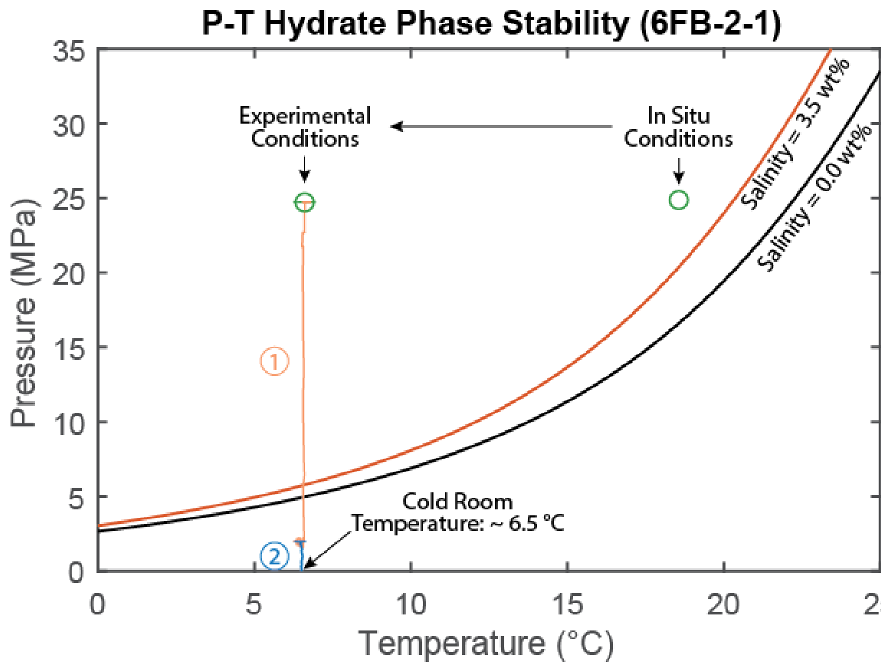

Figure 1-7: Initial experimental program in pressure-temperature space. We measured permeability within the hydrate stability zone (green circle) and then dissociated the sample and measured permeability (#2).

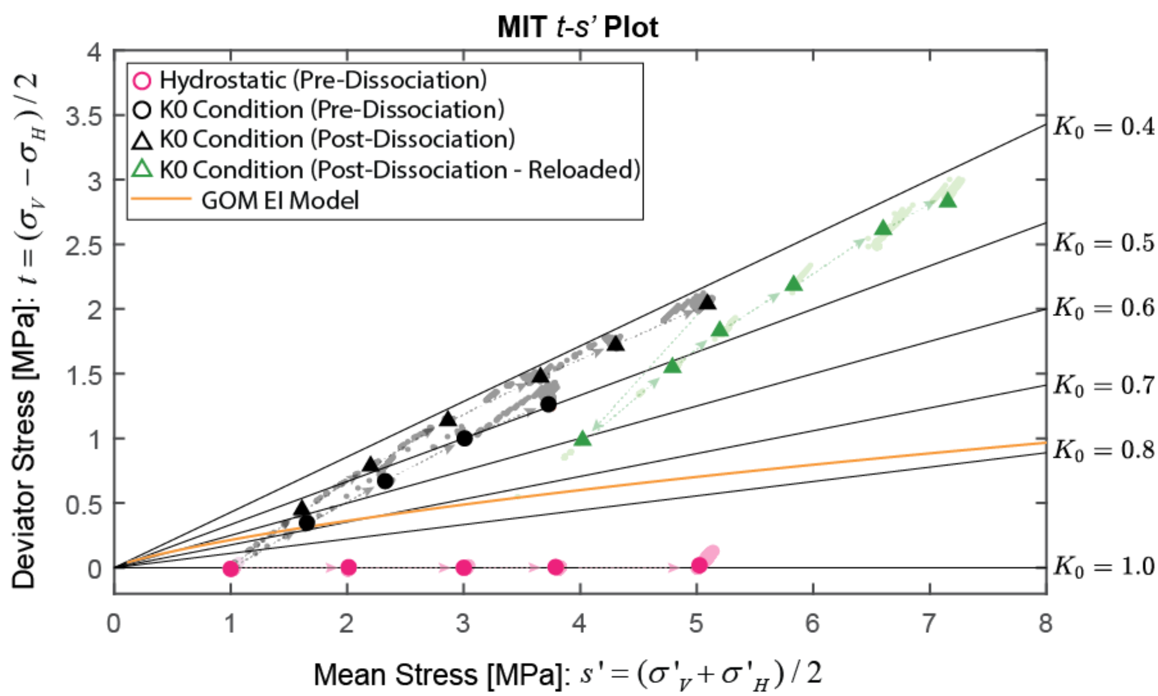

Figure 1-8: Stress path of experiments performed on Core 6FB2. At each sample point, permeability was measured. Initially the experiments were run within the hydrate stability zone under increasing isostatic stresses (pink circles). Then the sample was unloaded and reloaded (still within the hydrate stability zone) under uniaxial strain conditions (black circles). Then the sample was dissociated under constant effective stress. Then the sample was reloaded uniaxially (black triangles and green triangles). The K_0 coefficient (the ratio of lateral to vertical effective stress ($K_0 = \frac{\sigma_h'}{\sigma_v'}$) is between 0.4 and 0. 5. Dissociation of hydrate does not significantly change the K_0 coefficient (the black circles and the black triangles follow a similar path).

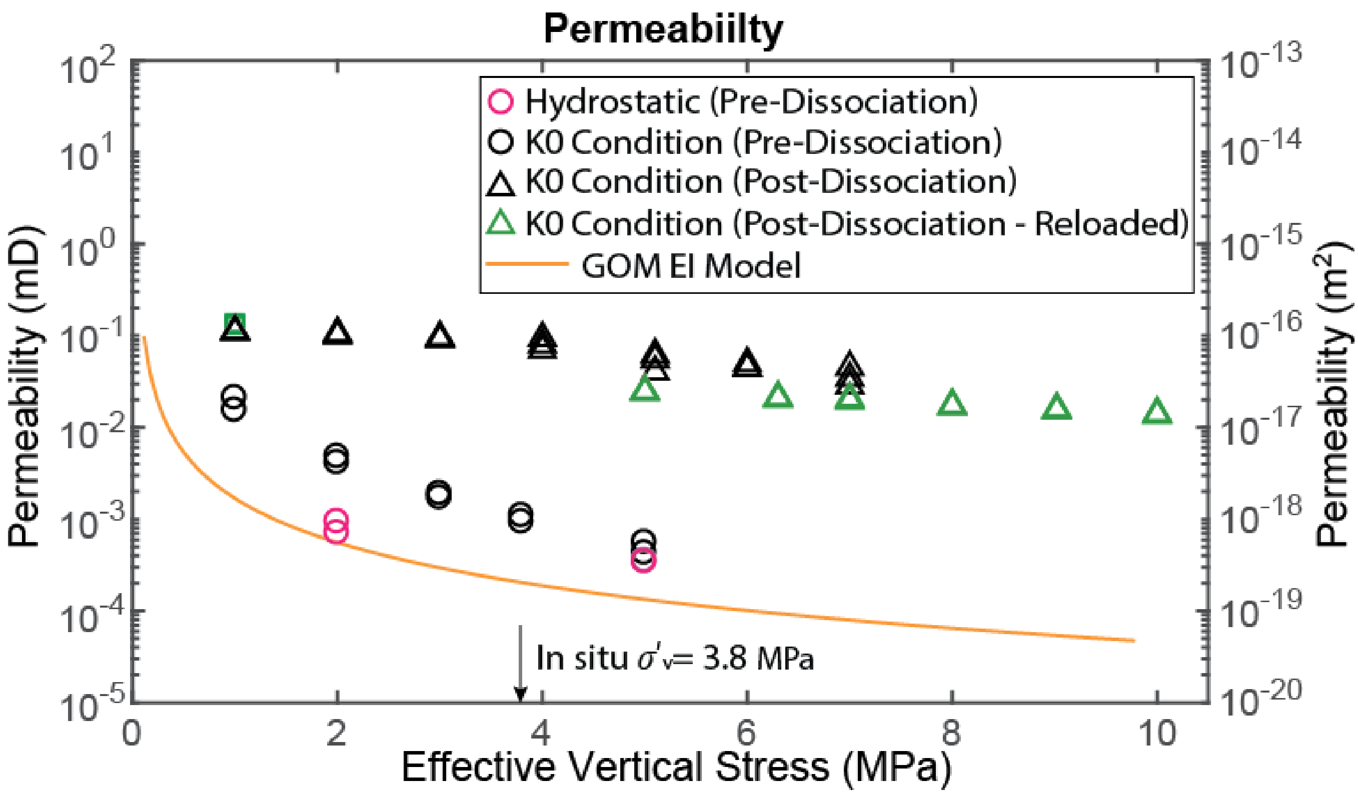

Figure 1-9: Steady state liquid permeability measurements on Core 6FB-2. The effective permeability measured in the presence of hydrate lies between ~10^{-2} mD to ~10^{-3} mD (~10^{-17} m^2 to ~10^{-18} m^2). After dissociation and after flowing multiple pore volumes of water through the sample, the absolute permeability is ~0.5 mD to 10-2 mD (~5 x10^{-16} m^2 to ~10^{-17} m^2). The permeability after dissociation is 1 to 2 orders of magnitude larger than that of pre-dissociation permeability. We emphasize that this is a preliminary measurement. X-ray imaging after the experiment revealed that there is a low permeability mudstone layer at the top of this sample and this may have resulted in the relatively low permeability.

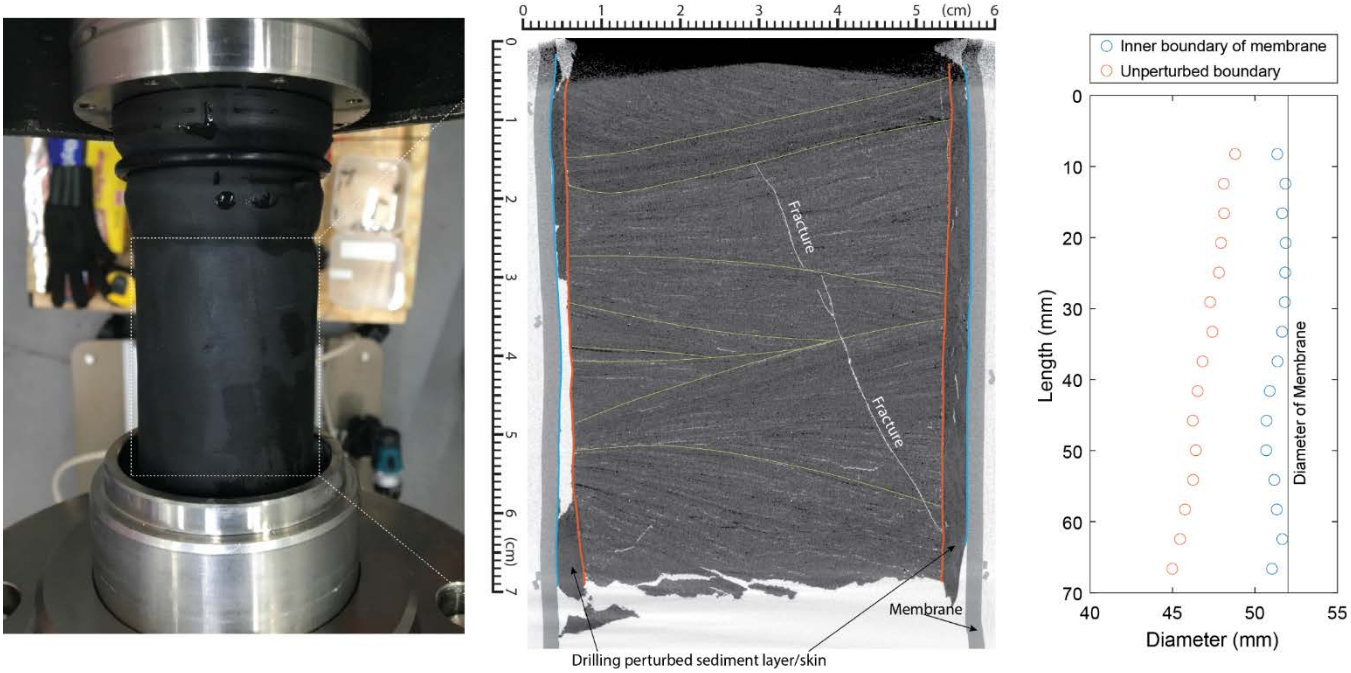

Figure 1-10: After the permeability measurements were completed, we did a high resolution cat-scan of the sample. Beautiful bedding was imaged.

A3. Pressure Core Distribution

- 4 degassing samples and 2 permeability/ K0 samples have been cut from 6FB2. Work continues on 6FB and then will move from compromised to high quality samples.

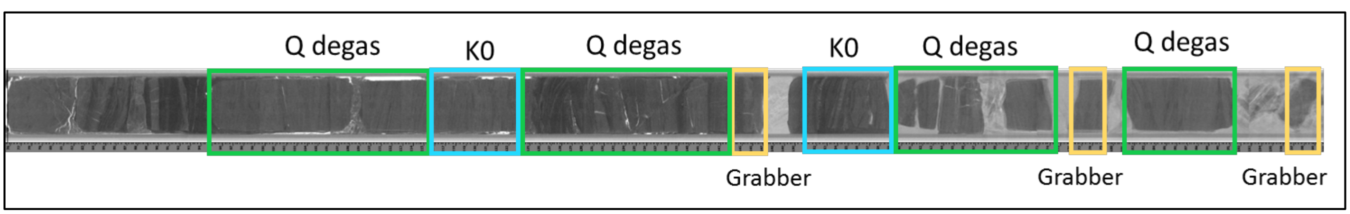

Figure 1-11: 2D CT image of Core 6FB-2 from PCATS

- UT continued to actively support the transfer of pressure cores to other institutions
  - o UT assisted NETL by providing technical feedback on their pressure core transport system design to ensure compatibility with Mini-PCATS.
  - o Began dialogue with USGS regarding transfer chamber design.
  - o Reviewed a Research agreement and drafted a material transfer agreement between UT and AIST (Japan) for the transfer of two 35 cm pressure core sections from UT-GOM^2-1-3FB-5 and 5FB-3.
  - o Discussed BIO chamber testing logistics with Georgia Tech personnel.

B. Depressurized Pressure Core Analysis

- OSU made Brunauer-Emmett-Teller (BET) measurements for pore surface area and porosity on two samples. Results showed that the surface area of the pore was ~5 m2/g in both samples.
- OSU started 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.
- All X-ray diffraction (XRD) analysis, XCT scanning and core photos of depressurized core from the GOM^2-1 marine test was completed.
- The University of Washington (UW) continued working on pore water chemistry analysis.
- The University of New Hampshire (UNH) continued working on bulk CHNS elemental and isotopic analysis, and laser-particle grain size analysis.
- UNH finished the nannofossil biostratigraphy analysis (sediments 0.43 to 0.91 Ma) report (**Appendix C**).
    - The report included the description and interpretation of 30 samples examined from GOM^2-1; 22 samples from Hole H002, and 8 samples from H005.
    - Semi-quantitative evaluations were conducted on all samples to identify age-diagnostic species/assemblages for interpreting geologic age. All samples contained significant Cretaceous reworking. These specimens are not considered part of the assemblage when making biostratigraphic interpretations; instead they are considered as part of the detrital sediment.
    - All samples examined from Hole H002 are interpreted to be Calabrian (Middle Pleistocene). Sample GOM^2-1-H002-1CS-1_24-25cm, 409.6 meters below sea floor (mbsf), provides the first age-diagnostic data and is interpreted to be no younger than 0.91 Ma. The lowermost sample, GOM^2-1-H002-8CS-5_27-28cm, 434.1mbsf, is interpreted to be no older than 1.06 Ma. This interpreted age range is assigned to the lowermost Calcareous Nannofossil Plio-Pleistocene (CNPL) Zone 10.
    - All samples examined from Hole H005 are also interpreted to be Calabrian. The uppermost sample, GOM^2-1-H005-1FB-3_163-184, 284.18 mbsf, is interpreted to be approximately 1.0 Ma, in the lower CNPL10 Zone. The next sample below this one is about 150 meters deeper, at 436.93 mbsf, and is interpreted to be in CNPL Zone 9 (1.06 – 1.25 Ma). The remaining samples from Hole H005, down to 445.28 mbsf, are also assigned to CNPL9; no older than 1.25 Ma. See **Appendix C** for details.
- Oregon State consulted UT on microbiology analysis of depressurized core.

Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis

OSU undergraduate Kathryn Smart worked with Dr. Cook and used UTAPWels, a well log forward-modeling software package, to link PCATS data at H005 with well log data measured in H001. We used the PCATs data and developed a model for H005 in the main sand reservoir because there was no log data over the hydrate reservoir interval. We used the PCATS data to identify bed and hydrate boundaries and construct a likely resistivity model for H005. Then the electromagnetic wave resistivity response was calculated from the model for H005. Figure 1-12 shows the model results for H005 and the possible sections that tie between the two wells. The results were not showing a strong tie between the two wells. The results suggest there may be a 1.8 to 3 m offset between wells. Cook has started to re-examine this data to see if it could be improved.

Portnov (OSU) submitted a manuscript to the American Association of Petroleum Geologists (AAPG) volume. The manuscript is focused on the effect of salt rise on the hydrate stability zone at GC955. Modeling shows that a salt-induced temperature anomaly, reaching 8 °C at the reservoir level, is sufficient to explain the position of the base of the Gas Hydrate Stability Zone (GHSZ).

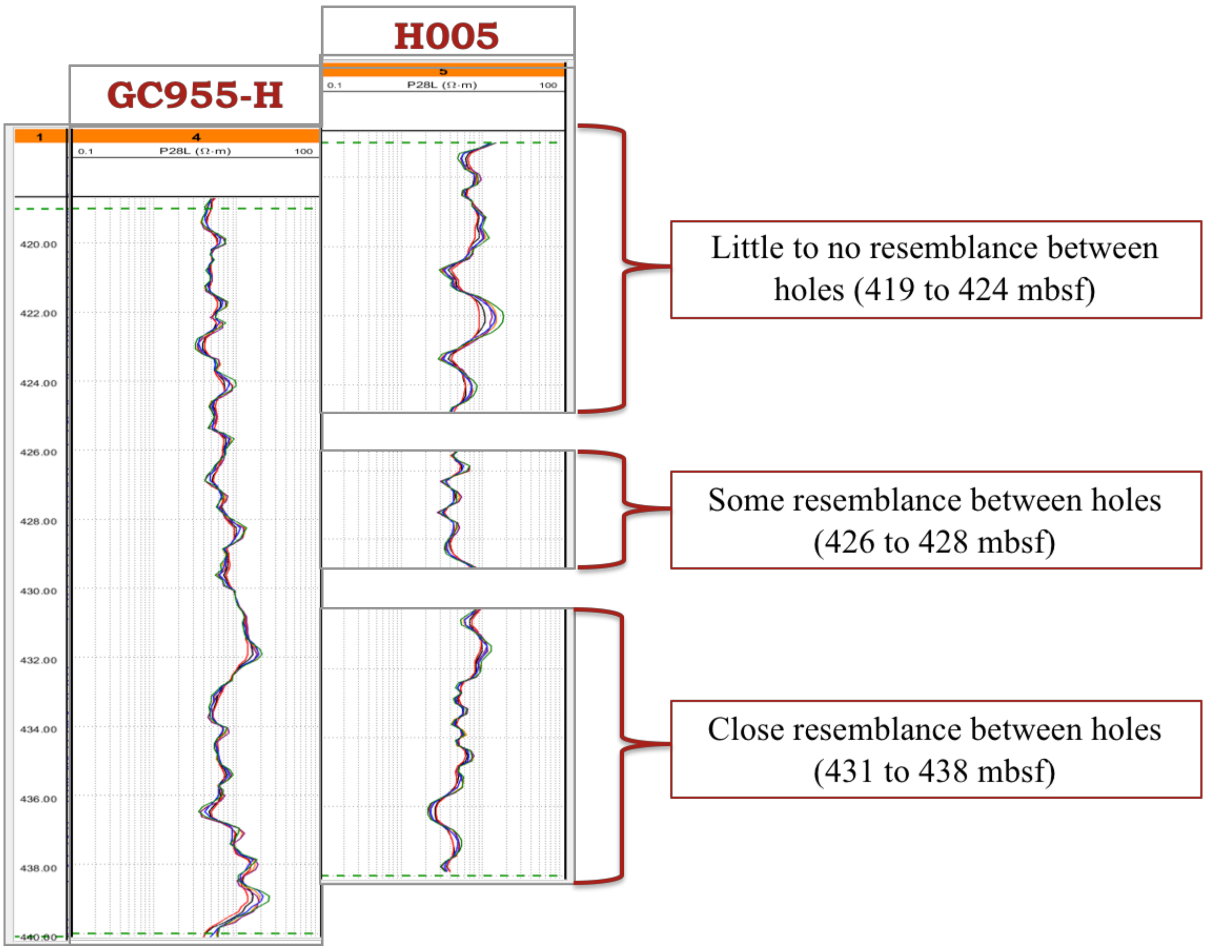

Figure 1-12: Electromagnetic-wave resistivity modeling by undergraduate Kathryn Smart using UTAPWels to try to link GC955H-001 to H005.

Subtask 10.6: Additional Core Analysis Capabilities

- Received design detail for 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.
- Sent specs for Sidewall Core Microanalysis to Geotek for their review.
    - As part of Phase 3 we are developing the capability to subsample the large diameter core into smaller chambers for pressurized micro-analysis.
        - The tool will produce 10 mm diameter micro-core/plugs from cuts of stored pressure core (51 mm outer diameter).
        - The cell will hold the produced plug under pressure, keeping them within the hydrate stability zone.
        - We are now working with Geotek to confirm the design for this system.
- Continued conversation with Geotek concerning possible Pre-consolidation Chamber purchase.

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

Status: On Schedule

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

- One maintenance tear down in June 2018.
- Cut two pressure core samples for the K0.
- Cut three pressure core samples for quantitative degassing.

Subtask 13.2: Hydrate Core Effective Stress Chamber

- K0 system software updated four times with minor changes to software/user interface.
- Some down time experienced due to software issues.
- Multiple system tests run with a Delrin rod sample to validate length measurements and load cell output from new software versions.
- Two pressure cores samples have been tested in the effective stress chamber. Both samples are from core 6FB-2.
- Both 6FB-2 samples were removed intact from the K0 at atmospheric pressure for additional grain size, porosity, and pore size analysis.

Subtask 13.3: Hydrate Core Depressurization Chamber

- Successfully transferred a section of pressure core from mini-PCATS to a small storage chamber and then attached to the degassing manifold.
- Performed a slow quantitative degassing while quantifying the amount of gas and liquid released, collecting gas samples, and monitoring pressure and temperature conditions within the sample chamber.

- Currently working with Ohio State University to improve our gas sampling capability.

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

- Started investigation of current capabilities and requirements for storing pressure cores that will be acquired in Phase 4 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: On Schedule

The PCTB Development Team (Peter Flemings, Tim Collett, Tom Pettigrew, Jesse Houghton, Rick Baker, and Ray Boswell) conducted a technical comparison of the PCTB to the High-Temperature/Pressure Corer (HPTC) to confirm the path forward for pressure coring technology for the GOM^2-2 project.

UT has worked with Aumann & Associates (now Geotek) to develop, test, and deploy the PCTB since 2014. In 2017 UT tested the PCTB in two boreholes in the Gulf of Mexico (GOM^2-2), during which some significant challenges were encountered due to failure of the PCTB autoclave to seal at core-point pressure. In 2018, the Japanese Oil, Gas and Metals National Corporation (JOGMEC) utilized an alternate pressure-coring tool developed by Geotek (HPTC) in the Nankai Accretionary Wedge off the coast of Japan, with high success. The PCTB Development Team conducted a technical review of tool performance and reviewed whether the HTPC is a possible alternative to the PCTB.

After conducting the review, the PCTB Development Team feels that the best decision for GOM^2-2 is to continue to test, develop, and deploy the PCTB. The reasons for this decision include lower cost, significant risk inherent in developing a new, untested, tool, and both tools sharing the same fundamental problem of pressure-sealing.

A detailed description of the PCTB Development Team review and decision criteria for the PCTB/HPTC review is attached to this document as **Appendix D**.

Subtask 14.1: PCTB Lab Testing and Analysis

- Future Task.

Subtask 14.2 Pressure Coring System Modifications/Upgrades

- Future Task.

Subtask 14.3: PCTB Land-Based Testing and Analysis

- Future Task.

<u>TASK 15.0 – FIELD PROGRAM / RESEARCH EXPEDITION OPERATIONS</u>

Status: In Progress

Subtask 15.1: Review and Complete NEPA Requirements

Future Task.

Subtask 15.2: Finalize Detailed Operational Plan for Field Program

A. The GOM^2-2 Operational Plan Report was submitted to DOE on April 12, 2018. The Operational Plan Report is a 'living document', and will continue to be updated and refined as required.

B. The UT GOM^2 project team envisioned that the GOM^2-2 Expedition would be executed by the JR in collaboration with the IODP. We completed all aspects of the proposal process, which included two complimentary project proposals, two addendums, and two Environmental Pollution and Safety Panels (EPSP). As an outcome of these efforts, we were scheduled to sail in spring 2020 for a ~56 day expedition that would log, core, and perform downhole experiments in the Orca Basin and the Terrebonne Basin.

   In spring 2018, the JRSO was informed by the USCG that the *JR* must fulfill all requirements of the 1989 IMO MODU Standard in order to be permitted for drilling and conducting deep stratigraphic tests (boreholes deeper than 500 feet below seafloor) on the Outer Continental Shelf (OCS). UT assisted the JRSO in performing an assessment of the MODU 1989 Standard requirements. In March and April, 2018, it became evident that the *JR* did not meet the regulatory requirements for a MODU under the MODU 1989 Standard as required by the USCG and BSEE.

The JRSO and ship owner, ODL/SIEM, determined that a large number of upgrades to the *JR* would be required to meet the 1989 IMO MODU standards, requiring significant costs and time. In April, 2018, ODL/SIEM withdrew from performing IODP Expedition 386 for the mid-2020 expedition as scheduled. Subsequently the JRFB canceled Expedition 386 and removed it from the *JR* schedule during the JRFB meeting May 15-16, 2018.

UT documented the events leading to this result with regards to the drilling with the *JR* and the anticipated path forward in a memo on 8 May, 2018 (**Appendix A**). A letter from the JRFB providing notification that Expedition 386 had been canceled and removed from the JR schedule was received on 21 May, 2018 (**Appendix B**). In this letter, the JRFB cited insufficient funds and insufficient time required for the upgrades to meet 1989 IMP MODU standards as the basis for their decision. However, JRFB specifically recommended that this science program be pursued through ECORD, and stated that JRFB would forward the GOM^2 complimentary project proposal and addenda to the EFB for consideration of implementing this project as a MSP.

On 8 June, 2018 UT presented ESO with the GOM^2-2 science and operational plan in a teleconference at which members of DOE, USGS, LDEO, and Pettigrew Engineering were present. Following the teleconference, UT transferring detailed documents to the ESO, including the GOM^2-2 operational plan and vessel requirements, to support their efforts to scope GOM^2-2 as an ECORD MSP. ESO is currently compiling a cost plan, working with their contracts group to determine qualified operators to execute the GOM^2 scope of work in the Gulf of Mexico, and assessing their schedule for a potential 2020 expedition.

In recognition of the possibility that GOM^2-2 may be pursued independently by the University of Texas (not with IODP), UT began a detailed budget analysis to project how we would pursue GOM^2-2 through available commercial vessels. We prioritized our science program and developed a series of options that included re-scoping the project to lower the total cost to the program.

Subtask 15.3: Permitting for Field Program

- Continued to refine G&G section of Bureau of Ocean Energy Management (BOEM) Exploration Plan for GOM^2-2.

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

- UT worked with Geotek to develop scope of work and draft service agreement for continued services throughout BP3 and BP4 in accordance with the GOM_2 SOPO. In addition to pressure coring tool development (Task 13) this scope of work includes GOM^2-2 PCTB deployment, preliminary pressure core analysis using PCATS, handling and transportation of pressure cores, and contingency services including conventional coring in the event that GOM^2-2 is executed independently by UT

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:

- Finalize Geotek contract for PCTB development, testing, and deployment scope.
- Initiate Task 14.1: PCTB Lab Testing and Analysis.
- Continue to coordinate search for GOM^2-2 vessel in the event that UT is required to execute GOM^2-2 independent of IODP/ECORD.

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 run this program as an MSP in conjunction with the IODP, we will increase the amount of science done on the expedition through both direct and indirect financial support.
- We expect to receive an update on the manner that ECORD may be able to support GOM^2-2 by September, 2018.

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
  - Work will move from compromised to 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.
  - We will continue to collect additional gas samples and continue to improve gas sampling methods.
- Ohio State will analyze data from their quadrupole MS to determine the concentration of major fixed gases (N2, CO2, C1, Ar) in the samples collected during quantitative degassing. These measurements

allowed us to evaluate the source of C1, N2, and noble gases and to continue to evaluate the integrity of the sampling procedure.

- Ohio State will analyze C1 to C5, N2, and CO2 molecular composition data from their Gas Chromatography runs to quantify the relative contributions of each component and determine the genetic source of gases (thermogenic, biogenic, mixed). OSU will confirm/compare the measurements to what was measured by Geotek on board and at the dock.
- Ohio State will analyze noble gas and isotope measurements from their Thermo Fisher Helix Split Flight Tube Mass Spectrometer to understand noble and hydrocarbon gas partitioning into/between the hydrates and pore fluids, evaluating the residence time of natural gases/hydrate formation.

B. Steady-state Permeability Tests

- Permeability of pressure cores. We will next run two experiments:

  Experiment 1:

  - Measure in-situ permeability (σ'v=3.8 MPa) with and without hydrate
  - Constant effective stress before, during and after dissociation
  - Sample characterization:
    - X-ray CT scan
    - Porosimetry
    - Mercury Injection Capillary Measurement

  Experiment 2:

  - Measure effective permeability before hydrate dissociation @ σ'_v= 0.5 MPa to 3.8 MPa
    - Measure compression behavior and lateral stress ratio under uniaxial strain from σ'_v= 0.5 MPa to 3.8 MPa
    - Measure effectively permeability, compression behavior and lateral stress ratio under uniaxial strain from σ'_v= 3.8 MPa to 12 MPa (hydrate hasn't begun to dissociate yet)
    - Measure compression behavior and lateral stress ratio under uniaxial strain from σ'_v= 12 MPa to 13.6 MPa (hydrate has begun to dissociate yet)
    - Measure intrinsic permeability after hydrate dissociation @ σ'_v= 13.6 MPa
    - Collect gas volume and water volume
    - Measure permeability of gas production case
      - Pore pressure drops for hydrate dissociation and gas production (P_0= 24.8 MPa to 15 MPa)
      - Effective vertical stress changes during gas production (σ'_v= 3.8 MPa to 13.6 MPa)
  - Sample characterization:
    - X-ray CT scan
    - Porosimetry (Final Step)

- Mercury Injection Capillary Measurement (Final Step)
- Particle size analysis (Final Step)

C. Pressure Core and Data Distribution

- Pressure Core and Core analysis that is detailed in the Expedition Report Chapters 2-4 will be released to the public at the end of the quarter.
- UT will continue coordinating with other institutions on plans for transferring pressure core per the final distribution plan. Pressure core distribution will start in September 2018.

Depressurized Core Analysis

- Ohio State 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 will work on the documentation/data report for Task 6.0
- Ohio State 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.

Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis

- Ohio State 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 Sidewall Core Microanalysis.
- UT will continue conversation with Geotek concerning possible Pre-consolidation Chamber purchase to estimate its possible value to UT.

Task 10: Other Work, AAGP Special Publication and Workshop

- In support of the AAGP Special Publication Vol I and II, Cook and Flemings will continue to participate as Special Volume Editors.
- Cook will lead a workshop on GC 955. The first day (Sept 24) will be focused on the ongoing science associated with GOM^2-1. The second day (Sept 25) will be focused on planning for GOM^2-2.

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 initiate Task 14 (PCTB Performance Assessment, Review, Modifications and Testing). Specifically, UT will work with Geotek to initiate development of 3-D drawings and a 3-D model of the PCTB, and will procure services for computational fluid dynamics (CFD) modeling.

TASK 15.0: FIELD PROGRAM PREPARATIONS

- UT will continue to provide support to ECORD in scoping GOM^2-2 as an ECORD MSP as needed.
- Continue to develop and refine contingency scenarios for GOM^2-2 expedition Operational Plan and Science Plan.
- Initiate search for GOM^2-2 drilling vessel vendor in the event that UT must execute GOM^2-2 independently as was done with Green Canyon 955 in 2017.
- Clarify path forward for executing GOM^2-2 as an ECORD MSP if such is deemed plausible by IODP, ECORD, UT, and DOE.
- Continue to refine G&G section of Bureau of Ocean Energy Management (BOEM) Exploration Plan for GOM^2-2.
- UT Austin and Ohio State will work together with BOEM, DOE and USGS to finalize drilling plans and well locations.
- UT Austin and Ohio State will continue to work towards permitting GOM^2-2 drilling locations.
- Ohio State will continue working with IODP as needed for shallow hazard assessments in support of efforts to mount GOM^2-2 and an ECORD MSP.

2 PRODUCTS

2.1 PUBLICATIONS, CONFERENCE PAPERS, AND PRESENTATIONS

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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 the spring of 2018, the JRSO and ODL-SIEMS withdrew from performing IODP Expedition 386 for the mid-2020 scheduled IODP Expedition 386 in the Gulf of Mexico (see discussion of Task 15). This is a significant challenge because the cost of using the JR is quite low compared to market rates for drilling vessels. UT and the GOM^2 team now are now developing an alternate plan to achieve the scientific objectives of GOM^2-2. The options we will pursue in the next quarter include:

1. **UT-Led Expedition**: One possibility is that UT executes GOM^2-2 independently, as we did with GOM^2-1 in Green Canyon 955. We will work with UT administration to select a drilling vessel and develop rigorous cost estimates. We will develop a scaled approach wherein we will have develop an approach and budget to achieve the full science program and also develop plans with reduced scope and reduced budget.
2. **ECORD MSP**: We will work with the European Science Operator to support them as they develop approaches to pursue an IODP Mission Specific Platform (MSP) through ECORD.
3. **IODP Hybrid**: We will communicate with the IODP USIO (United States Implementing Organization) to determine whether it will be possible to do analysis of our cores onboard the *JR* when it is docked between drilling operations.

By December 2018 we intend to have a full alternate approach scoped out to present to DOE for formal consideration.

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.

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.

By December 2018 we intend to have a full alternate approach scoped out to present to DOE for formal consideration.

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. Note: Y2 in the table is Y3 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							
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	**Phase 2 Extension**	$ 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		
Non-Federal Share		$ 211,985	$ 211,985	$ 207,161	$ 419,146		
Total Incurred Cost		$ 606,517	$ 606,517	$ 640,739	$ 1,247,256		
Variance							
Federal Share		$ (671,701)	$ (671,701)	$ (354,612)	$ (1,026,313)		
Non-Federal Share		$ (146,573)	$ (146,573)	$ (151,397)	$ (297,970)		
Total Variance		$ (818,274)	$ (818,274)	$ (506,009)	$ (1,324,283)		

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
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
PCTB	Pressure Core Tool with Ball Valve

ACRONYM	DEFINITION
PM	Project Manager
PMP	Project Management Plan
PMRS	Pressure Maintenance and Relief System
QRPPR	Quarterly Research Performance and Progress Report
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

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APPENDIX A

Memo – *Plan B: The Path Forwards for GOM^2-2*

THE UNIVERSITY OF TEXAS AT AUSTIN
DEPARTMENT OF GEOLOGICAL SCIENCES

John A. & Katherine G. Jackson School of Geoscience • http://www.geo.utexas.edu/
1 University Station, Austin, TX, 78712 • (512) 471-5172 • Fax (512) 471-9425

Memo

To: GOM^2 Program Participants and the *JOIDES Resolution* Facility Board
From: Peter B. Flemings (pflemings@jsg.utexas.edu)
Date: 5/8/2018
Re: Plan B: the path Forwards for GOM^2-2

Overview: This memo is to update the *JOIDES Resolution* Facility Board and GOM^2-2 participants of the status of GOM^2-2. UT leads a multi-institutional effort supported by the US Department of Energy to characterize coarse-grained methane hydrate reservoirs in the Gulf of Mexico (acronym = GOM^2). In spring 2017, UT led a 12-day engineering test (GOM^2-1) to sample methane hydrates in the Gulf of Mexico. The project plan is to execute a second drilling campaign (GOM^2-2) to more fully characterize several methane hydrate reservoirs in the Gulf of Mexico.

We envisioned that GOM^2-2 would be executed by the *JOIDES Resolution* through a Complimentary Program Proposal. We completed all aspects of the proposal process, which included two proposals, two addendums, and two Environmental Pollution and Safety Panels (EPSP). As an outcome of these efforts, we were scheduled to sail in spring 2020 for a ~56 day expedition that would log, core, and perform downhole experiments in the Orca Basin and the Terrebonne Basin (https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-386/)
(https://iodp.tamu.edu/scienceops/expeditions/gulf_of_mexico_hydrate.html).

***JOIDES Resolution* will not be used for GOM^2-2 in 2020:** In the spring of 2018, it became apparent that the *JOIDES Resolution* does not meet the regulatory requirements for a mobile offshore drilling unit (MODU) and the MODU 1989 Standard, which is required by the US Coast Guard and the Bureau of Safety and Environmental Enforcement (BSEE) for drilling and conducting deep stratigraphic tests (boreholes deeper than 500 feet below seafloor) on the Outer Continental Shelf (OCS). A preliminary review of the requirements for a MODU 1989 Standard performed by UT, the JR Science Operator (JRSO) and the JR ship owner (ODL-SIEMS), led to the conclusion that there was neither sufficient time (the JR is fully scheduled until mid-2020), nor sufficient funds, to modify the *JOIDES Resolution* to meet the MODU requirements. The UT GOM2 team and the DOE emphasized that they were willing to seek review of any potentially inappropriate regulations. However, we did not get an accounting of specific issues for which a discussion with the regulators might be worthwhile. Ultimately, in April 2018, the JRSO and ODL-SIEMS withdrew from performing IODP Expedition 386 for the mid-2020 scheduled IODP Expedition 386 for the GOM.

Possible Paths Forward for GOM²-2: UT, its partners, and the US DOE remain committed to the scientific goals of GOM²-2. We envision three possible paths to execute GOM²-2: 1) as an IODP expedition on a Mission Specific Platform; 2) as in independent expedition executed by UT in the same manner that UT-GOM²-1 was; and 3) some 'hybrid' of these two options.

1) IODP MSP Expedition: We are in preliminary discussions with the IODP over the possibility of executing this expedition as a Mission Specific Platform (MSP). MSPs are IODP platforms especially chosen to fulfil particular scientific objectives (http://www.ecord.org/expeditions/msp/concept/). The European Science Operator (ESO) is the operator responsible for such expeditions. Recently the ESO completed Expedition 381 (Corinth Active Rift Development) in the Gulf of Corinth (http://www.ecord.org/expedition381/) using the Fugro Synergy. Prior to this, they completed Expedition 364 (Chicxulub K-Pg Impact Crater) off the Yucatan Peninsula (http://www.ecord.org/expedition381/) using a jack-up rig.

Whether the ESO would be in a position to take on the GOM²-2 expedition remains to be seen. There are substantial advantages to remaining within the IODP umbrella. One advantage is that the core would be archived and analyzed through the auspices of the IODP. During the Chicxulub expedition, time critical measurements where made shipboard and the majority of the core was preserved as whole core. It was taken off the rig, cat-scanned in Houston (by Weatherford), and then shipped to the University of Bremen, Germany. There was then a 5-week program to analyze the core in Bremen at permanent facilities established there (MARUM). In addition, if GOM²-2 remained in the IODP, all publications would be managed by the IODP through the USIO Publications office (e.g. http://publications.iodp.org/proceedings/364/364title.html).

We also see challenges to staying within the IODP umbrella. One obvious challenge is that the regulatory challenges of drilling in US waters in the Gulf of Mexico are substantial. It might be difficult for the ESO to manage these obligations. A second challenge is that it is not clear how closely the ESO will be able to define their schedule given other commitments. We will need to schedule both the vessel and Geotek simultaneously. It is also not clear how the costs will be shared by the ESO and UT. There must be a clear understanding of what each party is in a position to contribute. Finally, there are clear technical requirements for a vessel. A concern that we have is how much control we would have in selecting and contracting a vessel.

2) UT Expedition: Our second path is to pursue this expedition independently in the same manner that we completed GOM²-1. This path will require UT to independently lease a vessel and assume all associated contractual costs (e.g. logging, mud, etc.). In this approach, there would most likely be a similar approach of limited measurements on the vessel and then the establishment of a shore-based facility for more detailed core analysis. The advantage of this approach is that there is a clear path forwards for implementation. UT is already established as a Gulf of Mexico operator and UT is now familiar with the details of regulations and reporting (https://ig.utexas.edu/files/2018/02/1.0-UT-GOM2-1-Expedition-Summary.pdf). In addition, we have previously contracted, bonded, and insured a similar expedition. The disadvantage of this approach is that there would most likely be substantially less conventional core recovered and relatively limited ability to analyze and archive these cores. Furthermore, this approach would not entrain as large a scientific community as could result through the IODP.

3) Hybrid Expedition: Ultimately, it is possible that a 'hybrid' MSP expedition could be accomplished where UT would take on some or all of the at-sea logistical details (e.g. permitting, vessel contracting) and the ESO would be responsible for core analysis and curation. However, this path has not been discussed and, to our knowledge, the ESO has not taken this approach previously.

Immediate Steps toward 'Plan B': The UT Team is now embarking on a technical analysis of the three pathways described above. For each approach we are asking the following.

1) How would we revise our science plan for each scenario?
2) How would we revise our operational plan for each scenario?
3) What are the benefits and risks each scenario?

UT is currently sketching out how this analysis will be performed. We will soon reach out the entire GOM2 team to refine this technical analysis. We will then work with potential institutions (essentially the ESO and private companies) to hold proposal clarification meetings. Ultimately, we will review our options, rank, and select a path forward.

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Deepwater Methane Hydrate Characterization and Scientific Assessment

APPENDIX B

Ref: IODP Proposal 887-CPP2 and Expedition 386

Dr. Peter Flemings
Jackson School of Geosciences
University of Texas at Austin
10100 Burnet Rd.
J.J.Pickle Research Campus, Bldg. 19
Austin, TX 78758

May 21, 2018

Ref: IODP Proposal 887-CPP2 and Expedition 386

Dear Peter,

During the recent JOIDES Resolution Facility Board (JRFB) meeting on 15-16 May 2018 in Washington DC, a major part of the discussion focused on the scheduling of the JOIDES Resolution in FY'20 and in the early part of FY'21. The JRFB has as its primary goal the implementation of all proposals that are thoroughly reviewed, scientifically evaluated, and forwarded by the Science Evaluation Panel (SEP), and that have been recommended for approval by the Environmental Protection and Safety Panel (EPSP). Decisions on the scheduling are principally dependent on the planned regional track of the JOIDES Resolution, maximizing the fit and balance of proposals to the IODP 2013-2023 Science Plan, funding and ship time availability, and safety, permitting and other logistical constraints.

Following last year's scheduling of IODP Expedition 386 on the FY'20 schedule of the JOIDES Resolution, I am sincerely regretting that I have to inform you that the JRFB canceled Expedition 386 and removed it from the JOIDES Resolution schedule. The decision is explained in JRFB1805 Consensus Statement 10 as well as JRFB's follow-up action:

> The US Coast Guard has informed the JRSO and ship owner ODL/SIEM that the JOIDES Resolution needs to fulfill all requirements of the Mobile Offshore Drilling Unit (MODU) 1989 Standard in order to receive permitting for Expedition 386 in the US EEZ of the Gulf of Mexico. Given the high costs and insufficient available time for the large number of upgrades required, the JRFB cancels Expedition 386 and removes it from the JOIDES Resolution schedule. However, the JRFB will forward proposal 887-CPP2 and 887-ADD2 to the ECORD Facility Board (EFB) for consideration of the potential implementation of this drilling project as a Mission Specific Platform (MSP). The JRFB highlights the fact that implementation of this drilling proposal addresses Challenge 13 in the IODP 2013-2023 Science Plan.

Although the JRFB expresses its deep disappointment with this unfortunate outcome, we are pleased that now this critical IODP expedition can be considered for implementation as an MSP. We therefore urge you and your proponent team to immediately start to work with the ECORD Facility Board (outgoing and incoming chairs Gilles Lericolais and Gabriele Uenzelmann-Neben), the ECORD Science Operator (David McInroy) and the ECORD Management Agency (Gilbert Camoin). The ECORD representatives present during the JRFB1805 meeting requested a quick start of conversations, in particular to chart out potential budget issues, required drilling operations and facilities, etc.

If you have any questions, I am happy to answer those via email or phone.

All the best,

Anthony Koppers, Chair of the JOIDES Resolution Facility Board

CC: IODP Science Support Office
Gilles Lericolais, Gabriele Uenzelmann-Neben, David McInroy
Gilbert Camoin

DOE Award No.: DE-FE0023919

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Deepwater Methane Hydrate Characterization and Scientific Assessment

APPENDIX C

UT-GOM2-1 Biostratigraphy Report

UT-GOM2-1 Biostratigraphy Report

Examination and Interpretation by Marcie Purkey Phillips, Biostratigrapher
University of Texas at Austin Institute for Geophysics
Marciepurkey@gmail.com
May 10, 2018

OVERVIEW

This biostratigraphy report includes the description and interpretation of 30 samples examined from 2 holes drilled during the 2017 UT-GOM2-1 Expedition in Green Canyon, Gulf of Mexico (GoM) – 22 samples from Hole H002, and 8 samples from H005 (see attachments).

The biozonation applied to this interpretation is the Calcareous Nannofossil Plio-Pleistocene (CNPL) Zonation of Backman et al. (2012), which assigns Plio-Pleistocene biochronology to calcareous nannofossil assemblages from low to middle latitudes. This biozonation is further calibrated to the 2016 Geologic Time Scale of Ogg et al. (2016)

Semi-quantitative evaluations were conducted on all samples to identify age-diagnostic species/assemblages for interpreting geologic age. All samples contain significant Cretaceous reworking. These specimens are not considered part of the assemblage when making biostratigraphic interpretations; instead they are considered as part of the detrital sediment.

All samples examined from Hole H002 are interpreted to be Calabrian (Middle Pleistocene). Sample UT-GOM2-1-H002-1CS-1_24-25cm, 409.6 mbsf, provides the first age-diagnostic data and is interpreted to be no younger than 0.91 Ma. The lowermost sample, UT-GOM2-1-H002-8CS-5_27-28cm, 434.1mbsf, is interpreted to be no older than 1.06 Ma. This interpreted age range is assigned to the lowermost CNPL Zone 10. See attachments for details.

All samples examined from Hole H005 are also interpreted to be Calabrian. The uppermost sample, UT-GOM2-1-H005-1FB-3_163-184, 284.18 mbsf, is interpreted to be approximately 1.0 Ma, in the lower CNPL10 Zone. The next sample below this one is about 150 meters deeper, at 436.93 mbsf, and is interpreted to be in CNLP Zone 9 (1.06 – 1.25 Ma). The remaining samples from Hole H005, down to 445.28 mbsf, are also assigned to CNPL9; no older than 1.25 Ma. See attachments for details.

Attachments (6)
H002 & H005 Data spreadsheet (1 document)
H002 Calcareous Nannofossil Distribution Chart
H002 Biostratigraphy Chart
H005 Calcareous Nannofossil Distribution Chart
H005 Biostratigraphy Chart
Backman et al. (2012) publication

UT-GOM2-1 HOLE H002 SAMPLE DESCRIPTIONS

H002-1CS-1_11-12cm, 409.46 mbsf: Calcareous nannofossil abundance is insufficient for biostratigraphic interpretation.

H002-1CS-1_24-25cm, 409.59 mbsf: Age diagnostic species including *Gephyrocapsa* “small” (3-4 um) and “medium” (>4um) and *Reticulofenestra asanoi* were observed in this sample. Based on this assemblage, geologic age is interpreted to be no younger than 0.91 Ma (Calabrian, CNPL10). It should be noted that only a single specimen of *R. asanoi* was observed. A single specimen of *Emiliania huxleyi* is interpreted to be the result of reworking or contamination. Specimens of *Sphenolithus abies*. (Pliocene-Miocene) were observed and are also interpreted to be reworked.

H002-2CS-1_0-45cm, 412.84 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-2CS-2_16-17cm, 413.01 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils indicating a strong influence of terrestrial runoff during this time of deposition. Presence and abundance of age diagnostic microfossils is insufficient. The preservation of Cretaceous specimens is noted to be very good.

H002-2CS-2_23cm, 413.07 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-2CS-2_37-38cm, 413.21 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed.

H002-2CS-3_59-60cm, 414.23 mbsf: This sample contains a greater diversity of Pleistocene and modern nannofossils, but total abundance remain very low. Age diagnostic species *Gephyrocapsa* “small” (3-4um) and “medium” (>4um) were observed, and the geologic age for this sample is interpreted to be within the Calabrian, Zone CNPL10.

H002-2CS-4_75-76cm, 415.39 mbsf: This sample is predominated by reworked Cretaceous specimens and low abundances of age diagnostic species including *Gephyrocapsa* “small” and “medium” support and age interpretation of Calabrian within CNPL Zone 10.

H002-3CS-1_13-14cm, 415.57 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed.

H002-5CS-1_75-76cm, 422.29 mbsf : This sample contains a greater diversity of Pleistocene and modern nannofossils, but total abundance remain very low. Age diagnostic species *Gephyrocapsa* “small” (3-4um) and “medium” (>4um) were observed, and the geologic age for this sample is interpreted to be within the Calabrian, Zone CNPL10.

H002-6CS-1_10-11cm, 424.69 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed.

H002-6CS-2_19-119cm, 424.78 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-6CS-3_119-219cm, 425.78 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Preservation of Cretaceous specimens is good. Presence and abundance of age diagnostic microfossils is insufficient.

H002-6CS-4_16-17cm, 426.94 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed. Large grains were notable in this sample, and all observed specimens were fragmented.

H002-6CS-5_8-9cm, 427.86 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils. It also contains low abundances of Pleistocene and modern nannofossils including *Gephyrocapsa* “medium” (≥4um) and one *Gephyrocapsa* “large” (>5.5um). The geologic age for this sample is interpreted to be within the Calabrian, Zone CNPL10. Ostracod shell fragments were also observed during examination. The single specimen of *E. huxleyi* is interpreted to be the result of reworking or contamination. There is insufficient data to determine with certainty whether the single specimen of *Gephyrocapsa* “large” is in situ.

H002-7CS-1_6-72cm, 427.69 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-8CS-2_57cm, 431.25 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils with very few Pleistocene nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-8CS-2_57-157cm, 432.25 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils with few specimens of *Gephyrocapsa* “small” observed, as well as a single specimen of the age-diagnostic *Pseudoemiliania lacunosa.* This combination continues to support the Calabrian age assignment. Unfortunately, *P. lacunosa* cannot provide a more precise age interpretation as it was only observed in this sample. The single specimen of *E. huxleyi* is interpreted to be a result of reworking or contamination.

H002-8CS-3_157-235cm, 432.25 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H002-8CS-4_5-6cm, 433.08 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils, and also contains moderate abundances of Pleistocene and modern nannofossils. Age diagnostic species of *Gephyrocapsa* "small" and "medium" were observed, which continue to support the interpreted geologic age of Calabrian, Zone CNPL10.

H002-8CS-4_33-34cm, 433.36 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed.

H002-8CS-5_27-28cm, 434.1 mbsf: This sample is predominantly composed of reworked Cretaceous nannofossils, but also contains low abundances of *Gephyrocapsa* "small" and "medium", which continue to support the interpreted geologic age of Calabrian, Zone CNPL10. Multiple specimens of juvenile forms of planktonic forams were also observed in this sample.

UT-GOM2-1 HOLE H005 SAMPLE DESCRIPTIONS

H005-1FB-3_163-184cm, 284.18 mbsf: This sample contains abundant age-diagnostic *Gephyrocapsa* "small" and "medium" and *P. lacunosa,* the combination of which suggests a geologic age of approximately 1.0 Ma in the Calabrian (M. Pleistocene), near the base of Zone CNPL10. Other Pliocene-Pleistocene age-diagnostic species were observed including *Ceratolithus cristatus, Discoaster challengeri*(?)*, D. pentaradiatus,* and *S. abies.* These four species; however, are interpreted to be reworked for various reasons including poor preservation, and relative abundance and geologic age to predominate age-diagnostic species.

H005-9FB-1_15-16cm, 436.93 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H005-9FB-2_34-35cm, 437.3 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. No microfossils from the interpreted time of deposition were observed.

H005-9FB-4_282-317cm, 439.36 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H005-9FB-4_10-11, 439.46 mbsf: Specimens of the age-diagnostic *Gephyrocapsa* "small" (3-4 um) were observed in very low abundances. The geologic age interpretation for this sample is Calabrian, Zone CNPL9.

H005-12FB-1_4-5cm, 444.44 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Specimens of the age-diagnostic *Gephyrocapsa* "small" (3-4 um), and *P. lacunosa* were observed in very low abundances, but support the age interpretation of Calabrian, Zone CNPL9. It should be noted that only a single specimen of *P. lacunosa* was observed and it appeared to be partially broken.

H005-12FB-2_15-16cm, 444.55 mbsf: This sample contains virtually 100% reworked Cretaceous nannofossils. Presence and abundance of age diagnostic microfossils is insufficient.

H005-12FB-4_12-13, 445.28 mbsf: Specimens of the age-diagnostic *Gephyrocapsa* "small" (3-4 um) were observed in low abundances, but support the age interpretation of Calabrian, Zone CNPL9.

Citations

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Quarterly Research Performance Progress Report Period Ending 06/31/2018

Deepwater Methane Hydrate Characterization and Scientific Assessment

APPENDIX D

Internal Memo: PCTB vs. HPTC Pressure Coring Tool for UT-GOM2-2

THE UNIVERSITY OF TEXAS AT AUSTIN
DEPARTMENT OF GEOLOGICAL SCIENCES

John A. & Katherine G. Jackson School of Geoscience • http://www.geo.utexas.edu/
1 University Station, Austin, TX, 78712 • (512) 475-8738• Fax (512) 471-9425

To: PCT Development Team

From: Peter Flemings
Re: Internal Memo: PCTB vs. HPTC Pressure Coring Tool for UT-GOM2-2 (DE-FE0023919)
Date: 6/20/18

1. Summary

The PCT Development team is composed of Peter Flemings (UT), Tim Collett (USGS), Tom Pettigrew (Pettigrew Engineering), Jesse Houghton (UT), Ray Boswell (DOE), and Rick Baker (DOE). This memo summarizes our recent comparison of HPTC and PCTB_CS and PCTB_FB performance for the purposes of confirming our path forward for pressure coring technology for the UT-GOM2 project.

2. Background

UT, through its DOE-sponsored GOM2 project, has worked with Aumann & Associates, Inc. (now Geotek Coring Ltd.), to develop, test, and deploy the Pressure Coring Tool with Ball-Valve (PCTB) since 2014. The PCTB has two versions: the cutting shoe (PCTB_CS) and the face bit (PCTB_FB). The BHA for the cutting shoe version can also be used for conventional coring and wireline logging. However, the face bit BHA cannot be used for either other coring, penetrometer deployment, or logging.

In 2017, UT tested the PCTB in two boreholes in the deepwater Gulf of Mexico (GOM^2-1): GC 955 H002 and GC 955 H005. A full description of the coring program is provided in the initial report (Flemings et al., 2018). Significant challenges were encountered during pressure coring due to the failure of the PCTB autoclave to seal at the core-point pressure in many cases. At H002, 8 pressure cores were attempted with the PCTB_CS, but only one pressure core was recovered to the rig floor at a pressure and temperature within the methane hydrate stability zone. A number of problems were identified that contributed to the lack of pressure in the 7 unsuccessful pressure core runs (Figure 1).

Pressure coring at H005 was accomplished with the PCTB_FB and was more successful than at H002, with 11 cores recovered on the rig floor at pressure within the methane hydrate stability zone. Although more successful than the cutting shoe version deployed at H002, the PCTB_FB at H005 only sealed at the core point depth 2 times. As with H002, numerous problems were identified that contributed to the failed, or partially successful cores in H005 (Figure 2).

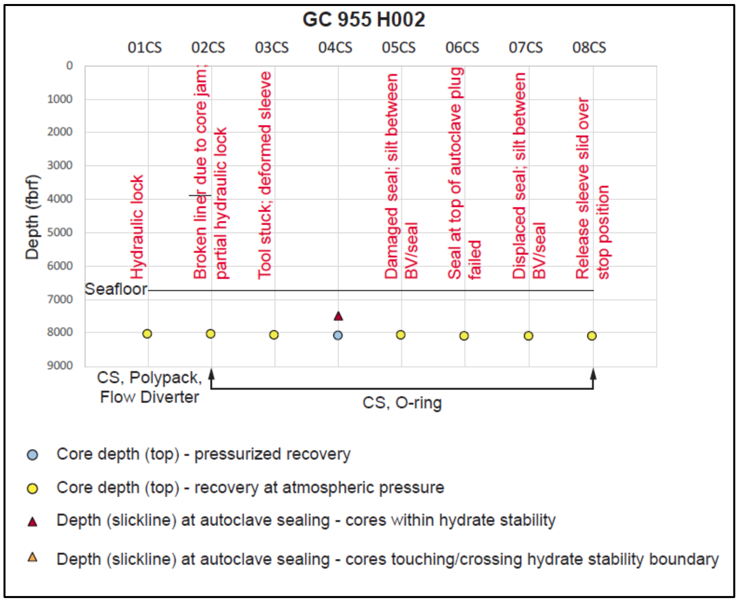

Figure 1: Tool configuration and failure mechanism for pressure cores at H002. 8 pressure cores were taken. Only one pressure core held pressure. Figure from (Flemings et al., 2018).

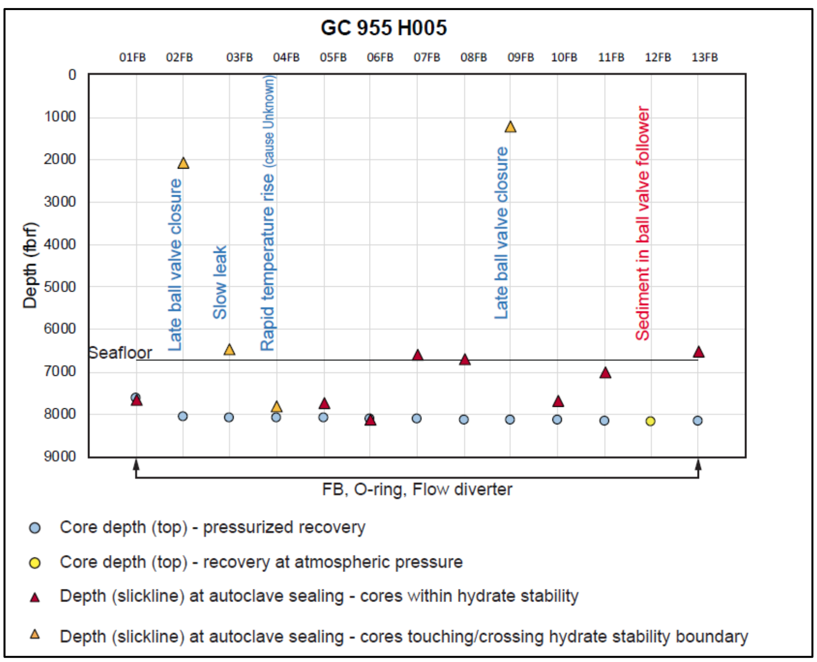

Figure 2 Tool configuration and failure mechanism for pressure cores at H005. 13 pressure cores were taken. Figure from (Flemings et al., 2018).

In 2018, the Japanese Oil, Gas and Metals National Corporation (JOGMEC) utilized an alternate pressure-coring tool developed by Geotek called the High Pressure and Temperature Corer (HPTC). This coring expedition was conducted in the Nankai Accretionary Wedge off the coast of Japan in approximately 1000 m of water. The HPTC was very successful (Figure 3). During this expedition 49 back-to-back pressure cores were taken in 2 wells (25 and 24, respectively).

13 of 49 runs had a late seal or boost, but within the hydrate stability zone. Two coring runs had no boost.

A comparison of PCTB performance on UT-GOM2-1 and of the HPTC in Nankai is presented in Figure 3.

TOOL - Location	RESULT	Frequency	%
HPTC-III Nankai (1000 m water)	"OK"	34/49	69%
	"Late Boost"	13/49	27%
	"No Boost"	2/49	4%
PCTB-FB GC 955 **(2033 m water)**	Boost applied at core depth	2/12*	17%
	Boost late but in the HSZ	7/12	58%
	Last Boost out of the HSZ	3/12	25%

Figure 3: Comparison of HPTC-III performance during spring 2018 deployment at Nankai with PCTB_FB performance in the Gulf of Mexico during UT-GOM2-1 in 2017.

3. Review of PCTB and HPTC-III performance

UT is preparing for a pressure coring expedition in the Gulf of Mexico to occur in 2020 (UT-GOM^2-2). A plan has been prepared for continued testing and development of the PCTB, which includes laboratory-based testing, engineering modifications, and a land-based test.
Given the success of the HPTC in offshore Japan, UT has now reviewed whether the HTPC is a possible alternative to the PCTB. The primary considerations are noted below.

Pressure Sealing: The largest concern with the PCTB is its inability to consistently seal at the coring-point pressure. Instead, it has commonly sealed as the tool was being pulled from the base of the hole (Figure 2). The performance described for the HPTC is considerably better than that of the PCTB, but it also has cases where it does not seal at the coring point (labeled as 'Late Boost', Figure 3).

It is not fully understood why the tools seal late in either the HPTC or the PCTB. Geotek suggests that problems encountered with the HPTC may be similar to the sealing problems encountered with the PCTB during UT-GOM^2-1. At this point, we do not know whether the HPTC has a significantly better design or whether incremental improvements made since the H005 well resulted in the better performance. Both the HPTC and the PCTB have similar designs for the upper end of the tools (pressure section). Thus, if the pressure sealing issues are related to this part of the tool (and not the ball valve), then we would expect both tools to perform similarly.

There is a mechanical seal for the ball valve of the HPTC. This design difference is because the HPTC has a wider diameter than the PCTB. There is a general consensus that the mechanical seal of the HPTC will result in more robust sealing of the ball valve than is possible for the spring-driven mechanism of the PCTB.

Core Quality: GeoTek has suggested that the core quality of the PCTB-FB may be slightly better than that of the HPTC. This is because the inner barrel of the HPTC does not have a bearing enabling free rotation as per the PCTB-FB. It is therefore likely to rotate during coring as does the PCTB-CS, where the inner barrel is locked to the outer barrel and is forced to rotate. Further evaluation of the core recovered at Nankai is necessary to make a definitive assessment.

Core Recovery: We do not know if the core recovery of the HPTC would be superior to that of the PCTB. Learnings from many of the problems encountered in the H002 well were applied both on the H005 well and on the 2018 Nankai expedition. In truth, based on the recovery success at the H005 well (Figure 2), core recovery is felt to be very good for both tools.

Tool Performance: The HPTC ball valve closure mechanism and the HTPC overall is most likely more robust than the PCTB due to its larger size.

Large Diameter Pipe: The HPTC requires use of wide diameter (WD) pipe that has a minimum tool joint/tube ID of 5.906”. The largest ID 6-5/8” rental pipe located to date has and ID of 5.625”, 30.29 ppf, V-150, Range 2 or 3, TT-M710 connections, drift ID: 5.500”, adj wt: 38.56 ppf. The only pipe that we know of that meets the HPTC requirement is owned by the Japanese.

The 6-5/8” rental pipe or the Japanese wide diameter pipe, described above can be used for the PCTB holes or conventional coring. However, we would need to use a 10.5" bit. At present, there is only one 10.5" bit owned by the project. Furthermore, it is not thought to be optimal to drill with a 10.5” bit for the PCTB holes or conventional coring.

If we drilled a hole with the HPTC, we would still have to trip pipe and change the BHA to run the wide diameter logging tools. HPTC is a face bit configuration and will not allow in-situ tools to pass through the bit.

If we run the PCTB_CS, we can use narrow diameter pipe and will not have to pull the string to perform conventional coring or logging. However, if we run the PCTB_FB, we will need to pull the string to perform penetrometer tests, log, or perform conventional coring.

Vessel Considerations: Use of large diameter pipe required for the HPTC may preclude using some vessels. Calculating string weight and hook load it will be around 115 tons. Some smaller vessels only have 100-ton capacities. Others have 150-ton capacity.

Cost and Schedule:Additional cost would be required to build the HPTC unless UT has means of ‘borrowing’ the JOGMEC HPTC. Additional costs would also be required to make the UT pressure core center compatible with the larger HPTC core liner. Laboratory and land-based testing programs would be required for both tools.
UT currently estimates that the costs of tool development are as follows:

- PCTB Development: $2.0MM
- HPTC Development and Rental from Geotek: $2.8MM
- HPTC Development and Purchase from Geotek: $3.6MM

Other Issues: Of the tools discussed, the PCTB-FB is the only version where neither the inner core barrel nor the liner are locked to the rotation of the BHA. The GOM^2 pressure coring tool development team collectively holds the belief that this configuration is the optimal approach for core quality.

The team has high hopes that the planned laboratory effort to develop a single trigger for sealing may resolve sealing timing issues in the top of the PCTB tool by removing a lag in closing the vent valve. If so, this might dramatically improve tool performance for both the PCTB and HPTC.

We recognize that the spring-loaded ball valve in the PCTB is less robust than the physical arm used in the HPTC to close the ball valve. However, if the problem relates to the PCTB pressure section, then the ball valve is not the weak point.

At this point, the PCTB development team is familiar with the PCTB. If we switch to the HTPC, we will be almost back to the start of the learning curve. We will be testing, getting familiar, and re-treading ground we've already covered with PCTB.

If our goal was to develop a pressure coring tool for the next 10 years, we might choose to go to the HPTC. However, if we are trying to have the optimum performance for the next expedition, we feel it is more judicious to continue with the PCTB.

4. Decision: Move forward with the PCTB_CS and PCTB_FB

The team feels that the best decision for pressure coring for an expedition to be mounted in 2020 is to continue to test, develop, and deploy the PCTB_FB and PCTB_CS tools. The costs are lower with this path. In addition, there is significant risk of poor performance if we were to choose the HPTC because we would be developing and deploying an entirely new version of a pressure coring tool in a short (less than 24 month) time window.

Furthermore, the most fundamental problem with the tool is pressure-sealing. This problem may be due to a common technology used with both tools. The tool testing and development plan for the PCTB is designed to address the remaining concerns associated with the sealing of the PCTB and we believe the results will place the performance of the PCTB at functional level exceeding that of the HPTC III.

The team also recommends continuing with the development and testing of both the PCTB_FB and the PCTB_CS. The BHA for PCTB_CS can also be used for conventional coring, wireline logging, and penetrometer deployment. There are significant operational advantages to being able to use the same BHA and hence borehole for all of these measurements. In contrast, the PCTB_FB has the operational advantage that a single borehole can be drilled over the entire depth of the hole, instead of having to pull the BHA when transitioning from the APC/XCB to the RCB. Furthermore, there is evidence that the PCTB_FB may cut higher quality core than the PCTB_CS. Finally, the vast majority of the PCTB_FB and PCTB_CS tools are identical. Thus, the incremental cost of continuing to maintain the PCTB_CS and PCTB_FB is small.

5. References

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National Energy Technology Laboratory

626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940

3610 Collins Ferry Road
P.O. Box 880
Morgantown, WV 26507-0880

13131 Dairy Ashford Road, Suite 225
Sugar Land, TX 77478

1450 Queen Avenue SW
Albany, OR 97321-2198

Arctic Energy Office
420 L Street, Suite 305
Anchorage, AK 99501

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