NATIONAL ENERGY TECHNOLOGY LABORATORY

DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report

(Period Ending 03/31/21)

Deepwater Methane Hydrate Characterization & Scientific Assessment

Project Period 5: 10/01/20 - 09/30/22

Submitted by:

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

Office of Fossil Energy

DISCLAIMER

1 ACCOMPLISHMENTS

This report outlines the progress of the second quarter of the seventh fiscal year of the project (Budget Period 5, Year 1). Highlights from this period include:

- **PCTB Ball-Valve Testing and Modifications**: The ‘pressure coring tool with ball valve’ (PCTB) was upgraded to a new version termed the Mk 5. This upgraded version diverted grit from the ball valve assembly with wiper rings, screens, improving centralization throughout actuation, and improved flow paths. Bench tests were conducted on the upgraded PCTB toolsets, resulting in 100% success rates with the exception of one intentionally induced failure. Preparations were made for a land test that will occur in the next performance period at Catoosa Test Facility in Oklahoma.

- **UT-GOM2-2 Permits**: UT completed numerous UT-GOM2-2 permit documents, including the Right of Use and Easement (RUE) letter request (30 CFR 550.160 & 550.161), Initial Exploration Plan (30 CFR 550.211-235; 30 CFR 550.125-126; NTL No. 2008-G04), Coastal Zone Management (CZM) Consistency Certification (NTL No. 2008-G04), and BOEM 0137 OCS Plan Information forms.

1.1 Major Project Goals

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 Table 1-1, Table 1-2, and Table 1-3.

Table 1-1: Previous Milestones

Budget Period	Milestone	Milestone Description	Estimated Completion	Actual Completion	Verification Method
1	M1A	Project Management Plan	Mar-15	Mar-15	Project Management Plan
	M1B	Project Kick-off Meeting	Jan-15	Dec-14	Presentation
	M1C	Site Location and Ranking Report	Sep-15	Sep-15	Phase 1 Report
	M1D	Preliminary Field Program Operational Plan Report	Sep-15	Sep-15	Phase 1 Report
	M1E	Updated CPP Proposal Submitted	May-15	Oct-15	Phase 1 Report
	M1F	Demonstration of a Viable Pressure Coring Tool: Lab Test	Sep-15	Sep-15	Phase 1 Report
2	M2A	Document Results of BP1/Phase 1 Activities	Dec-15	Jan-16	Phase 1 Report
	M2B	Complete Updated CPP Proposal Submitted	Nov-15	Nov-15	QRPPR
	M2C	Scheduling of Hydrate Drilling Leg by IODP	May-16	May-17	Report directly to DOE PM
	M2D	Demonstration of a Viable Pressure Coring Tool: Land Test	Dec-15	Dec-15	PCTB Land Test Report, in QRPPR
	M2E	Demonstration of a Viable Pressure Coring Tool: Marine Test	Jan-17	May-17	QRPPR
	M2F	Update UT-GOM2-2 Operational Plan	Feb-18	Apr-18	Phase 2 Report
3	M3A	Document results of BP2 Activities	Apr-18	Apr-18	Phase 2 Report
	M3B	Update UT-GOM2-2 Operational Plan	Sep-19	Jan-19	Phase 3 Report
4	M4A	Document results of BP3 Activities	Jan-20	Apr-20	Phase 3 Report
	M4B	Demonstration of a Viable Pressure Coring Tool: Lab Test	Feb-20	Jan-20	PCTB Lab Test Report, in QRPPR
	M4C	Demonstration of a Viable Pressure Coring Tool: Land Test	Mar-20	Mar-20	PCTB Land Test Report, in QRPPR

Table 1-2: Current Milestones

Budget Period	Milestone	Milestone Description	Estimated Completion	Actual Completion	Verification Method
5	M5A	Document Results of BP4 Activities	Dec-20	Mar-21	Phase 4 Report
	M5B	Complete Contracting of UT-GOM2-2 with Drilling Vessel	May-21	-	QRPPR
	M5C	Complete Project Sample and Data Distribution Plan	Jul-22	-	Report directly to DOE PM
	M5D	Complete Pre-Expedition Permitting Requirements for UT-GOM2-2	Dec-21	-	QRPPR
	M5E	Complete UT-GOM2-2 Operational Plan Report	May-21	-	QRPPR
	M5F	Complete UT-GOM2-2 Field Operations	Jul-22	-	QRPPR

Table 1-3: Future Milestones

Budget Period	Milestone	Milestone Description	Estimated Completion	Actual Completion	Verification Method
6	M6A	Document Results of BP5 Activities	Dec-22	-	Phase 5 Report
	M6B	Complete Preliminary Expedition Summary	Dec-22	-	Report directly to DOE PM
	M6C	Initiate comprehensive Scientific Results Volume	Jun-23	-	Report directly to DOE PM
	M6D	Submit set of manuscripts for comprehensive Scientific Results Volume	Sep-24	-	Report directly to DOE PM

1.2 What Was Accomplishments Under These Goals

1.2.1 Previous Project Periods

Tasks accomplished in previous project periods (Phase 1, 2, 3, and 4) are summarized in Table 1-4, Table 1-5, Table 1-6, and Table 1-7.

Table 1-4: Tasks Accomplished in Phase 1

PHASE 1/BUDGET PERIOD 1	
Task 1.0	**Project Management and Planning**
Task 2.0	**Site Analysis and Selection**
Subtask 2.1	*Site Analysis*
Subtask 2.2	*Site Ranking / Recommendation*
Task 3.0	**Develop Operational Plan for UT-GOM2-2 Scientific Drilling Program**
Task 4.0	**Complete IODP Complimentary Project Proposal**
Task 5.0	**Pressure Coring and Core Analysis System Modifications and Testing**
Subtask 5.1	*PCTB Scientific Planning Workshop*
Subtask 5.2	*PCTB Lab Test*
Subtask 5.3	*PCTB Land Test Prep*

Table 1-5: Tasks Accomplished in Phase 2

PHASE 2/BUDGET PERIOD 2	
Task 1.0	**Project Management and Planning**
Task 6.0	**Technical and Operational Support of Complimentary Project Proposal**
Task 7.0	**Continued Pressure Coring and Core Analysis System Modifications and Testing**
Subtask 7.1	*Review and Complete NEPA Requirements for PCTB Land Test*
Subtask 7.2	*PCTB Land Test*
Subtask 7.3	*PCTB Land Test Report*
Subtask 7.4	*PCTB Modification*
Task 8.0	**UT-GOM2-1 Marine Field Test**
Subtask 8.1	*Review and Complete NEPA Requirements for UT-GOM2-1*
Subtask 8.2	*UT-GOM2-1 Operational Plan*
Subtask 8.3	*UT-GOM2-1 Documentation and Permitting*
Subtask 8.4	*UT-GOM2-1 Marine Field Test of Pressure Coring System*
Subtask 8.5	*UT-GOM2-1 Marine Field Test Report*
Task 9.0	**Develop Pressure Core Transport, Storage, and Manipulation Capability**
Subtask 9.1	*Review and Complete NEPA Requirements for Core Storage and Manipulation*
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	**Core Analysis**
Subtask 10.1	*Routine Core Analysis (UT-GOM2-1)*
Subtask 10.2	*Pressure Core Analysis (UT-GOM2-1)*
Subtask 10.3	*Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)*
Task 11.0	**Update Science and Operational Plans for UT-GOM2-2 Scientific Drilling Program**
Task 12.0	**UT-GOM2-2 Scientific Drilling Program Vessel Access**

Table 1-6: Tasks Accomplished in Phase 3

PHASE 3/BUDGET PERIOD 3	
Task 1.0	**Project Management and Planning**
Task 6.0	**Technical and Operational Support of CPP Proposal**
Task 9.0	**Develop Pressure Core Transport, Storage, and Manipulation Capability**
Subtask 9.8	*X-ray Computed Tomography*
Subtask 9.9	*Pre-Consolidation System*
Task 10.0	**Core Analysis**
Subtask 10.4	*Continued Pressure Core Analysis (UT-GOM2-1)*
Subtask 10.5	*Continued Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)*
Subtask 10.6	*Additional Core Analysis Capabilities*
Task 11.0	**Update Science and Operational Plans for UT-GOM2-2 Scientific Drilling Program**
Task 12.0	**UT-GOM2-2 Scientific Drilling Program Vessel Access**
Task 13.0	**Maintenance and Refinement of Pressure Core Transport, Storage, and Manipulation Capability**
Subtask 13.1	*Hydrate Core Manipulator and Cutter Tool*
Subtask 13.2	*Hydrate Core Effective Stress Chamber*
Subtask 13.3	*Hydrate Core Depressurization Chamber*
Subtask 13.4	*Develop Hydrate Core Transport Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.5	*Expansion of Pressure Core Storage Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.6	*Continued Storage of Hydrate Cores from UT-GOM2-1*
Task 14.0	**Performance Assessment, Modifications, and Testing of PCTB**
Subtask 14.1	*PCTB Lab Test*
Subtask 14.2	*PCTB Modifications/Upgrades*
Task 15.0	**UT-GOM2-2 Scientific Drilling Program Preparations**
Subtask 15.1	*Assemble and Contract Pressure Coring Team Leads for UT-GOM2-2 Scientific Drilling Program*
Subtask 15.2	*Contract Project Scientists and Establish Project Science Team for UT-GOM2-2 Scientific Drilling Program*

Table 1-7: Tasks Accomplished in Phase 4

PHASE 4/BUDGET PERIOD 4	
Task 1.0	**Project Management and Planning**
Task 10.0	**Core Analysis**
Subtask 10.4	*Continued Pressure Core Analysis (GOM2-1)*
Subtask 10.5	*Continued Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)*
Subtask 10.6	*Additional Core Analysis Capabilities*
Subtask 10.7	*Hydrate Modeling*
Task 11.0	**Update Science and Operational Plans for UT-GOM2-2 Scientific Drilling Program**
Task 12.0	**UT-GOM2-2 Scientific Drilling Program Vessel Access**
Task 13.0	**Maintenance and Refinement of Pressure Core Transport, Storage, and Manipulation Capability**
Subtask 13.1	*Hydrate Core Manipulator and Cutter Tool*
Subtask 13.2	*Hydrate Core Effective Stress Chamber*
Subtask 13.3	*Hydrate Core Depressurization Chamber*
Subtask 13.4	*Develop Hydrate Core Transport Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.5	*Expansion of Pressure Core Storage Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.6	*Continued Storage of Hydrate Cores from UT-GOM2-1*
Subtask 13.7	*X-ray Computed Tomography*
Subtask 13.8	*Pre-Consolidation System*
Task 14.0	**Performance Assessment, Modifications, and Testing of PCTB**
Subtask 14.1	*PCTB Lab Test*
Subtask 14.2	*PCTB Modifications/Upgrades*
Subtask 14.3	*PCTB Land Test*
Task 15.0	**UT-GOM2-2 Scientific Drilling Program Preparations**
Subtask 15.3	*Permitting for UT-GOM2-2 Scientific Drilling Program*

1.2.2 Current Project Period

Current project period tasks are shown in Table 1-8.

Table 1-8: Current Project Tasks

PHASE 5/BUDGET PERIOD 5	
Task 1.0	**Project Management and Planning**
Task 10.0	**Core Analysis**
Subtask 10.4	*Continued Pressure Core Analysis (UT-GOM2-1)*
Subtask 10.5	*Continued Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)*
Subtask 10.6	*Additional Core Analysis Capabilities*
Subtask 10.7	*Hydrate Modeling*
Subtask 10.8	*Routine Core Analysis (UT-GOM2-2)*
Subtask 10.9	*Pressure Core Analysis (UT-GOM2-2)*
Subtask 10.10	*Core-log-seismic Integration (UT-GOM2-2)*
Task 11.0	**Update Science and Operational Plans for UT-GOM2-2 Scientific Drilling Program**
Task 12.0	**UT-GOM2-2 Scientific Drilling Program Vessel Access**
Task 13.0	**Maintenance and Refinement of Pressure Core Transport, Storage, and Manipulation Capability**
Subtask 13.1	*Hydrate Core Manipulator and Cutter tool*
Subtask 13.2	*Hydrate Core Effective Stress Chamber*
Subtask 13.3	*Hydrate Core Depressurization Chamber*
Subtask 13.4	*Develop Hydrate Core Transport Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.5	*Expansion of Pressure Core Storage Capability for UT-GOM2-2 Scientific Drilling Program*
Subtask 13.6	*Continued Maintenance and Storage of Hydrate Pressure Cores from UT-GOM2-1*
Subtask 13.7	*Maintain X-ray CT*
Subtask 13.8	*Maintain Preconsolidation System*
Subtask 13.9	*Transportation of Hydrate Core from UT-GOM2-2 Scientific Drilling Program*
Subtask 13.10	*Storage of Hydrate Cores from UT-GOM2-2 Scientific Drilling Program*
Subtask 13.11	*Hydrate Core Distribution*
Task 14.0	**Performance Assessment, Modifications, and Testing of PCTB**
Subtask 14.4	*PCTB Modifications/Upgrades*
Subtask 14.5	*PCTB Land Test III*
Task 15.0	**UT-GOM2-2 Scientific Drilling Program Preparations**
Subtask 15.3	*Permitting for UT-GOM2-2 Scientific Drilling Program*
Subtask 15.4	*Review and Complete NEPA Requirements*
Subtask 15.5	*Finalize Operational Plan for UT-GOM2-2 Scientific Drilling Program*
Task 16.0	**UT-GOM2-2 Scientific Drilling Program Field Operations**
Subtask 16.1	*Mobilization of a Scientific Ocean Drilling and Pressure Coring Capability*
Subtask 16.2	*Field Project Management, Operations and Research*
Subtask 16.3	*Demobilization of Staff, Labs, and Equipment*

1.2.2.1 Task 1.0 – Project Management & Planning

Status: Ongoing

1. **Coordinate the overall scientific progress, administration and finances of the project:**
   - Monitored and controlled project scope, costs, and schedule.

2. **Communicate with project team and sponsors:**
   - Organized and coordinated project team and stakeholder meetings.
   - Organized task-specific team working meetings to plan and execute project tasks per the Project Management Plan and Statement of Project Objectives (e.g. PCTB development, UT-GOM2-2 operations planning, UT-GOM2-2 science and sample distribution planning, UT-GOM2-2 permitting, and UT-GOM2-2 vessel selection).
   - Organized sponsor meetings.
   - Managed SharePoint sites, email lists, and archive/website.

3. **Coordinate and supervise subcontractors and service agreements:**
   - Managed subcontractors.
   - Monitored schedules and ensured that contractual obligations were met.
   - Held operational planning and contractual discussions with Geotek regarding continued performance assessment, modification, and testing of the PCTB (Task 14).
   - Negotiated scope of work and amended service agreement with Geotek to perform the following tasks:
     1. Upgrade all PCTB toolsets to Mk 5 ball-valve specifications,
     2. Conduct post-modification bench tests at the Geotek testing facility in Salt Lake City, Utah.
   - Drafted new scope of work for Geotek to perform a land test of the PCTB. This service agreement amendment will be finalized and executed in the next quarter.
   - Organized recurring technical/science meetings with Geotek to identify and address science and engineering challenges pertaining to UT Pressure Core Center and field science program for the UT-GOM2-2 Scientific Drilling Program.

1.2.2.2 Task 10.0 – Core Analysis

Status: Ongoing

1.2.2.2.1 Subtask 10.4 – Continued Pressure Core Analysis (UT-GOM2-1)

A. Pressurized Core Analysis

A1. Quantitative Degassing and Gas Analysis

Noble Gas Summary

Ohio State summarized the results from noble gas geochemistry measurements made in the last quarter. In addition to the data published in Moore et al., 2020 (Applied Geochemistry) and Moore et al., 2021 (in press at AAPG), eight unique samples from Hole H005 (Segments 2FB-2 and 7FB-3, each at two separate time points) were degassed in the summer of 2020 and analyzed for major, hydrocarbon, and noble gas geochemistry, while an additional sample was analyzed from H002 (H002-04CS-2). The summary data are reported in Table 1-9, Table 1-10, and Table 1-11 below. Stable isotope analyses are in progress and will be reported within the next month.

The majority of data are broadly consistent with the findings reported in Moore et al., 2020, Moore et al, 2021; and elsewhere. In 6 of the 8 new samples from Hole H005, we observed principally methane with low concentrations of ethane and propane. These data are consistent with the occurrence of predominantly microbial methane throughout Hole H005. An important and notable derivation from these data were found in two samples from the **H005-7FB-3 A** core segment collected on 06/26/2020 and 08/04/2020, respectively. In these two samples, a notable increase in the proportion of thermogenic natural gas was observed. This interpretation is supported by marked increases in the C_1/C_2+, increased concentrations of wet gases (especially during the 06/26/2020 sampling event), marked increase in radiogenic concentrations of ^4He, and associated decrease in the helium isotopic values toward a crustal/radiogenic endmember ($0.02R_A$). These data are consistent with the presence of a marked increase in thermogenic natural gas associated with core segment **H005-7FB-3 A.** In Figure 1-1, we note that the PCATS X-ray scan from **H005-7FB-3 A** reveals a higher number of fractures compared to other cores.

Table 1-9: Bulk Gas Geochemistry and BTU Content.

Samples	CH_4 ccSTP/cc	N_2 ccSTP/cc	CO_2 ccSTP/cc	O_2 ccSTP/cc	H_2 ccSTP/cc	Ar ccSTP/cc	GROSS BTU	NET BTU
H005-2FB-2 A 7172020	0.769	0.191	1.40E-02	2.30E-02	1.34E-03	2.98E-03	778.79	701.07
H005-2FB-2 A 842020	0.877	0.106	8.17E-03	6.21E-03	1.57E-03	1.43E-03	888.69	800.01
H005-2FB-2 B 7172020	0.862	0.120	8.67E-03	6.87E-03	1.99E-03	1.81E-03	872.98	785.87
H005-2FB-2 B 842020	0.878	0.102	1.15E-02	7.07E-03	1.42E-04	1.36E-03	889.47	800.71
H005-7FB-3 A 6262020	0.882	0.167	9.29E-03	1.74E-02	1.41E-03	2.05E-03	814.59	733.31
H005-7FB-3 A 842020	0.966	0.028	4.37E-03	b.d.l.	1.71E-03	5.28E-04	979.05	881.35
H005-7FB-3 B 6262020	0.804	0.167	9.29E-03	1.74E-02	1.41E-03	2.05E-03	814.59	733.31
H005-7FB-3 B 742020	0.972	0.022	4.07E-03	b.d.l.	1.68E-03	3.94E-04	984.83	886.56
H002-04CS-2	0.976	0.016	6.18E-03	b.d.l.	2.17E-03	3.22E-04	987.87	889.28

Table 1-10: Hydrocarbon Data.

Samples	CH_4 / C_2H_6+	CH_4 ccSTP/cc	C_2H_6 ccSTP/cc	C3 ccSTP/cc	Ci-4 ccSTP/cc	Cn-4 ccSTP/cc	Ci-5 ccSTP/cc	C-5 ccSTP/cc	C-6 ccSTP/cc
H005-2FB-2 A 7172020	2586	0.769	2.90E-04	3.97E-06	9.53E-07	8.70E-07	2.00E-06	b.d.l.	b.d.l.
H005-2FB-2 A 842020	1422	0.877	5.99E-04	9.28E-06	2.75E-06	1.88E-06	3.36E-06	1.16E-06	b.d.l.
H005-2FB-2 B 7172020	2243	0.862	3.76E-04	4.80E-06	1.05E-06	b.d.l.	2.64E-06	b.d.l.	b.d.l.
H005-2FB-2 B 842020	2378	0.878	3.55E-04	8.75E-06	2.41E-06	1.34E-06	2.14E-06	b.d.l.	b.d.l.
H005-7FB-3 A 6262020	366	0.882	1.62E-03	4.13E-04	7.40E-05	1.49E-04	6.05E-05	6.78E-05	2.54E-05
H005-7FB-3 A 842020	1409	0.966	6.69E-04	9.02E-06	6.00E-06	1.54E-06	b.d.l.	b.d.l.	b.d.l.
H005-7FB-3 B 6262020	2116	0.804	3.68E-04	6.69E-06	1.47E-06	1.35E-06	2.94E-06	b.d.l.	b.d.l.
H005-7FB-3 B 742020	1311	0.972	7.26E-04	9.13E-06	2.08E-06	1.64E-06	2.26E-06	b.d.l.	b.d.l.
H002-04CS-2	2922	0.976	3.34E-04	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.	b.d.l.

Table 1-11: Noble Gas data

Samples	^{3}He pcc/cc	^{4}He μcc/cc	^{20}Ne μcc/cc	^{36}Ar μcc/cc	^{40}Ar μcc/cc	R/R_A	^{4}He / ^{20}Ne	^{20}Ne / ^{36}Ar
H005-2FB-2 A 7172020	3.19	2.76	3.421	10.12	2984.18	0.8351	0.81	0.338
H005-2FB-2 A 842020	1.33	1.14	1.884	4.83	1429.24	0.8430	0.61	0.390
H005-2FB-2 B 7172020	1.12	0.91	1.689	6.13	1813.36	0.8933	0.54	0.275
H005-2FB-2 B 842020	1.17	0.98	2.154	4.59	1358.48	0.8607	0.46	0.469
H005-7FB-3 A 6262020	30.22	223.57	2.645	5.45	1619.22	0.0977	84.53	0.485
H005-7FB-3 A 842020	6.04	23.28	1.134	1.78	528.36	0.1874	20.52	0.636
H005-7FB-3 B 6262020	1.82	1.57	0.719	6.92	2046.57	0.8354	2.19	0.104
H005-7FB-3 B 742020	0.68	0.61	0.577	1.33	393.84	0.7989	1.06	0.433
H002-04CS-2	0.37	0.26	0.502	1.08	322.16	1.0126	0.53	0.467

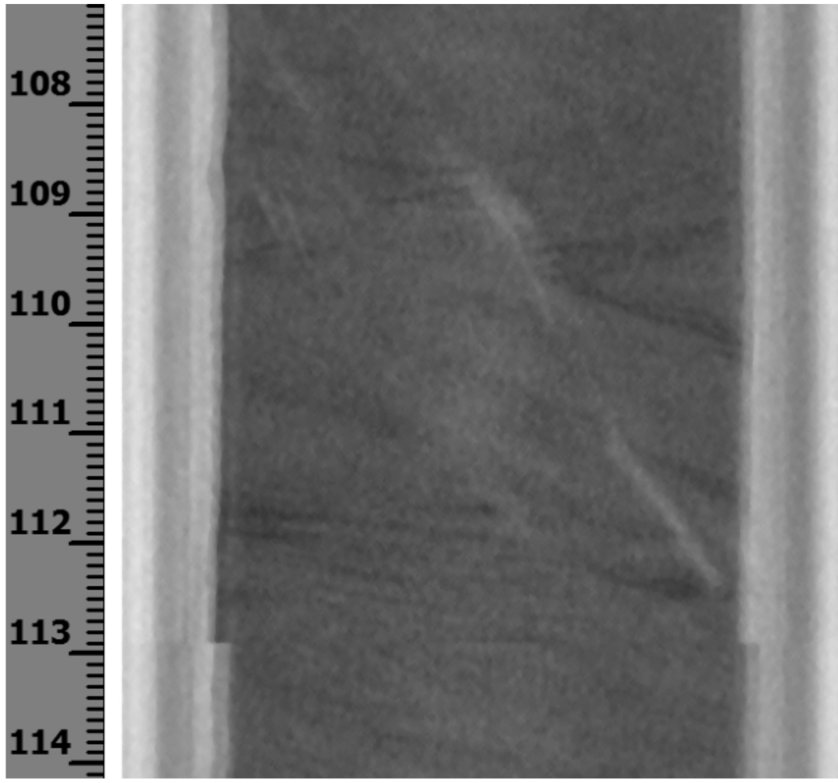

Figure 1-1: PCATS X-ray scan of H005-7FB-3 (Photo provided by S. Phillips) displaying a relatively high number of fractures compared to other cores, especially just above the top of the 7FB-3 gas samples (starting at 112 cm). We also observed small offsets in laminations, however sufficient data is not present to determine if these are faults.

A2. Stress ratio measurement of pressure core

- UT continued measuring the stress ratio (the ratio of horizontal to vertical effective stress under uniaxial strain) of UT-GOM2-1 hydrate-bearing pressure cores.
  - UT found that when the core sample was held under a fixed volume condition (i.e., zero volumetric strain), the axial effective stress decreased significantly during hydrate dissolution. This effect could be due to the fact that the hydrate bears a certain among effective stress in the formation or that creep is occurring in the sediment itself (Figure 1-2).
  - UT found that the core sample with 79% hydrate saturation has higher stress ratio (K = ~0.6) than the same sample with zero hydrate saturation (K = 0.4) (Figure 1-3).

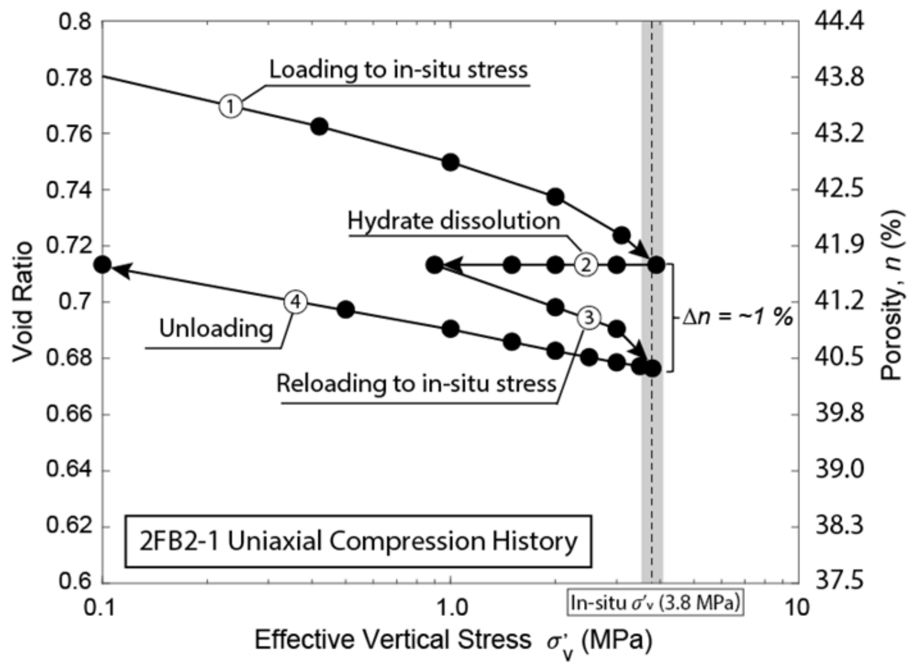

Figure 1-2: Evolution of void ratio with vertical effective stress during compression. The sample experienced four stages: (1) loading to the in-situ effective stress (zero-lateral strain), (2) hydrate dissolution under fixed bulk volume (zero volumetric change), (3) reloading to the in-situ stress (zero-lateral strain), and (4) unloading (zero-lateral strain).

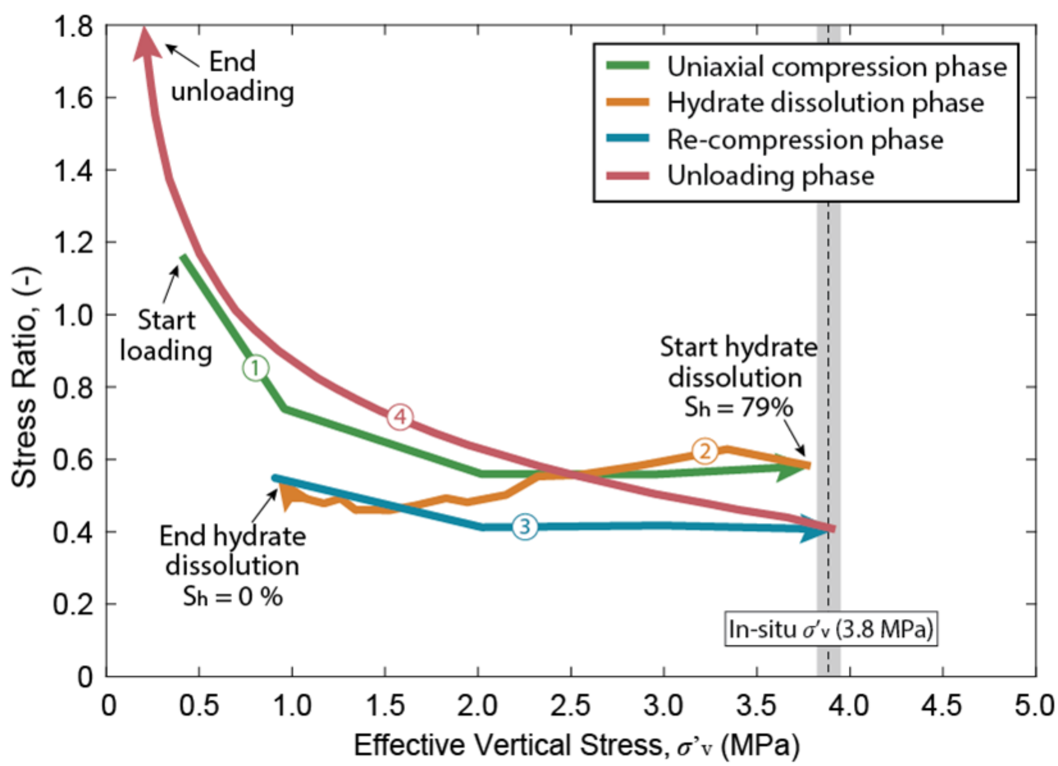

Figure 1-3: The evolution stress ratio of hydrate-bearing pressure core measured from the uniaxial compression test. The stress ratio is calculated as $K = \sigma'_h / \sigma'_v$. The sample experienced four stages: (1) loading to the in-situ effective stress (zero-lateral strain), (2) hydrate dissolution under fixed bulk volume (zero volumetric change), (3) reloading to the in-situ stress (zero-lateral strain), and (4) unloading (zero-lateral strain).

B. Pressure Core Degradation

- An analysis was completed of the UT-GOM2-1 pressure cores to determine the impact of 1) improved spacer use and 2) a reduction in the storage chamber inner diameter on core degradation. The analysis assumed that core degradation was proportional to the amount of storage fluid surrounding the core. This included the storage fluid around the core liner and the drilling fluid trapped between the liner and the core. The improvement in core degradation was estimated directly from the reduction in storage fluid estimated for each change. The actual amount of storage fluid used was calculated for each of the 21 UT-GOM2-1 pressure cores brought back to UT from the size of the storage chamber and the length of core and spacers inside. Figure 1-4 shows the reduction in storage fluid volumes if better packing of solid spacers had been used (compare orange dots (volumes with better packing) to blue dots (actual volumes)). The estimated reduction in core degradation from better packing ranged from 10 to 35%. Since there is no cost for implementing this change, we plan to use better packing procedures on UT-GOM2-2.
- Figure 1-5 shows the reduction in storage fluid volumes if storage chambers with a smaller inner diameter (6.25 vs 6.50 cm) were used (compare green dots (volumes with smaller inner diameter chamber) to blue dots (actual volumes)). The estimated reduction in core degradation using a smaller inner diameter ranged from 19 to 37%. The cost to modify existing storage chambers is being explored. Any additional new storage chambers for UT-GOM2-2 will likely be ordered with a smaller inner diameter.
- Figure 1-5 also shows the reduction in storage fluid volumes if better packing and storage chambers with a smaller inner diameter had been used (see grey dots). The estimated reduction in core degradation using both methods ranged from 34 to 54%.
- UT continued to explore charging storage fluid with methane without creating additional hydrate as a potential remedial measure for reducing pressure core degradation.

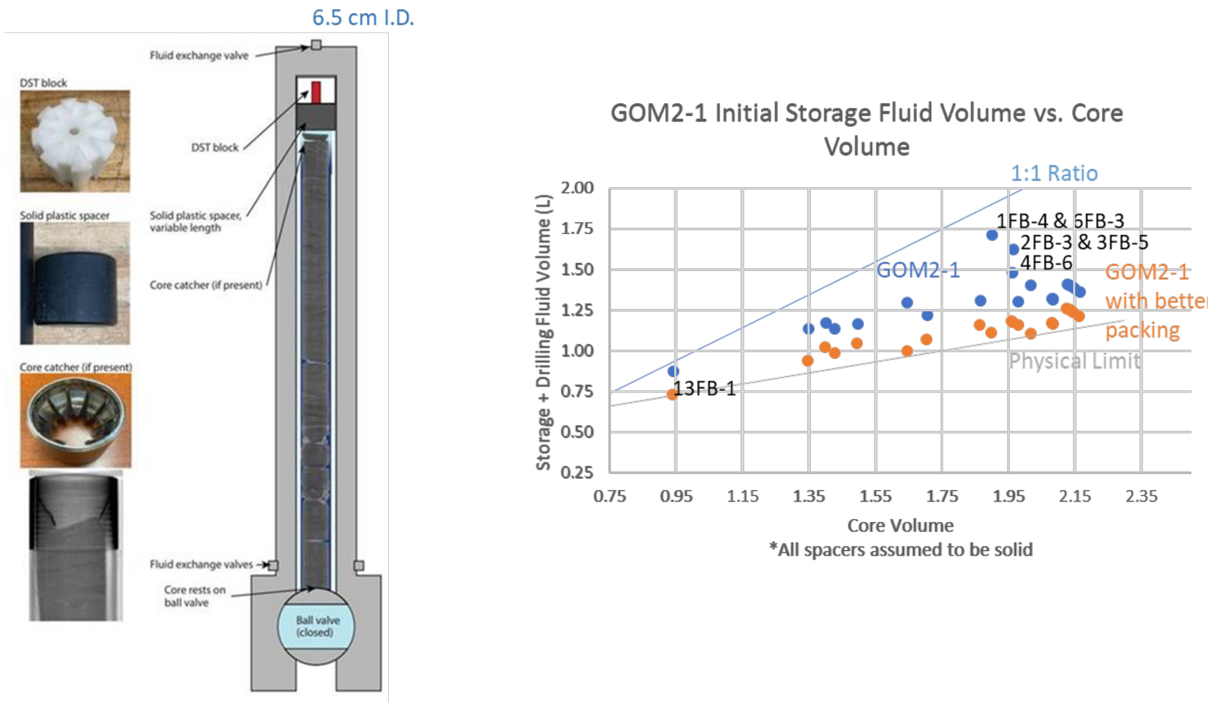

Figure 1-4: UT-GOM2-1 Storage Fluid volumes as packed and with improved packing. A. Schematic of the SC_{120} storage chamber with images of the different packing materials including the Data Storage Tag (DST Block), solid spacer, and core catcher. B. Plot of storage fluid vs core volume. Blue dots record the storage and trapped drilling fluid volume for each of the UT-GOM2-1 pressure cores at UT. The solid blue line records the case where the storage volume equals the core volume. Orange dots show the storage and trapped drilling fluid volume for UT-GOM2-1 pressure cores with the maximum length of solid spacers added (spacers can be added in 5 cm increments). The grey line reflects the lower limit of storage fluid assuming solid spacers could be cut to any length and added to completely fill any extra length in the chamber.

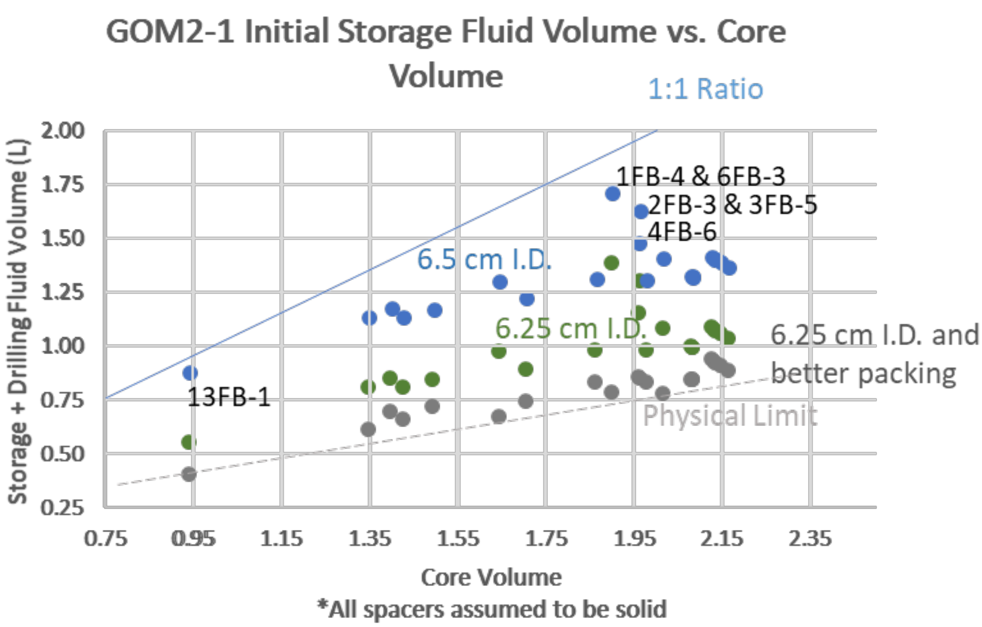

Figure 1-5: UT-GOM2-1 Storage Fluid volumes as packed (blue dots), with a reduced inner diameter of the pressure vessels (green dots), and with both better packing and a reduced inner diameter of the pressure vessels (grey dots). Blue

dots show the storage and trapped drilling fluid volume for each of the UT-GOM2-1 pressure cores at UT. The solid blue line reflects the case where the storage volume equals the core volume. Green dots show the storage and trapped drilling fluid volume for each of the UT-GOM2-1 pressure cores assuming storage chambers with an inner diameter of 6.25 cm. Grey dots show the storage and trapped drilling fluid volume for each of the UT-GOM2-1 pressure cores assuming storage chambers with an inner diameter of 6.25 cm and better packing. The grey dashed line reflects the lower limit of storage fluid assuming solid spacers could be cut to any length and added to completely fill any extra length in the chamber.

C. Depressurized Pressure Core Analysis: Bulk sediment CHNS elemental analysis, Bulk sediment TOC, N, and S isotopes and Grain size using a laser particle size analyzer

- During the second quarter of BP5, UNH completed the full data analyses/interpretations for all of the UNH derived GOM2-1 samples. This work included integration of the UT-GOM2-1 data with existing data sets in the Gulf of Mexico (Figure 1-6). These data document the consistent presence of terrestrial dominated TOC throughout the GOM2-1reservoir and at other similar sites where turbidity currents dominate the stratigraphic record.
- UNH also took delivery of and set up a new Elementar CHNS Elemental Analyzer to replace the one damaged during the 2020 flood. This instrument will be utilized extensively on samples collected during the GOM2-2 expedition

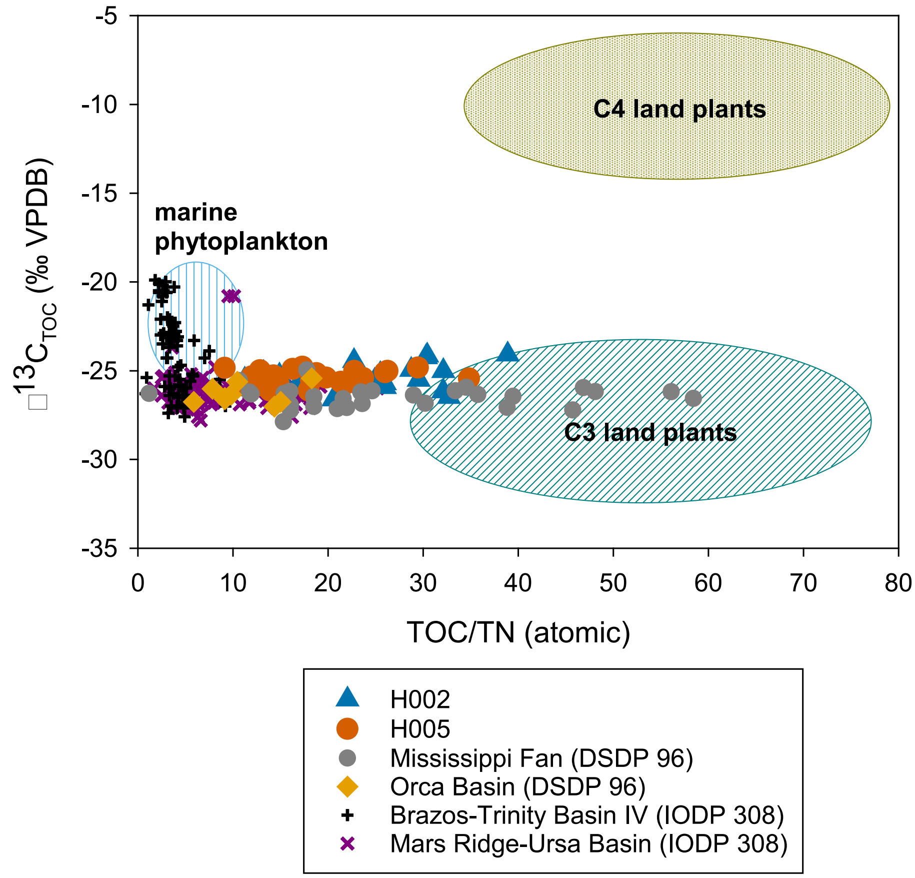

Figure 1-6: Atomic TOC/TN versus isotopic del13C ratios of sediments for Holes H002 and H005 along with data from the Mississippi Fan (Deep Sea Drilling Project, DSDP Sites 614-617, 620-624) (Kennicutt et al., 1986), Orca Basin (DSDP Sites 618-619) (Kennicutt et al., 1986), Brazos-Trinity Basin IV (Integrated Ocean Drilling Program, IODP Sites U1319-U1320) (Gilhooly et al. 2008), and Ursa Basin (IODP Sites U1322,U1324) (Gilhooly et al. 2008) document the predominance of terrestrial derived organic carbon at the GOM2-1 sites. Approximate ranges for marine plankton and terrestrial plant sources are based on Meyers (1994).

1.2.2.2.2 Subtask 10.5 – Continued Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)

- No update this period.

1.2.2.2.3 Subtask 10.6 – Additional Analysis Capabilities

- No update this period

1.2.2.2.4 Subtask 10.7 – Hydrate Modeling

- No update this period.

1.2.2.2.5 Subtask 10.8 – Routine Core Analysis (UT-GOM2-2)

- Future Task.

1.2.2.2.6 Subtask 10.9 – Pressure Core Analysis (UT-GOM2-2)

- Future Task.

1.2.2.2.7 Subtask 10.10 – Core-log-seismic Integration (UT-GOM2-2)

- Future Task.

1.2.2.2.8 Other – Publication and Presentation Work

- AAPG Editors continued working on the AAPG Bulletin GC 955 dedicated Volume 2
- GOM2 participants continued working on their AAPG Vol 2 submissions. Table 1-12 shows the current status

Table 1-12: AAPG Vol 2 submissions

Primary Author	Working Title	Accepted
Oti	Using X-ray Computed Tomography (XCT) to Estimate Hydrate Saturation in Sediment Cores from Green Canyon 955, northern Gulf of Mexico	Accepted
Moore	Integrated geochemical approach to determine the source of methane in gas hydrate from Green Canyon Block 955 in the Gulf of Mexico	Accepted
Daigle	Pore structure of sediments from Green Canyon 955 determined by mercury intrusion	Accepted
Wei	Methane migration mechanisms for the GC 955 gas hydrate reservoir, northern Gulf of Mexico	1st revision in review
Santra	High concentration gas hydrate in fault-compartmentalized anticline and the role of seal- Green Canyon, abyssal Gulf of Mexico	Accepted, pending revisions
Yoneda	Comprehensive study on mechanical-hydrological properties of hydrate-bearing pressure core sediments from Gulf of Mexico CG955	Accepted
Fang	Permeability of methane hydrate-bearing sandy silts in the deepwater Gulf of Mexico (Green Canyon block 955)	Accepted, pending revisions
Fang	Compression behaviors of methane hydrate-bearing sandy silts in the Green Canyon block 955 in the deepwater Gulf of Mexico	Revising after 1st review
Phillips	Salinity evolution of natural gas hydrate-bearing sediments during dissociation	Accepted, pending revisions
You	Two-dimensional Focused Free Gas Flow Forms Concentrated Methane Hydrate Deposits	In review

1.2.2.3 Task 11.0 – Update Science and Operations Plans for UT-GOM2-2 Scientific Drilling Program

Status: Ongoing

Operations Plan

No update this period. The *UT-GOM2-2 Operations Plan Rev. 2.0* and *UT-GOM2-2 Operations Plan Addendum A* (which addresses the expanded science program) were completed in the previous performance period. The operations plan will be updated as needed as we draw closer to UT-GOM2-2 mobilization and execution.

Science and Sample Distribution Plan

Work continued on version 2 of the UT-GOM2-2 Science and Sampling Plan. Additional planning included:

- Completed an extensive analysis of the use of PCATS on-board (similar to the analysis of PCATS activity for GOM2-1 leading up to the approval of the GOM2-1 Auxiliary dockside remobilization). At least 4 autoclaves, 15 long storage chambers (SC_{350}), 40 medium storage chambers (SC_{120}), 2 short degassing chambers (SC_{35}), and three manifolds on-board to support the PCATS. PCATS will again need to be remobilized at the dock.

1.2.2.4 Task 12.0 – UT-GOM2-2 Scientific Drilling Program Vessel Access

Status: Ongoing

- Fugro declined to issue comments on the *UT-GOM2-2 Rig Specification Requirements* and *UT-GOM2-2 Operations Summary, Schedule, and Well Design* documents distributed to vessel contractors in the previous performance period. UT has been informed that Fugro will most likely not bid on UT-GOM2-2, citing difficulties managing deck space requirements for UT-GOM2-2 laboratory containers and drill pipe.

1.2.2.5 Task 13.0 – Maintenance & Refinement of Pressure Core Transport, Storage, & Manipulation Capability

Status: Ongoing

- UT was able to achieve moderate sealing capabilities of the K0 bottom cap and generate hydraulic axial loading. This was accomplished with a combined approach of engineering tests in the K0 and UT's clear acrylic chamber. See Section 1.2.2.5.2 Subtask 13.2 – Hydrate Core Effective Stress Chamber.
- Improvements were made at UT for processing 2D X-Ray and 3D CT scans. UT image quality is now on par with Geotek. See Section 1.2.2.5.7 Subtask 13.7 – X-ray Computed Tomography.

1.2.2.5.1 Subtask 13.1 – Hydrate Core Manipulator and Cutter Tool

- System underwent a maintenance teardown with replacement of seals and bearings. In addition to the cleaning of mini-PCATS sediment traps.
- The x-ray system underwent a quarterly calibration.
- Shims were added to the pipe cutter wheel and the cutting wheel was sharpened to help create better stabilized cuts of the core liner during K0 subsampling of pressure cores.

1.2.2.5.2 Subtask 13.2 – Hydrate Core Effective Stress Chamber

- Effective stresses equivalent to in-situ conditions of the sands targeted in our next expedition were achieved for the first time using the remainder of the H005-6FB-1 pressure core. The K0 procedural changes needed to achieve this milestone require successful hydraulic loading. The following measures were implemented:
    - Horizontal instead of vertical sample extrusion: minimizes gravitational sediment infiltration around O-rings. To limit the misalignment of the different components, an intermediate vertical extrusion step is needed until the bottom cap is engaged in the extrusion sleeve.
    - Retraction of the bottom cap: helps position the O-ring correctly in the groove and displaces sediments around (see Figure 1-7).
    - Sharpening of cutting wheels: provides smoother core liner cuts, which reduces the likelihood of O-ring failure.
    - Bottom cap attached to the actuator with brass instead of stainless-steel screws: transitioning from mechanical to hydraulic load requires bottom cap detachment. This is easily achieved by hydraulically breaking the weaker brass screws.
- These changes resulted in an increase in axial effective stress capacity from 4 MPa to 12 MPa. Additional changes will need to be implemented in order to be able to measure sample displacement with hydraulic loading.
- UT continues work to resolve the K0 bottom cap sealing issue identified in March 2020, with assistance from Geotek.
    - UT continued to use a clear acrylic test chamber to evaluate the K0 bottom cap sealing issue and investigate corrective measures. The internal dimensions of the chamber match the dimensions and geometry of the K0 Permeameter. The chamber allows observation of the interaction of mechanical components and sediments during core sample extrusion. 14 tests were conducted showing improvement in sealing using retraction of the bottom cap (Figure 1-7), however the sealing issue was not totally resolved. Additional new seals have been ordered by Geotek and will be tested using the acrylic cell in the next period.
- UT purchased two higher scale load cells from Geotek to remedy the maxed-out load cell readings identified during the K0 dummy sample testing in Q3, 2020. The new load cells have been delivered and are undergoing validation to allow testing at higher loads.

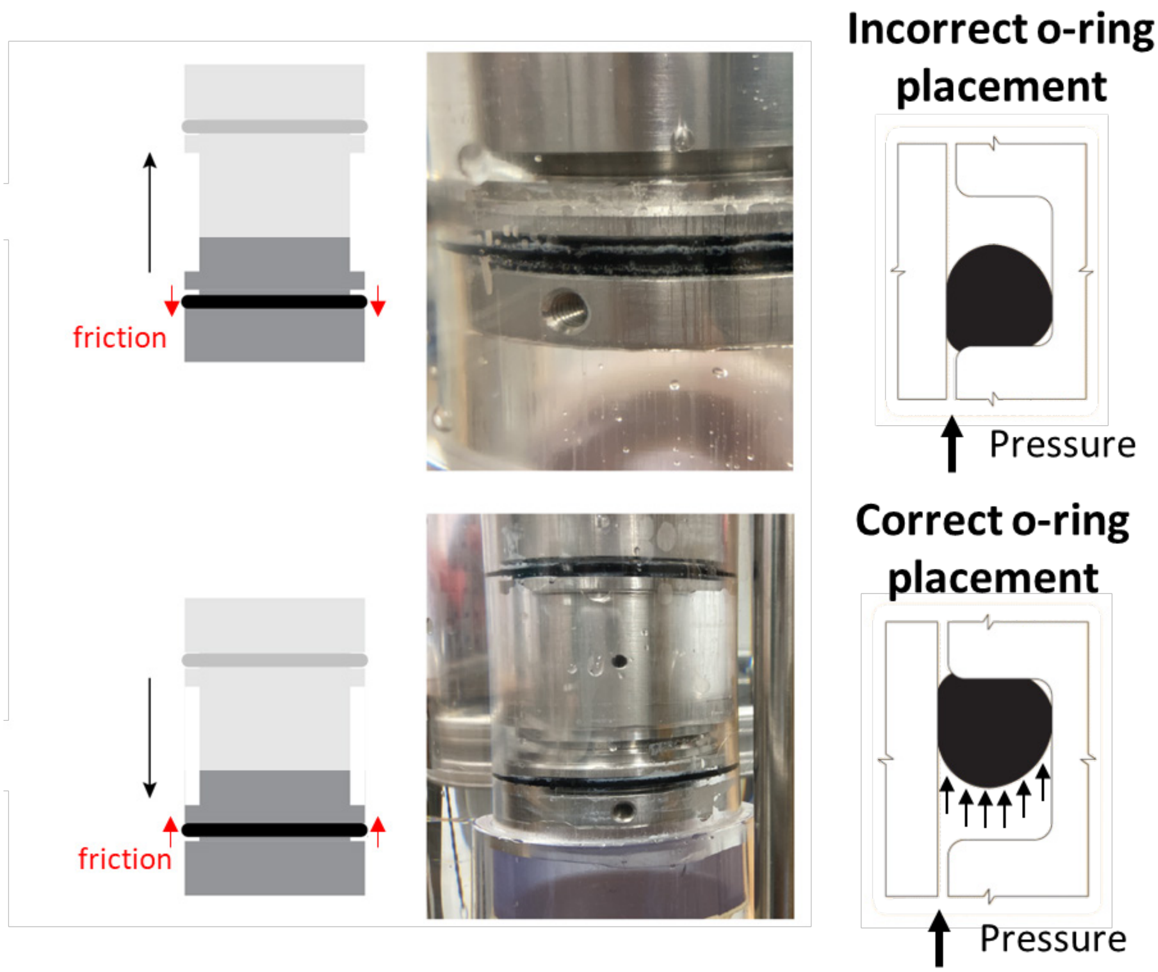

Figure 1-7: Schematics and Images of the K0 acrylic testing chamber to evaluate the impact of retracting the bottom cap on sealing. Better sealing was noted with gritty pressure cores from UT-GOM2-1 with the addition of retraction as it helps position the O-ring in the correct place. Fluid flux between 0.01 and 2 ml/min was still noted.

1.2.2.5.3 Subtask 13.3 – Hydrate Core Depressurization Chamber

- The system was used to quantify dissociated methane hydrate small remainder samples of pressure cores.
- The system underwent maintenance and cleaning.

1.2.2.5.4 Subtask 13.4 – Develop Hydrate Core Transport Capability for UT-GOM2-2

- No update this period.

1.2.2.5.5 Subtask 13.5 – Expansion of Pressure Core Storage Capability for UT-GOM2-2

- UT is reviewing quotes to manufacture new core chamber orientation supports. A single quad configuration base to be ordered for evaluation.

- Expansion of pressure maintenance system is required to increase storage capability sufficient to receive UT-GOM2-2 cores. UT is reviewing quotes for additional pressure lines.
- Expansion of pressure safety venting system will also be required. UT is reviewing quotes for additional venting lines.
- Evaluation and maintenance testing of methane monitoring system and possible expansion being explored.

1.2.2.5.6 Subtask 13.6 – Continued Storage of Hydrate Cores from UT-GOM2-1

- Core storage expansion in the PCC is anticipated to accommodate any remaining pressure cores acquired from UT-GOM2-1, even when additional cores are collected during UT-GOM2-2 and transferred to the PCC.

1.2.2.5.7 Subtask 13.7 – X-ray Computed Tomography

- Improvements were made for processing 2D X-Ray and 3D CT scans. UT image quality is now on par with Geotek. See Figure 1-8.
    - Installed new version of Geotek imaging software onto new image processing computer.
    - Developed a consistent method for better processing 2D X-Ray and 3D CT scans using the Geotek software.
    - Reprocessed all past 2D and 3D scans from raw data.
- The X-Ray CT continues to operate as designed.
- During this period, the system was calibrated.

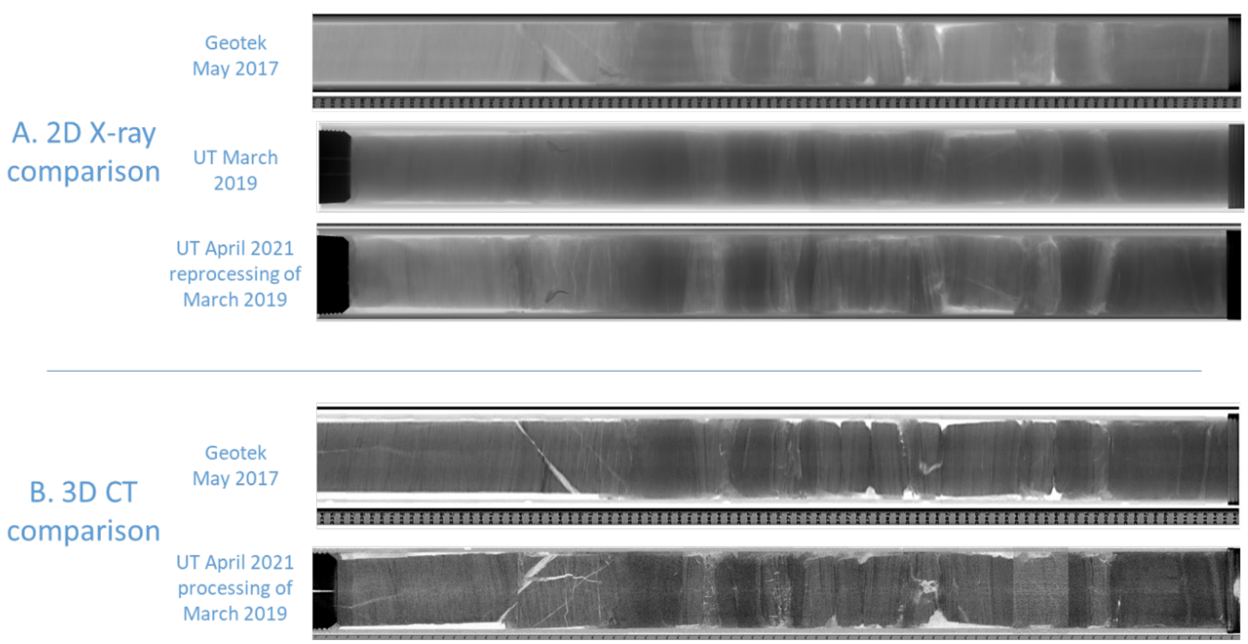

Figure 1-8: Comparison of Geotek and UT X-ray imaging capability. A. 2-D x-ray comparison. The top image shows the original 2D X-ray image of UT-GOM2-1 H005-4FB-8 taken by Geotek using PCATS in May of 2017. The middle image shows the original processing of the raw data from a scan of 4FB-8 taken in March of 2019 using mini-PCATS at UT. The bottom image of A shows the reprocessed image of the March 2019 scan. The top and bottom image are of equal resolution. B. 3-D CT comparison. The top image shows the original 3D CT digital slab image of UT-GOM2-1 H005-4FB-8 taken by Geotek using PCATS in May of 2017. The bottom image of A shows the newly processed image of a March 2019 scan of 4FB-8. The top and bottom image are of equal resolution.

1.2.2.5.8 Subtask 13.8 – Pre-Consolidation System

- Replacement parts for a leaking Pre Consolidation System hydraulic accumulator were installed and tested in Q1, 2021. Long-term nitrogen leak test of bladders will be done in Q2, 2021.

1.2.2.5.9 Subtask 13.9 – Transportation of Hydrate Core from UT-GOM2-2 Scientific Drilling Program

Future Task.

1.2.2.5.10 Subtask 13.10 – Storage of Hydrate Cores from UT-GOM2-2 Scientific Drilling Program

Future Task.

1.2.2.5.11 Subtask 13.11 – Hydrate Core Distribution

Future Task.

1.2.2.6 Task 14.0 – Performance Assessment, Modifications, And Testing Of PCTB

Status: Ongoing

1.2.2.6.1 Subtask 14.4 – PCTB Modifications/Upgrades

PCTB Upgrades

All PCTB toolsets were upgraded to Mk 5 ball-valve specifications. The design improvements focused on diverting grit away and cleaning the sliding surfaces with wiper rings, improving centralization throughout actuation, and improving flow paths throughout the tool to route drilling fluids away from the sliding surfaces.

The following parts were modified in the PCTB Mk. 5 design:

1. Extended Seal Carrier
    a. The seal carrier was modified to have a single seal groove to fit a low-friction Polypak lip seal. The second seal groove was eliminated along with O-rings. The seal carrier was also modified to have an extended back shoulder that fits tightly into the spring collet. This feature will help with centralizing the seal carrier during actuation and eliminate any potential sticking when sliding

through the seal bore. The seal carrier was also modified to have a finer surface finish to reduce friction during actuation and improve dynamic sealing

2. Ball Valve Housing
    a. The ball valve housing was modified to include an upper and lower seal groove for loose wiper rings. These wiper rings should assist in diverting fine grit particles away from the tight tolerance sliding seal surfaces. The wiper rings ride on both the seal carrier and the ball follower during actuation.
3. Ball Follower
    a. The upper shoulder was lengthened to ensure that the wiper ring remains in contact with the follower shoulder during the entire actuation. A new ball valve return spring was designed wherein the total coils and compression ratio percentage are reduced. This should eliminate a tightly compressed area produced with the previous spring design that caused binding. The Ball Follower shoulder length was modified to fit the new ball valve return spring.
    b. Fluid compensation ports were milled around the diameter of the ball follower, recessed in a groove, to solve hydro-locking problem created by adding wiper ring seals to the system and filtering particles from building up on the follower surface. 75µm stainless steel mesh was wrapped around the diameter of the ball follower to protect from ingress of particles while maintaining communication of fluid.
4. Extended Cutting Shoe Sleeve
    a. The cutting shoe sleeve was modified to eliminate the inner seal groove and O-ring. The seal groove was changed to the outer diameter and sized to fit a custom diversion seal. The part was extended in length so that the diversion seal now seals on the inner diameter of the housing extension and the flow path is now not directed at the ball follower sliding surface. This should eliminate particles building up between the surface of the ball follower and cutting shoe sleeve and prevent jamming.
5. Ball Valve Housing Extension
    a. The modified housing extension includes steeper angled flow ports to better streamline flow through the housing extension and out of the cutting shoe. This modification should improve the flow through the cutting shoe ports and help prevent plugging and bit balling when coring with the cutting shoe.

PCTB Bench Test

Bench tests of the upgraded PCTB Mk 5 were performed at the Geotek testing facility in Salt Lake City, Utah from Feb 14-19. Isolated ball valve tests were conducted in a clear, rotational test fixture to evaluated the MK 5 ball valve performance when fine grit particles are present. Pressure actuation tests were conducted in Geotek's downhole pressure chamber, to validate proper boosting and sealing functions of the upgraded tool in a downhole environment. Geotek's bench test report is provided as **Appendix A**.

- **Isolated Ball Valve Tests**
  - 13 tests were performed with a fine aluminum oxide grit solution
    - 12 tests using 0.24% aluminum oxide resulted in 100% success
    - 1 test conducted using 1% solids by weight intentionally induced failure
  - 6 tests were performed with Min-U-Sil solution
    - 6 tests using 0.24% solids by weight resulted in 100% success

- **Pressure Actuation Tests**
  - **Test 1:** 1,600 psi resulted in a full boost and sealed above in-situ pressure
  - **Test 2:** 3,000 psi resulted in a full boost and sealed above in-situ pressure

The PCTB Bench Tests demonstrated consistency of the Mk 5 ball valve assembly when operating in conditions were fine grit particles are present. The Mk 5 ball valve assembly successfully fires and closes in gritty solutions with concentrations comparable to what was observed in CTTF 2020 testing, where the tool previously failed to close and seal. Two pressure actuation tests demonstrated the tool boost timing and sealing functionality work as anticipated with the upgraded Mk 5 ball valve assembly.

1.2.2.6.2 Subtask 14.5 – PCTB Land Test III

UT initiated discussions with the Schlumberger Cameron Test and Training Facility (CTTF) in the previous performance period with regard to a spring 2021 land test. Schlumberger confirmed that CTTF has been 'winterized' and would not be available until late 2021.

UT, Geotek, and Pettigrew Engineering evaluated alternative sites for a land test, including Catoosa Test Facility (Catoosa), Keystone Test Facility and Quest Test Facility. The latter two sites are closed. Pettigrew Engineering and Geotek visited Catoosa on February 11 to assess suitability. Catoosa near Jennings, Oklahoma has been upgraded since 2015, and is under new management. UT, Geotek, and Pettigrew Engineering agree that a successful test can be performed with some additional oversight and vendor arrangements.

The PCTB Land Test III will be conducted at the Catoosa Test Facility (CTF) near Jennings, Oklahoma on April 12-22.

1.2.2.7 Task 15.0 – UT-GOM2-2 Scientific Drilling Program Preparations

Status: In Progress

1.2.2.7.1 Subtask 15.3 – Permitting for UT-GOM2-2 Scientific Drilling Program

- UT submitted an inquiry with the Bureau of Ocean Energy Management (BOEM) regarding two new regulatory issues:
    1. Secretarial Order No. 3395
        - 60 day suspension of new oil & gas leasing and drilling permits for Federal land & water
    2. Executive Order 14008: Tackling the Climate Crisis at Home and Abroad, Sec. 208
        - Paus of new oil & natural gas leases on public lands or offshore waters pending completion of a comprehensive review and reconsideration of Federal oil & gas permitting and leasing practices.

  The response from BOEM is that BOEM and BSEE are still accepting and processing new applications.

- The **Right of Use and Easement (RUE)** letter request was completed (30 CFR 550.160 & 550.161).
- The **Exploration Plan** was completed (30 CFR 550.211-235; 30 CFR 550.125-126; NTL No. 2008-G04).
- The **Coastal Zone Management (CZM) Consistency Certification** was completed (NTL No. 2008-G04).
- BOEM 0137 forms were completed for each surface location.
- BOEM Exploration Plan service fees were paid for each surface location.
- Ads for public participation were published in the Houston Chronicle and New Orleans Advocate from February 9-23, 2021 (30 CFR 551.7)
- RUE and Exploration Plan signature pages were submitted to The University of Texas at Austin, Office of the Vice President for Research (BOEM-Authorized Delegate) for review and execution.

1.2.2.7.2 Subtask 15.4 – Review and Complete NEPA Requirements

Future Task.

1.2.2.7.3 Subtask 15.5 – Finalize Operational Plan for UT-GOM2-2 Scientific Drilling Program

Future Task.

1.2.2.8 Task 16.0 – UT-GOM2-2 Scientific Drilling Program Field Operations

Status: Future Task

1.2.2.8.1 Subtask 16.1 – Mobilization of Scientific Ocean Drilling and Pressure Coring Capability

Future Task.

1.2.2.8.2 Subtask 16.2 – Field Project Management, Operations, and Research

Future Task.

1.2.2.8.3 Subtask 16.3 – Demobilization of Staff, Labs, and Equipment
Future Task.

1.3 What Will Be Done In The Next Reporting Period To Accomplish These Goals

1.3.1 Task 1.0 – Project Management & Planning

- UT will continue to execute the project in accordance with the approved Project Management Plan and Statement of Project Objectives.
- UT will continue to 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 Project Management Plan.

1.3.2 Task 10.0 – Core Analysis

- Work will continue on measuring the petrophysical and geomechanical properties of pressure cores using the UT K0 Permeameter once the tool sealing issues have been resolved.
- Work will continue on quantifying core degradation during long-term storage and testing for improved core preservation will start.
- Work will continue on finalizing and posting Data Reports
- UT, Ohio State, and the University of New Hampshire continue working on contributions to the AAPG Special Bulletin Volumes (2, and 3).
- Oregon State with Texas A&M Corpus Christi will continue assessing the microbial communities in GC 955 sediment as possible depending on how long labs are shut down.

1.3.3 Task 11.0 – Update Operations Plan for UT-GOM2-2 Scientific Drilling Program

- UT will update the Operations Plan, as required.
- UT will continue to develop the UT-GOM2-2 Science and Sample Distribution Plan incorporating recommendations from the TAG and the Core Analysis Team, adding plan for geomechanical testing of background and bounding mud, and drafting protocols for the handling of samples.

1.3.4 Task 12.0 – UT-GOM2-2 Scientific Drilling Program Vessel Access

- UT will initiate procurement of the UT-GOM2-2 drilling vessel.

1.3.5 Task 13.0 – Maintenance And Refinement Of Pressure Core Transport, Storage, & Manipulation Capability

- The Mini-PCATS, PMRS, analytical equipment, and storage chambers will undergo continued observation and maintenance at regularly scheduled intervals and on an as-needed basis. Installation of new or replacement parts will continue to ensure operational readiness.

- Engineering tests will be conducted with the K0 Permeameter, acrylic cell, and pressure cores to refine remedial actions and procedures that enhance K0 sealing.
- Develop constant rate of strain (CRS) loading in K0 permeameter with assistance from Geotek.
- Develop calibration algorithms to compensate for K0 apparatus compressibility.
- Conduct geotechnical testing (e.g., compressibility and permeability) at higher axial stresses in hydrate-bearing sediments.

1.3.6 Task 14.0 – Performance Assessment, Modifications, And Testing Of PCTB

- The PCTB will undergo a land test (PCTB Land Test III) at Catoosa Test Facility, near Jennings, Oklahoma.

1.3.7 Task 15.0 – UT-GOM2-2 Scientific Drilling Program Preparations

- The project team will obtain signatures from the University of Texas Vice President for Research, the *BOEM-Authorized Delegate*, on various permit documents.
- UT will submit the Exploration Plan (EP), Shallow Hazards Assessments, Right-of-Use-and-Easement (RUE) request, and Geological and Geophysical (G&G) permit documents to BOEM.

1.3.8 Task 16.0 – UT-GOM2-2 Scientific Drilling Program Field Operations

- No update.

2 PRODUCTS

Project publications webpage: https://ig.utexas.edu/energy/gom2-methane-hydrates-at-the-university-of-texas/gom2-publications/

2.1 Publications

Boswell, R., Collet, T.C., Cook, A.E., Flemings, P.B., 2020, Introduction to Special Issue: Gas Hydrates in Green Canyon Block 955, deep-water Gulf of Mexico: Part I: AAPG Bulletin, v. 104, no. 9, p. 1844-1846, http://dx.doi.org/10.1306/bltnintro062320.

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Chen, X., Verma, R., Espinoza, D. N., and Prodanović, M., 2018, Pore-Scale Determination of Gas Relative Permeability in Hydrate-Bearing Sediments Using X-Ray Computed Micro-Tomography and Lattice Boltzmann Method: Water Resources Research, v. 54, no. 1, p. 600-608. https://doi.org/10.1002/2017wr021851

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Flemings, P. B., Phillips, S. C., Boswell, R., Collett, T. S., Cook, A. E., Dong, T., Frye, M., Guerin, G., Goldberg, D. S., Holland, M. E., Jang, J., Meazell, K., Morrison, J., O'Connell, J., Pettigrew, T., Petrou, E., Polito, P. J., Portnov, A., Santra, M., Schultheiss, P. J., Seol, Y., Shedd, W., Solomon, E. A., Thomas, C., Waite, W. F., and You, K., 2020, Pressure coring a Gulf of Mexico Deepwater Turbidite Gas Hydrate Reservoir: Initial results from the UT-GOM2-1 hydrate pressure coring expedition: AAPG Bulletin, v. 104, no. 9, p. 1847-1876. https://doi.org/10.1306/05212019052

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2.3 Proceeding of the UT-GOM2-1 Hydrate Pressure Coring Expedition

Volume contents are published on the UT-GOM2-1 Expedition website and on OSTI.gov.

2.3.1 Volume Reference

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition, Austin, TX (University of Texas Institute for Geophysics, TX), https://dx.doi.org/10.2172/1646019

2.3.2 Prospectus

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2.3.3 Expedition Report Chapters

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2.3.4 Data Reports

Fortin, W.F.J., Goldberg, D.S., Küçük, H.M., 2020, Data Report: Prestack Waveform Inversion at GC 955: Trials and sensitivity of PWI to high-resolution seismic data, In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition: Austin, TX (University of Texas Institute for Geophysics, TX). http://dx.doi.org/10.2172/1647733, 7 p.

Heber, R., Cook, A., Sheets, J., Sawyer, 2020. Data Report: High-Resolution Microscopy Images of Sediments from Green Canyon Block 955, Gulf of Mexico. In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition: Austin, TX (University of Texas Institute for Geophysics, TX). https://dx.doi.org/10.2172/1648312, 6 p.

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Coring Expedition: Austin, TX (University of Texas Institute for Geophysics, TX). https://dx.doi.org/10.2172/1648320 14 p.

2.4 Websites

- Project Website:

https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/

- 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

- 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

2.5 Technologies Or Techniques

Nothing to report.

2.6 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

Nothing to report

3.3 Changes That Have A Significant Impact On Expenditures

Nothing to report.

3.4 Change Of Primary Performance Site Location From That Originally Proposed

Nothing to report.

4 SPECIAL REPORTING REQUIREMENTS

4.1 Current Project Period

Task 1.0 – Revised Project Management Plan

Subtask 15.5 – Final UT-GOM2-2 Scientific Drilling Program Operations Plan

4.2 Future Project Periods

Task 1.0 – Revised Project Management Plan

Subtask 17.1 – Project Sample and Data Distribution Plan

Subtask 17.3 – UT-GOM2-2 Scientific Drilling Program Scientific Results Volume

5 BUDGETARY INFORMATION

The Budget Period 5 cost summary is provided in Table 5-1.

Table 5-1: Phase 5 / Budget Period 5 Cost Profile

Baseline Reporting Quarter	Budget Period 5							
	Y1Q1		Y1Q2		Y1Q3		Y1Q4	
	10/01/20-12/31/20		01/01/21-03/31/21		04/01/21-06/30/21		07/01/21-09/30/21	
	Y1Q1	Cumulative Total	Y1Q2	Cumulative Total	Y1Q3	Cumulative Total	Y1Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 587,651	$ 31,973,595	$ 581,151	$ 32,554,746	$ 5,466,306	$ 38,021,052	$ 581,151	$ 38,602,203
Non-Federal Share	$ 150,293	$ 23,871,255	$ 148,630	$ 24,019,885	$ 1,398,018	$ 25,417,903	$ 148,630	$ 25,566,533
Total Planned	$ 737,944	$ 55,844,850	$ 729,781	$ 56,574,631	$ 6,864,324	$ 63,438,955	$ 729,781	$ 64,168,736
Actual Incurred Cost								
Federal Share	$ 589,548	$ 589,548	$ 426,667	$ 1,016,215				
Non-Federal Share	$ 220,056	$ 220,056	$ 374,124	$ 594,180				
Total Incurred Cost	$ 809,604	$ 809,604	$ 800,791	$ 1,610,395				
Variance								
Federal Share	$ 1,897	$ 1,897	$ (154,484)	$ (152,587)				
Non-Federal Share	$ 69,763	$ 69,763	$ 225,493	$ 295,257				
Total Variance	$ 71,661	$ 71,661	$ 71,010	$ 142,670				
Baseline Reporting Quarter	**Budget Period 5**							
	Y2Q1		Y2Q2		Y2Q3		Y2Q4	
	10/01/21-12/31/21		01/01/22-03/31/22		04/01/22-06/30/22		07/01/22-09/30/22	
	Y2Q1	Cumulative Total	Y2Q2	Cumulative Total	Y2Q3	Cumulative Total	Y2Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 4,433,883	$ 43,036,085	$ 749,973	$ 43,786,058	$ 20,274,089	$ 64,060,147	$ 710,837	$ 64,770,984
Non-Federal Share	$ 700,232	$ 26,266,765	$ 118,441	$ 26,385,206	$ 3,201,835	$ 29,587,040	$ 112,261	$ 29,699,301
Total Planned	$ 5,134,114	$ 69,302,850	$ 868,414	$ 70,171,264	$ 23,475,924	$ 93,647,188	$ 823,097	$ 94,470,285
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

6 ACRONYMS

Table 6-1: List of Acronyms

ACRONYM	DEFINITION
AAPG	American Association of Petroleum Geologists
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CFR	Code of Federal Regulation
CHNS	Carbon, Hydrogen, Nitrogen, Sulfur
CPP	Complimentary Project Proposal
CT	Computed Tomography
CTF	Catoosa Test Facility
CZM	Coastal Zone Management
DST	Data Storage Tag
DOE	U.S. Department of Energy
DSDP	Deep Sea Drilling Program
EP	Exploration Plan
G&G	Geologic and Geophysical
GC	Green Canyon
IODP	International Ocean Discovery Program
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
NTL	Notice To Lessees
OCS	Outer Continental Shelf
PCATS	Pressure Core Analysis and Transfer System
PCC	Pressure Core Center
PCTB	Pressure Core Tool with Ball Valve
PCTB-CS	Pressure Core Tool with Ball Valve - Cutting Shoe
PCTB-FB	Pressure Core Tool with Ball Valve - Face Bit
PDT	Probe Deployment Tool
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
RUE	Right-of-Use-and-Easement
SOPO	Statement of Project Objectives
T2P	Temperature to Pressure Probe
TOC	Total Organic Carbon
TN	Total Nitrogen
UNH	University of New Hampshire
UT	University of Texas at Austin
UW	University of Washington

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

APPENDIX A

2021 PCTB Mk. 5 Ball Valve Bench Test Report

2021 PCTB IV BALL VALVE TESTING

UT/DOE 2021

GEOTEK LTD DOCUMENT NO. UT2021 (R1)

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UT/DOE

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ISSUE	REPORT STATUS	PREPARED	APPROVED	DATE
1	FINAL	AB	MM	02/22/2021

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EXECUTIVE SUMMARY

2021 PCTB IV Ball Valve Testing is a continuation of the previous report, *2020 PCTB IV Ball Valve Upgrades and Testing*. The purpose of this iteration of testing was to demonstrate and collect a final batch of testing data with UT/DOE representatives present before moving forward to a downhole test facility where sample cores will be taken. The two primary sections of this test report include the following:

1. Isolated ball valve testing
2. Pressure actuation testing

The first section of the report includes the testing results and data from the isolated ball valve testing. Each test was performed in the clear, rotational test fixture used in the previous test program. 13 tests were performed in a fine grit Aluminum Oxide (53-125 μm particle size) solution, and six tests were performed in a Min-U-Sil and water solution, for a total of 19 tests. Of the 13 Aluminum Oxide tests, 12 were performed in a solution containing 0.24% Aluminum Oxide by weight, all 12 of these tests were successful. One test was performed in an Aluminum Oxide solution containing 1% solids by weight, this test produced a failure.

Six more tests were performed in the rotational test fixture using a Min-U-Sil and water solution. Four of these tests were performed in a solution containing 0.24% solids by weight, all four of these tests were successful. The last two tests included a solution containing a 1% Min-U-Sil and a 3% Min-U-Sil solution, both tests were successful.

The second section of the report includes results of two downhole pressure actuation tests. The first test was performed at 1,600 psi and the second test was performed at 3,000 psi. Both tests fully boosted and sealed above in-situ pressure.

1 ISOLATED BALL VALVE TESTING

1.1 SECTION 1 TESTING SUMMARY

19 total isolated ball valve tests were performed in the clear, rotational test facility. Two different Mark 5 ball valve assemblies were used for testing. Each test included a measured-out amount of fine grit particles combined with water to circulate and actuate the tool in. Each test followed the protocol listed below in section 1.2.

The two fine grit particles used in the ball valve testing are Aluminum Oxide, with a particle size ranging from 53-125 µm, and Min-U-Sil with a 5-40 µm range. 12 tests were performed in a 0.24% Aluminum Oxide by weight solution, or 0.05 lbs Aluminum Oxide per 2.5 gallons of water. These 12 tests were successful, resulting in a fully closed ball valve. One unscheduled test was run at the request of the client with a goal to visually see the ball valve fail to close. Using previous testing data, we knew that using Aluminum Oxide at about 4X the amount of fine grit particles extracted from the CTTF mud sample (0.24%) will consistently make the tool fail. With this information, we ran the next test with a 1% concentration, or about 0.2 lbs Aluminum Oxide per 2.5 gallons of water. This test resulted in a failure; the ball valve actuated about halfway before jamming up.

The next six tests were performed in a Min-U-Sil and water solution. The Min-U-Sil was much less invasive than the Aluminum Oxide on the tool, so full pressure washing and tool rebuilding was not required between tests (step 10 of section 1.2). The first four Min-U-Sil tests were performed using a concentration of 0.24%. These four tests were successful. The next two tests were performed using a 1.00% concentration, and a 3.00% concentration of Min-U-Sil. The increase in Min-U-Sil quantity did not cause any issues during actuation and the ball valve on both tests successfully closed.

Figure 1 below shows the ball valve assembly inside the rotational test fixture in a heavy concentration of Min-U-Sil. We were not able to record the real-time actuation of the ball valve because of the murky color of the solution, but instead had to check the closure status after draining the solution.

A summary of the test results is listed in section 1.3 below in table 1.

Figure 1. Ball valve assembly in test fixture with Min-U-Sil and water solution

1.2 BALL VALVE TESTING P~~R~~ROCEDURE

Each isolated ball valve test was performed using the protocol listed below:

1. Place the assembled ball valve into acrylic test fixture with core liner section through the tool
2. Weigh out the amount of fine grit for the test
3. Mix and pour the grit and water solution into the test fixture
4. Allow the grit to settle throughout the assembly
5. Assemble clamps, plugs, and other fixturing to secure the tool inside of the test cylinder
6. Rotate the fixture multiple times to fully circulate the grit throughout the tool
7. Remove plug and add actuation fixturing to the release sleeve
8. Remove core liner section from the assembly
9. Use the overhead crane to pull the release sleeve and actuate the ball valve while recording a slow-motion video for data
10. Disassemble and pressure wash each component of the assembly

1.3 BALL VALVE TESTING DATA

MARK 5 BALL VALVE ASSEMBLY TEST DATA

TEST #	GRIT TYPE	GRIT % BY WEIGHT	ASSEMBLY #	PASS/FAIL
1	Aluminum Oxide	0.24%	1	Pass
2	Aluminum Oxide	0.24%	1	Pass
3	Aluminum Oxide	0.24%	1	Pass
4	Aluminum Oxide	0.24%	1	Pass
5	Aluminum Oxide	0.24%	1	Pass
6	Aluminum Oxide	0.24%	1	Pass
7	Aluminum Oxide	0.24%	2	Pass
8	Aluminum Oxide	0.24%	2	Pass
9	Aluminum Oxide	0.24%	2	Pass
10	Aluminum Oxide	0.24%	2	Pass
11	Aluminum Oxide	0.24%	2	Pass
12	Aluminum Oxide	0.24%	2	Pass
13	Aluminum Oxide	1.00%	2	Fail
14	Min-U-Sil	0.24%	1	Pass
15	Min-U-Sil	0.24%	1	Pass
16	Min-U-Sil	0.24%	2	Pass
17	Min-U-Sil	0.24%	2	Pass
18	Min-U-Sil	1.00%	1	Pass
19	Min-U-Sil	3.00%	2	Pass

Table 1. Isolated ball valve testing data

2 PRESSURE ACTUATION TESTING

2.1 PRESSURE ACTUATION TESTING SUMMARY

Two pressure actuation tests were performed to validate proper boosting and sealing functions of the tool in a downhole environment with the upgraded ball valve assembly.

The first pressure actuation test was actuated at an in-situ pressure of 1,695 psi. The tool was assembled with a pressure section with a regulated boost pressure set at 2,005 psi and a reservoir fill pressure of 4,000 psi. The pressure distribution plot of both the "ocean" pressure and the tool autoclave pressure is shown in section 2.2 below in figure 2. We can see from figure 2 that the tool was actuated at around 11:52 where there is an instant pressure increase to around 2,200 psi. The surrounding "ocean" pressure in the system was then reduced at a rate of around 2 psi/second. The autoclave successfully sealed and captured a final sealing pressure of 2,181 psi.

The second pressure actuation test was actuated at an in-situ pressure of 2,974 psi. The pressure section for this test was set to a regulated boost pressure of 3,510 psi and a reservoir fill pressure of 7,000 psi. The pressure distribution plot of this test is shown in section 2.2 below in figure 3. Similar to the first test, the tool successfully captures a pressure boost and seals at a final pressure of 3,641 psi.

2.2 PRESSURE ACTUATION TESTING DATA

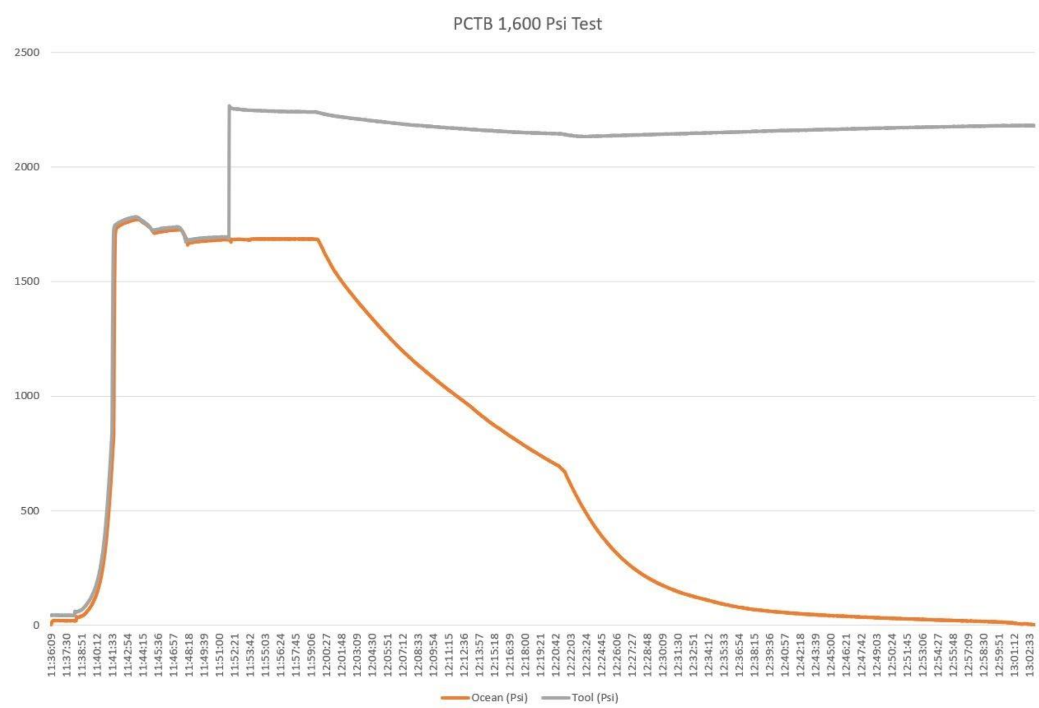

Figure 2. PCTB pressure actuation test #1, actuated at an in-situ pressure of 1,695 psi

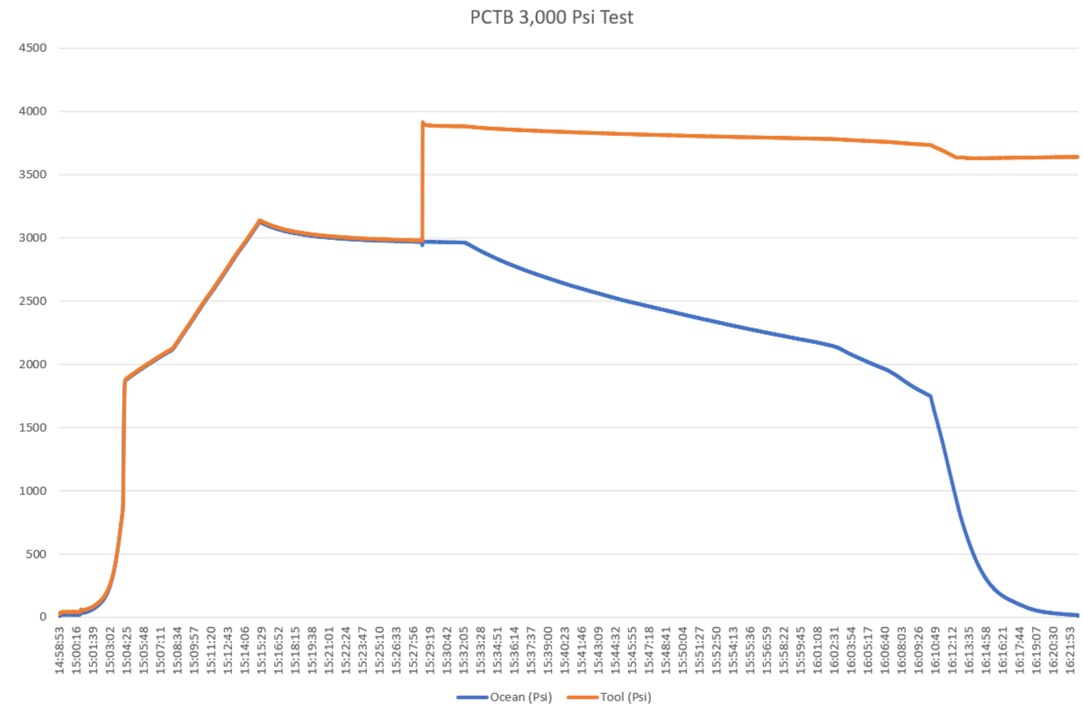

Figure 3. PCTB pressure actuation test #2, actuated at an in-situ pressure of 2,975 psi

3 CONCLUSION

During this iteration of testing, we were able to represent the improved consistency of the upgraded Mark 5 ball valve assembly when operating in conditions where fine grit particles are present. The assembly successfully fires and closes in gritty solutions with comparable concentrations to what was observed in CTTF 2020 testing, where the tool previously failed to close and seal.

Finally, two pressure actuation tests performed in the Geotek Coring Inc. downhole test facility proved the tool boost timing and sealing functionality work as anticipated with the upgraded Mark 5 ball valve assembly. These tests were performed at a different in-situ pressure to validate sealing functionality at various offshore depths.