DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report

(Period Ending 09/30/22)

Deepwater Methane Hydrate Characterization & Scientific Assessment

Project Period 5: 10/01/20 - 09/30/23

Submitted by:

Peter B. Flemings

Peter B Flemings

Signature

The University of Texas at Austin
DUNS #: 170230239
101 East 27th Street, Suite 4.300
Austin, TX 78712-1500
Email: pflemings@jsg.utexas.edu
Phone number: (512) 475-8738

Prepared for:
United States Department of Energy
National Energy Technology Laboratory

Nov 17, 2022

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

Office of Fossil Energy

Submitted By:

Peter B. Flemings, Principle Investigator

Jesse Houghton, Senior Project Manager

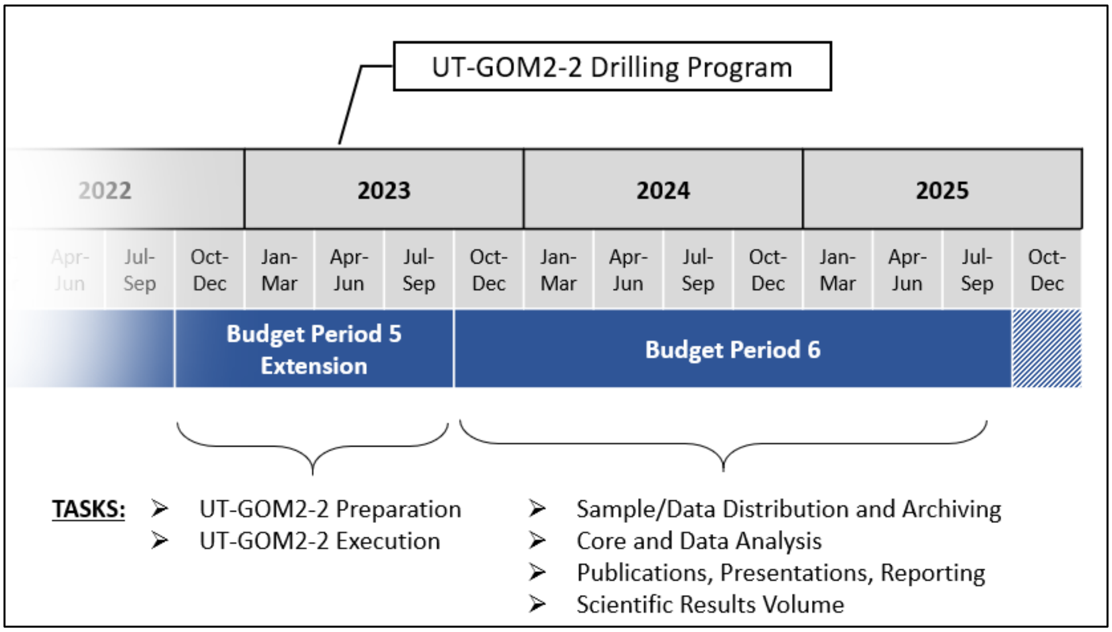
Carla Thomas, Science/Technical Program Manager

DISCLAIMER

1 ACCOMPLISHMENTS AND UPDATES

This report outlines the progress of the fourth quarter of the eighth fiscal year of the project (Budget Period 5, Year 2). Highlights from this period include:

- **Completed BP5 Budget Period Transition / Project Continuation**
  UT completed and submitted a budget period transition/ modification to DOE, which was approved and became effective October 1, 2022. BP5 has been extended for one year through September 30, 2023, followed by a 2-year Budget Period 6 (BP6) ending September 30, 2025.



New DE-FE0023919 project schedule. BP5 has been extended for one year, from Oct. 1, 2022 through Sep 30, 2022. BP6 will now occur from Oct. 1, 2023 through Sep. 30, 2025.

- **UT-GOM2-2 will be performed in spring 2023**
  As an outcome of the budget period transition/ modification, UT has committed to performing the UT-GOM2-2 drilling program in spring, 2023. UT developed a reduced-scope GOM2-2 science and operations scope that can be accomplished with the current project funding as of 2022. However, if additional funding is provided to the project in the 2023 congressional appropriation, UT is will rapidly expand the UT-GOM2-2 science and operational program to realize more of the originally envisioned science scope.

- **Executed contract with Geotek to perform UT-GOM2-2 in 2023**
  UT negotiated and finalized a service contract with Geotek Ltd. to perform PCTB pressure coring operations, conventional coring operations, field analysis and curation of pressure cores and conventional cores, and related activities for the UT-GOM2-2 field program in Spring 2023.

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	Feb-22	QRPPR
	M5C	Complete Project Sample and Data Distribution Plan	Jul-22	Oct-21	Report directly to DOE PM
	M5D	Complete Pre-Expedition Permitting Requirements for UT-GOM2-2	Mar-23	-	QRPPR
	M5E	Complete UT-GOM2-2 Operational Plan Report	May-21	Sep-21	QRPPR
	M5F	Complete UT-GOM2-2 Field Operations	Jul-23	-	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-23	-	Phase 5 Report
	M6B	Complete Preliminary Expedition Summary	Dec-23	-	Report directly to DOE PM
	M6C	Initiate comprehensive Scientific Results Volume	Jun-24	-	Report directly to DOE PM
	M6D	Submit set of manuscripts for comprehensive Scientific Results Volume	Sep-25	-	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*
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	*Execute UT-GOM2-2 Field Program*
Optional Subtask 16.2	*Add Conventional Coring*
Optional Subtask 16.3	*Add Spot Pressure Coring*
Optional Subtask 16.4	*Add Second Hole at H-Location*
Optional Subtask 16.5	*Add Additional Cores and Measurements*
Task 17.0	**UT-GOM2-2 Core Analysis**
Subtask 17.1	*Routine UT-GOM2-2 Core Analysis*
Optional Subtask 17.2	*UT-GOM2-2 Expanded Core Analysis*

1.2.2.1 Task 1.0 – Project Management & Planning

Status: Ongoing

- **Coordinate the overall scientific progress, administration and finances of the project:**
    - UT monitored and controlled the project budget, scope, and schedule.
    - UT developed and submitted a budget period transition /continuation proposal to DOE to make the following modifications to the project. The budget period transition was approved by DOE, effective 10/1/22.
        1. Defer Task 16 (UT-GOM2-2) from 2022 to 2023
           Defer UT-GOM2-2 no more than one calendar year from its originally intended execution of Spring 2022, to Spring 2023.
        2. Extend BP5 by 1-Year, Adding 1-Year to Overall Project Duration
           Extend the current budget period, Budget Period 5 (BP5), for one year due to the requirement to delay of UT-GOM2-2 (Task 16) to 2023. BP5 will be extended through September 30, 2023. This will result in a 1 year delay in commencement of BP6, which currently occurs from October 1, 2022 through September 30, 2024. BP6 will now occur from October 1, 2023 through September 30, 2025.
        3. Modify Scope and Budget for Task 16 (UT-GOM2-2) – Phase 5A
           Modify the scope of the UT-GOM2-2 field program so that it can be accomplished with current funding, under Task 16, '**Phase 5A'** (see Operations Plan Rev. 2.2)
        4. Optional Expanded Scope and Budget for Task 16 (UT-GOM2-2) – Phase 5B
           Add 'Optional Subtasks' to Task 16 to re-instate components of the original UT-GOM2-2 science objectives if sufficient funding is available in FY23. The optional expanded Task 16 subtasks would be accomplished under Task 16, '**Phase 5B'**. The magnitude of the expanded scope will be adjusted to match the available funding, and will only performed upon formal authorization of Phase 5B by US DOE.

- **Communicate with project team and sponsors:**
    - Organized sponsor and stakeholder meetings.
    - Organized task-specific working meetings to plan and execute project tasks per the Project Management Plan and Statement of Project Objectives.
    - Managed SharePoint sites, email lists, and archive/website.

- **Coordinate and supervise service agreements:**
    - UT finalized and executed a service agreement with Geotek to perform pressure coring, conventional coring, field analysis and curation of pressure cores and conventional cores, and related science and operational activities for the 2023 UT-GOM2-2 Scientific Drilling Program.

- UT continued to hold 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.
- UT initiated recurring technical meetings with Helix to plan the 2023 UT-GOM2-2 field program, and refine requirements for third party subcontracts covering drill pipe-make up, wireline operations, Drilling Fluid, supply boats, Dock services, Well certification, Deck layouts, etc.
- UT initiated discussions with ANCO Insurance, to insure UT-GOM2-2 field program personnel and equipment.

- **Coordinate subcontractors:**
  - UT negotiated modified budgets with all subcontractors to align with the new GOM modified scope and budget for BP5A and BP5B.
  - UT continued to monitor and control contractor efforts.

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. Geomechanical viscoplastic behavior

- Over the last year, we have made incremental steps to refine our experimental approach to studying the geomechanical behavior of pressure cores. As a result of these improvements, we have successfully measured the compression behavior of sample 8FB3-3 during this quarter.
- We conducted constant rate uniaxial strain experiments (CRS) and measure the lateral stress ratio (K_0), including lengthy axial stress hold periods to explore the K_0 response with time. The hydrate-bearing sediments behave visco-plastically. For example, the void ratio decreases significantly during the stress holds and its magnitude is similar to the CRS compression (Figure 1-1a). Furthermore, the K_0 depends on the loading rate. During stress holds, there is an increase in K_0 with time that ultimately converges on isotropic conditions (Figure 1-1c). These results are fundamentally different from the results for the non-hydrate bearing sediment, where the void ratio slightly decreases during the stress hold (Figure 1-1b) and K_0 remains constant with time (Figure 1-1c).

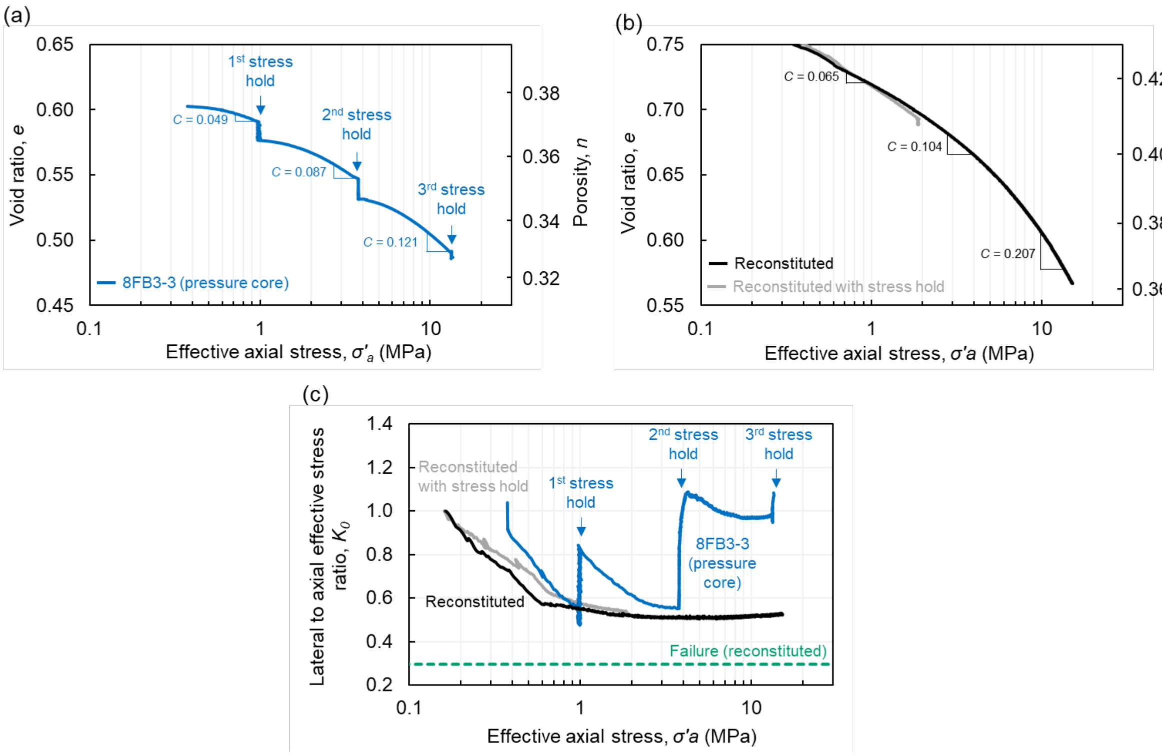


Figure 1-1: (a) Evolution of void ratio e and with axial effective stress σ'_a during uniaxial strain compression for pressure core sample 8FB3-3. The compression is paused three times, holding the axial stress constant. (b) Void ratio evolution with effective stress for reconstituted sandy-silt material from the same hydrate reservoir. One test included a stress hold at the end of the compression phase. (c) Lateral to axial effective stress ratio K_0 during uniaxial strain compression (blue: pressure core 8FB3-3, black and gray: reconstituted sandy-silt material from the same hydrate reservoir). The stress ratio at failure for the reconstituted material is superimposed.

- The compression curves during the stress holds resemble a consolidation process, where the axial strain steepens and then flattens with time as overpressured water is expelled out of the pores (blue line, Figure 1-2a). However, the time scale for deformation predicted by the theory of consolidation is ~ 1 min. Our results indicate that half of the total deformation (Δe) has occurred at t = 200 min (blue line, Figure 1-2a). We use a standard linear solid model (spring and dashpots) to model the compression behavior (yellow line, Figure 1-2a). The model accurately predicts compression trends and highlight the deformation is related to viscous hydrate flow.
- Figure 1-2b shows the K_0 increase lags the deformation during the stress holds. The K_0 starts to increase at 200 min, where half of the deformation has occurred. We interpret the hydrate flow viscously without exerting stresses on lateral boundaries. After significant deformation, the hydrate pushes laterally and K_0 starts to increase. The complex interplay between deformation and K_0 is not captured with our first-order spring and dashpot model (yellow line, Figure 1-2b).

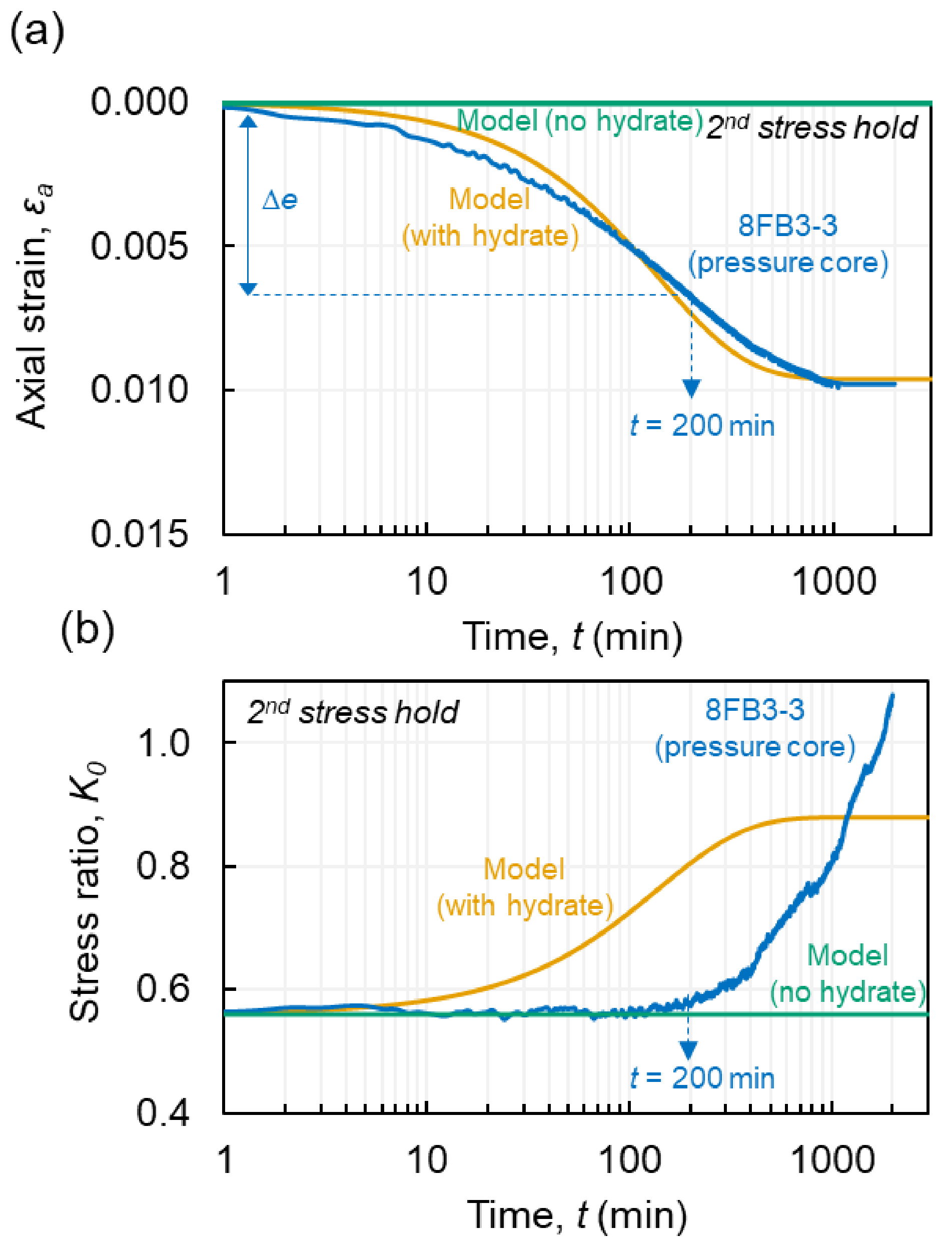


Figure 1-2: Time-dependent evolution of the (a) axial strain and (b) stress ratio K0 during the second stress holds at σ'ₐ = 3.8 MPa for the sample 8FB3-3 (blue line). The initial time corresponds to the beginning to the stress hold. The standard linear solid model predictions are superimposed (yellow line), together with model results with no hydrate (green line).

- These results suggest that on the time scale of hydrate production (days to months), the hydrate will undergo significant viscous deformation. Unexpected reservoir settlement may occur far from the wellbore after production has ceased as the sediment with unproduced hydrate can creep.
- Our results also highlight that the in-situ stress ratio of hydrate-bearing layers may be unexpectedly high, which in turn affects completion and drilling strategies. Similar to salt formations that exhibit $K_0 \approx 1$, excessive torque, pack-offs and casing collapse may be present during and post-drilling. Hydraulic

fracturing designs should recognize the near isotropic state of stress and the ensuing complex fracture distributions.

1.2.2.2.2 Subtask 10.6 – Additional Analysis Capabilities

- Ohio State is using measurements of ^{4}He and ^{20}Ne release from UT-GOM2-1 sandy silt to constrain Monte Carlo simulations of GC 955 biogenic methane residence time.

1.2.2.2.3 Subtask 10.7 – Hydrate Modeling

- UT developed a two-dimensional radial symmetric numerical model to simulate gas production from methane hydrate reservoirs and applied the model to a laboratory depressurization experiment conducted under constant axial (3.8 MPa) and radial (1.8 MPa) effective stress. The sample is 8 cm in length and 2.35 cm in radius. It has a porosity of 0.39, methane hydrate saturation of 0.84, and intrinsic permeability of 9.25 mD. During the depressurization experiment, pore pressure was decreased incrementally from 24.8 MPa to atmospheric pressure within 70 hours (Figure 1-3) from one end of the sample while maintaining the other end closed. The accumulated volume of gas produced was measured over the experiment (Figure 1-3). The experiment was conducted in a cold room with an average temperature of 6.5 ^{o}C.
- Our model is based on thermodynamic equilibrium that methane hydrate keeps dissociating until the local pressure, temperature and salinity reach those on the methane hydrate phase boundary. We simulate the flow of liquid water and free gas and the transport of water, methane and salt in the hydrate-bearing core only, but simulate the heat flow within the entire sample including the steel chamber, the confining fluid, the rubber sleeve and the hydrate-bearing sediment (Figure 1-3a). We conduct four different simulations to explore the processes that control the hydrate dissociation and gas production. In Case-1 (Figure 1-6, solid red line), we assume there is no outside heat supply to the entire modeling domain. In Case-2 (Figure 1-6, solid green line), we maintain the surface of the steel chamber a constant temperature 6.3 ^{o}C. In Case-3 (Figure 1-6, solid blue line), we assume a constant air temperature surrounding the chamber 6.3 ^{o}C and simulate the heat convection between the steel chamber and the surrounding air. Case-4 (Figure 1-6, solid black line) is similar to Case-3 expect that we change the effective permeability model from pore coating to pore filling which calculates a lower effective permeability at the same hydrate saturation (Kleinberg et al., 2003). In all four cases, we use the series model to calculate the bulk thermal conductivity which predicts the lower bound (Waite et al., 2009).
- The key observations include: (1) Hydrate dissociates from the radial and axial surface to the inside (Figure 1-5). This corresponds with a decreasing temperature from the radial and axial surface to the inside. There are very small differences in accumulative volume of gas production between Case-3 and Case-4 (Figure 1-6). The only difference in Case-3 and Case-4 is the effective permeability model of hydrate-bearing sediment. Case-3 uses the Kleinberg et al. (2003) pore coating model, and Case-

4 uses the pore filling model. Case-3 has an effective sediment permeability two orders of magnitude larger than Case-4 but predicts a negligible increase in gas production rate compared with Case-4. These observations indicate that the predicted rate of hydrate dissociation and gas production is controlled by heat supply to the hydrate dissociation front and sediment permeability plays a minor role. (2) All modeled cases, except the insulated case, predict faster hydrate dissociation and gas production than measurements over the experiment (Figure 1-6). The modeled insulated case (Figure 1-6, solid red line) also predicts a higher rate of gas production than measurements (Figure 1-6, blue dots) at early stage (0-10 hours). Our modeled rate of hydrate dissociation is controlled by heat supply. The difference between the predicted and observed methane production rate indicate that the rate of gas production in the laboratory experiment is limited by a process that is slower than heat supply (e.g., microscale processes that are not simulated in the model, such as the methane transport away from the surface of dissociating hydrate). This conclusion assumes that the laboratory measurements and the modelled heat supply are accurate.

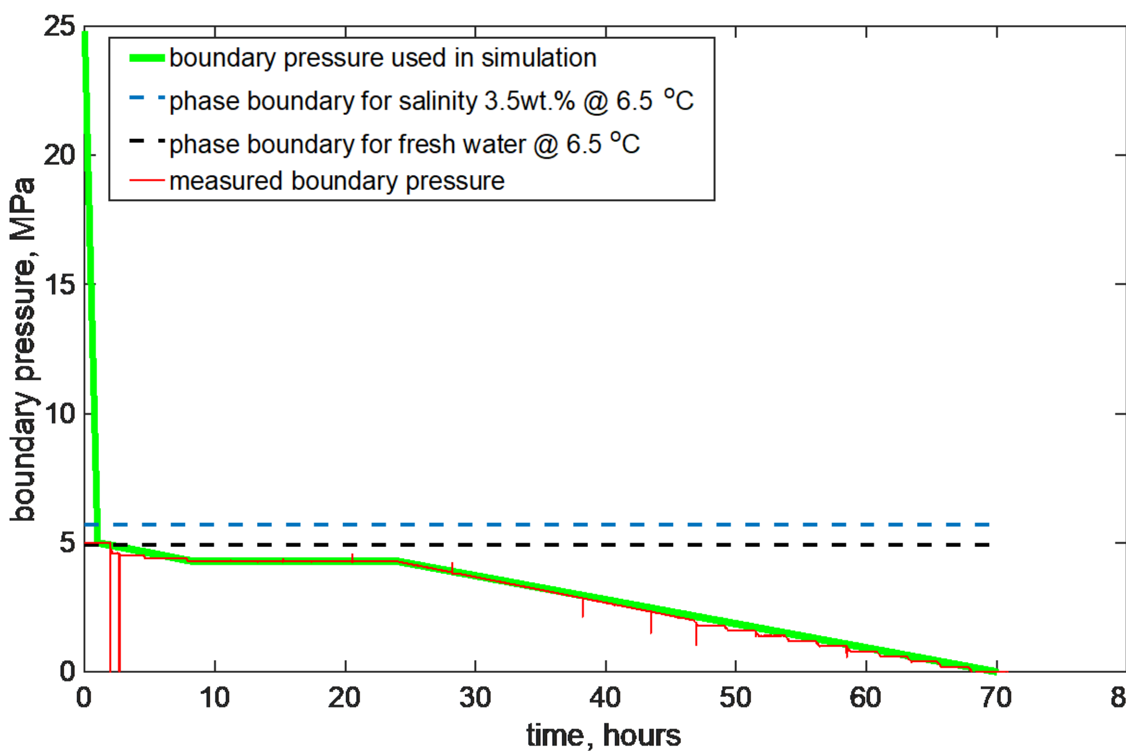


Figure 1-3: Measured pressure at the open end of the sample during the gas production experiment (the red line). We use the green line as the boundary pressure in our model for simplicity. The dashed blue and black lines are the methane hydrate phase boundary with seawater salinity 3.5 wt.% and fresh water.

To further understand the processes controlling gas production from methane hydrate reservoirs, we implemented a new measuring protocol where we track the temperature evolution inside the sample, within the confining fluid and outside the steel chamber. Figure 1-4 shows the experimental device with the location of the new temperature sensors (red squares). This new instrumentation with the capabilities to conduct uniaxial strain compression tests will allow us to reproduce production conditions more closely. The total stress will be maintained constant while the pore pressure is decreased under uniaxial strain conditions. More frequent and accurate measurements of mass/volume of gas production during the experiment will also improve our understandings. The new experimental improvements will provide new data that can be used to validate hydrate production models.

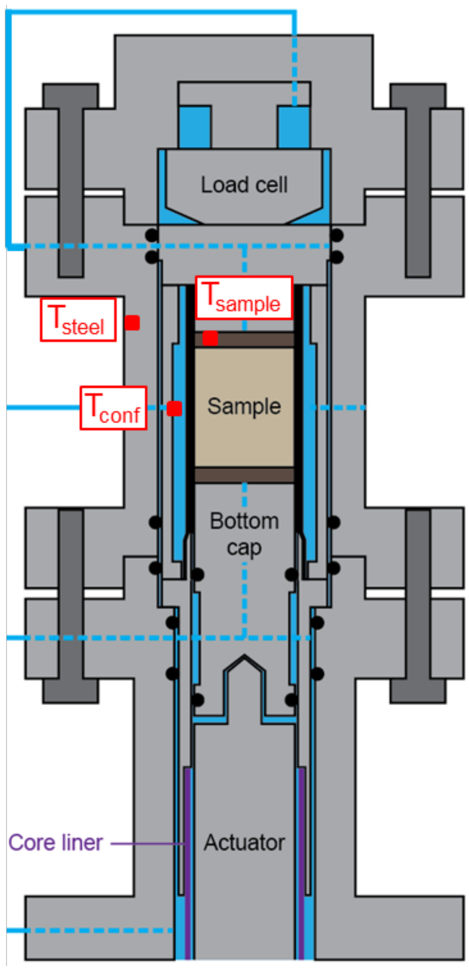
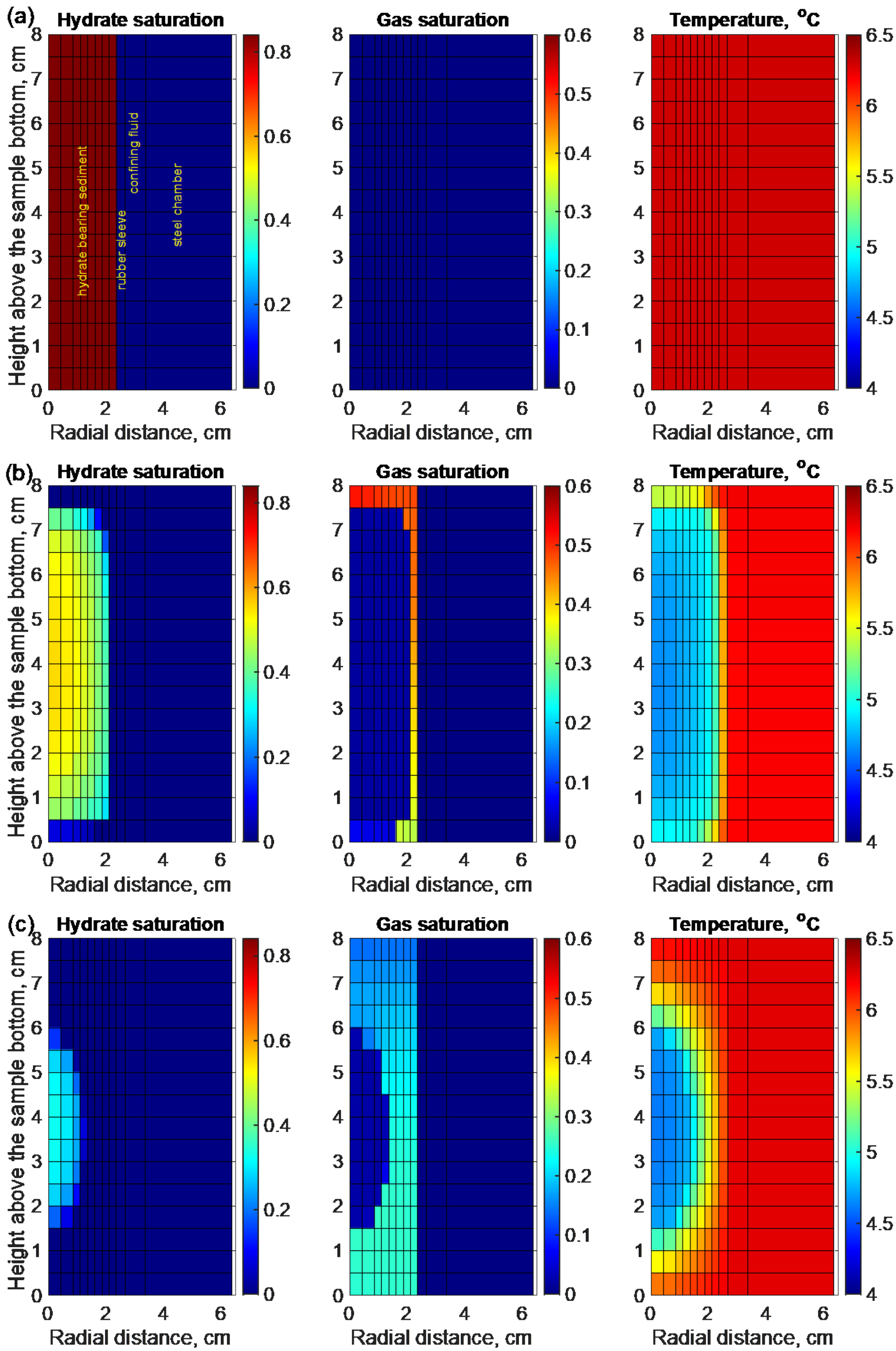


Figure 1-4: Experimental triaxial device used to conduct uniaxial strain compression tests on pressure cores. The red squares indicate the location of the new temperature sensors installed in the system, where we track the temperature inside the sample (T_{sample}), within the confining fluid (T_{conf}), and outside the steel chamber (T_{steel})



(a)
Hydrate saturation
Gas saturation
Temperature, °C
hydrate bearing sediment
rubber sleeve
confining fluid
steel chamber
(b)
Hydrate saturation
Gas saturation
Temperature, °C
(c)
Hydrate saturation
Gas saturation
Temperature, °C
Height above the sample bottom, cm
Radial distance, cm

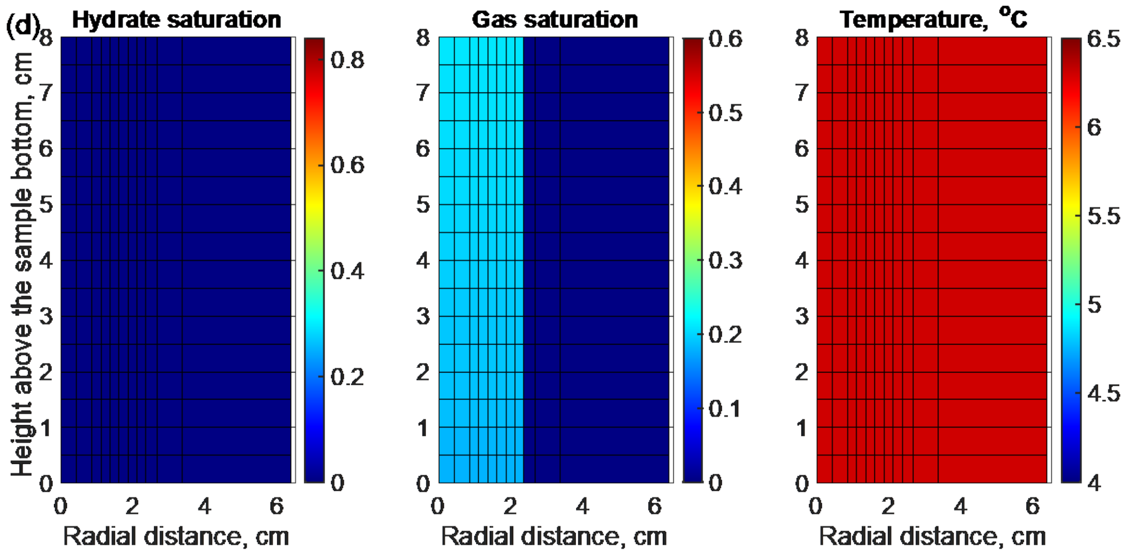


Figure 1-5: Case-3: Simulated hydrate saturation, gas saturation and temperature at (a) 0 hr, (b) 7 hr, (c) 12 hr, and (d) 50 hr from the start of the experiment. In Case-3, we assume a constant air temperature of 6.5 oC, simulate the heat convection between the depressurization chamber and the surrounding air, and use the pore-coating model to calculate the sediment effective permeability.

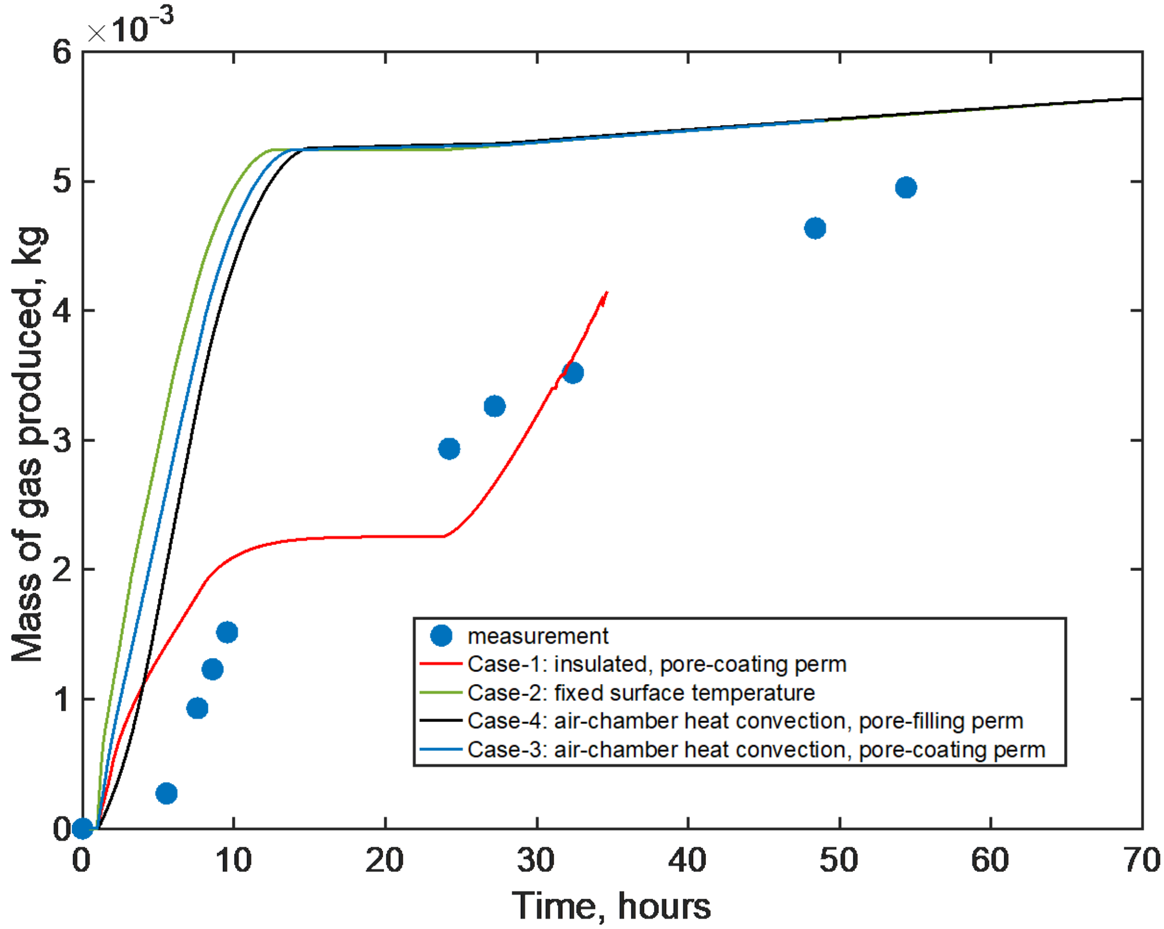


Figure 1-6: Simulated and measured accumulative mass of gas production from the gas production experiment. Laboratory gas production was conducted using depressurization where pore pressure was decreased incrementally from 24.8 MPa to atmospheric pressure while maintaining a constant room temperature ~6.5 oC, constant axial (3.8 MPa) and radial (1.8 MPa) effective stress. In Case-1, there is no heat supply to the entire depressurization chamber, and we use the Kleinberg et al. (2003) pore-coating model to calculate the sediment effective permeability ($k = k_0(1 - S_h)^2$, where k is sediment effective permeability; k_0 is sediment intrinsice permeability; $S_h$is hydrate saturation). In Case-2, we fix the temperature at the outside of the depressurization chamber to 6.5 oC throughout the simulation and use the pore-coating model to calculate the sediment effective permeability. In Case-3, we assume a constant air temperature of 6.5 oC, simulate the heat convection between the depressurization chamber and the surrounding air, and use the pore-coating model to calculate the sediment effective permeability. In Case-4, we assume a constant air temperature of 6.5 oC, simulate the heat convection between the depressurization chamber and the surrounding air, and use the the Kleinberg et al. (2003) pore-filling model to calculate the sediment effective permeability ($k = k_0\left[1 - S_h^2 + \frac{2(1-S_h)^2}{log(S_h)}\right]$).There is a bench in Case-1 (red line) between ~10 hours and ~25 hours. During this time period, the temperature in the hydrate-bearing core maintains at ~4.25 oC, pressure ~4.14 MPa and sailinity ~1.1 wt.%. The system is at three-phase equilibrium. Therefore, hydrate stops dissociation and the accumulative mass of gas production is almost constant. At ~25 hours, we open the valve at the top of the chamber and drops the core pressure again (Figure 1-3). Decreasing pressure from the hydrate phase boundary induces more hydrate dissociation. In addition, decreasing pressure drives gas expansion from the core into the gas collection system. Therefore, we observe increasing gas production after 25 hours. Our simulation stops convergence at ~34 hours when the temperature, pressure, and salinity in the hydrate-bearing core are ~1.8 oC, 3.4 MPa and 0.7 wt.%, respectively, and the average hydrate saturation is 18.5%. We will continue to improve the model convergence.

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

- Future Task.

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

- Future Task.

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

- No Updates.

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

Status: Complete (Milestones 5C, 5E)

See notes in Section 1.2.2.7.3 Subtask 15.5 – Finalize Operational Plan for UT-GOM2-2 Scientific Drilling Program.

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

Status: Complete (Milestone 5B)

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

Status: UT conducted a new core degradation simulation on pressure core 8FB-1 (see subtask 10.7), collected new pore water samples for chemical analysis (see Table 1-10), and is analyzing core volume loss by comparing the CT images collected in 2017 and 2019 in ImageJ now.

- UT continues to make progress on understanding the mechanisms and extent of core degradation during high pressure storage in fresh water. Work continues on extracting samples of storage fluid from high pressure chambers. The method of storage fluid extraction was refined. New samples were extracted from the top and bottom of two pressure chambers, analyzed for salinity and dissolved methane concentration as shown in Table 1-9. Results were compared to the initial storage fluid condition (0 ppt salinity and 0 mol/kg of methane), pore water salinity (estimated by quantitative degassing to be equivalent to seawater at 3 ppt), and methane saturation (7.50×10^{-2} mol/kg). Results confirm that the storage fluid has not reached equilibrium (storage fluid is still not saturated with methane), meaning that the cores are still degrading but degrading very slowly (over many years).

Table 1-9. Measured salinity and dissolved methane concentration of newly extracted storage fluid samples.

Pressure core name	5FB-2		8FB-1		8FB-2		8FB-3	
Sampling position	Top	Bottom	Top	Top	Top	Bottom	Top	Bottom
Gas volume collected (cm3)	4.3	8.5	2.7	8.6	3.2	5.8	10.2	12.4
Water mass collected (g)	7.0	7.2	3.8	7.6	7.4	6.9	7.0	7.0
Salinity (wt.%)	0	0.2	0.1	0.1	0.0	0.2	0.0	0.2
Experimental pressure (MPa)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Experimental temperature (°C)	6	6	25	25	25	25	25	25
Dissolved methane concentration (mmol/kg)	27.1	50.6	31.2	48.7	19.5	36.5	60.9	73.8
Methane solubility in storage chamber (mmol/kg)	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2	75.9 ± 3.2
Month/Year of sampling	02/22	02/22	05/21	06/21	02/22	02/22	06/22	06/22

- Previous simulations of core degradation have modeled a change in storage fluid salinity and dissolved methane concentration as a function of time and space (see Y7Q1 (Flemings, 2021a) or Y7Q2 (Flemings, 2021b)). These modeled changes are a result of dissolved methane diffusion and advection from the pore space into the fresh storage fluid, and loss of hydrate in the pore space of the exposed surfaces of the core. Modeling of the dissolved methane concentration and salt diffusion and advection expected after 15 months predicted dissolved methane concentrations around 5 x 10^{-2} mol/kg with low salinity at the top of the chamber and dissolved methane concentrations close to saturation with higher salinity at the bottom of the chamber. Measurements of the new sample are consistent with the model and further confirm our interpretation of the degradation mechanism being the loss of hydrate as methane is pulled into the fresh storage fluid, and that the degradation mechanism is slow and still occurring. The majority of the equipment to allow UT to create and exchange methane-charged water has been delivered to UT. The pressure vessel has been delivered after it had undergone a manufacturing delay. The next step is to fabricate a mobile stand for the vessel to begin assembly of the equipment in Q4, 2022.

1.2.2.5.1 *Subtask 13.1 – Hydrate Core Manipulator and Cutter Tool*

- UT attempted to test samples 8FB3-K04, 8FB3-K05, and 8FB1-K01. However, it was evident that debris generated during cutting was transferred into the Effective Stress Chamber. As a result, the actuator in the Effective Stress Chamber is jammed and it is not possible to apply high axial stresses to the sample. In this quarter, UT and Geotek designed a sediment trap that aims to collect this debris during sample transfer from the mini-PCATS system to the Effective Stress Chamber. This new capability will be manufactured and tested in the next quarter.

- The mini-PCATS system underwent a saw maintenance teardown. Seals and bearings were replaced and mini-PCATS sediment traps were cleaned. The core liner cover was replaced on the actuator to ensure better grip from the rotator.
- The X-ray system underwent quarterly calibration.
- The P-wave Velocity system underwent a calibration.
- Core H005-08FB-03 underwent additional cutting.
    - Two sub-samples were cut from the remaining core in mPCATS and placed in Effective Stress Chamber test sections and underwent testing.
        - 8FB-03-K04
        - 8FB-03-K05
- Core H005-08FB-01 underwent cutting.
    - Two sub-samples were cut from the core. Remainder of core returned to storage vessel with solid spacers to occupy open volume.
        - 8FB-01-K01 – Currently undergoing testing in the Effective Stress Chamber
        - 8FB-01-K02 – Testing in next quarter.

1.2.2.5.2 *Subtask 13.2 – Hydrate Core Effective Stress Chamber*

- The Effective Stress Chamber underwent a full maintenance teardown and reassembly. All seals and consumable ball-bearings were replaced.
- We have refined our experimental approach to studying permeability and compression behavior under uniaxial strain over the last year. This resulted in successful geomechanical measurements in sample 8FB3-3. However, there are pending issues we addressed during this quarter. These are summarized below:
    - We focus on whether system compressibility is causing an overestimation of the vertical displacement. UT conducted multiple calibration tests at high stresses using a steel sample. Results revelated significant equipment deformation that can cause errors of up to 10%. UT will implement and test a new pump protocol that will correct for these effects.
    - We focused on making a ‘production test’ on a hydrate-bearing sample, where we monitor the geomechanical behavior during hydrate dissociation. A key variable for our effort is the temperature of the sample. Using a steel sample, UT successfully tested the custom-made temperature monitoring system and sensors from Geotek to measure the temperature directly in the sample and confining fluid.

1.2.2.5.3 Subtask 13.3 – Hydrate Core Depressurization Chamber

- The system underwent maintenance and cleaning.

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

- UT has negotiated with Geotek to perform transport of hydrate-bearing pressure cores that will be recovered during UT-GOM2-2 to the UT Austin Pressure Core Center. Geotek has developed the required technology and resources, and maintains valid DOT permits for pressure core transport operations.

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

- After obtaining and evaluating a single example of the new design, UT has determined that the base needs to be enlarged slightly to ensure proper access to pressure chamber valves and pressure relief lines. A refined design will be produced and sent out for an updated quote to make the required quantity of bases needed for storage expansion while ensuring expedient manufacturing and material longevity of the support bases.
- Expansion of pressure maintenance system is required to increase storage capability sufficient to receive UT-GOM2-2 cores. UT will obtain an updated quote for additional pressure maintenance manifolds to ensure expedient delivery while reducing costs from the previous quote obtained. Expansion of pressure safety venting system will also be required. UT will obtain an updated quote for additional venting lines with expedient delivery and reduced costs. UT continues to evaluate how to streamline the expansion of the pressure maintenance system and venting system.
- 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. UT shipped ten pressure core storage chambers to Geotek in Q4, 2022. This shipment allowed for more open storage space for the remaining cores from UT-GOM2-1 and the anticipated cores from UT-GOM2-2.

1.2.2.5.7 Subtask 13.7 – X-ray Computed Tomography

- The X-Ray CT continues to operate as designed.
- During this period, the system was calibrated.
- The Dell Image Reconstruction computer continues to operate properly.

1.2.2.5.8 Subtask 13.8 – Pre-Consolidation System

- After repair of the hydraulic accumulators, the system appears to be holding the nitrogen charging pressure. The system will continue to be evaluated and checked to ensure proper pressure maintenance to generate effective stresses in pressure cores in the future. With continued success in nitrogen gas retention, the Pre-Consolidation system can be used to store pressure cores with effective stresses applied in both axial and confining directions.

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: Complete

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 held web conference with BOEM on August 25, 2022 and September 1, 2022 to discuss permit status and plan forward. It was determined that UT will re-purpose WR313 F001 and WR313 F002 (which were included in the Initial Exploration Plan, but are no longer included in the revised UT-GOM2-2 project plan) wells to the same location as WR313 H002. WR313 F001 is now WR313 H003 and WR313 F002 is now WR313 H003, serving as a back-up well in case of the need for a 're-drill'.
- UT is in the final stage of completing a Revised Exploration Plan that will be submitted in the next quarter. The Revised Exploration Plan is being submitted to update the drilling and activity schedule, well designations and well locations, vessel information, and air emissions information, as required by BOEM.
- UT is revising the Permit to Conduct Geological or Geophysical Exploration for Mineral Resources for Mineral Resources or Scientific Research on the OCS (BOEM-0327 and BOEM-0329) to reflect the same

changes reflected in the Revised Exploration Plan. UT will complete and submit this permit in the next quarter.

- UT successfully created eWell and Technical Information Management System (TIMS) accounts, required by BOEM and BSEE for submission of specific permits and notifications.
- The status of permit submission and approval for the UT-GOM2-2 field program is shown in Table 1-10.

Table 1-10: UT-GOM2-2 Permit Status

AGENCY	REQUIREMENT	STATUS	TRACKING INFO
BOEM	Qualified Operator Certification	Approved 03/21/17	No. 3487
BOEM	BOEM Qualification Update	Approved 01/10/22	Dr. Daniel Jaffe, VPR
BOEM	Lease Bond	Approved 07/19/21	Bond No. ROG000193
BOEM	Right-of-Use and Easement (RUE)	Approved 11/12/21 Effective 02/11/22	OCS-G 30392
BOEM	Initial Exploration Plan	Approved 11/12/21	N-10162
BOEM	Permit to Conduct Geological or Geophysical Exploration for Mineral Resources or Scientific Research on the OCS	Under revision	--
BSEE	Application for Permit to Drill (APD)	--	--
BSEE	Application for Permit to Modify (APM)	--	--
LDNR	CZM Consistency Cert.	Approved 11/05/21	C20210156
US CG	Letter of Determination (LOD)	--	--
US DOE	NEPA Environmental Questionnaire (EQ)	Approved 03/10/22	--
US EPA	NPDES Electronic Notice of Intent (eNOI)	--	--

1.2.2.7.2 Subtask 15.4 – Review and Complete NEPA Requirements

Status: In Progress

- A NEPA Categorical Exclusion for the UT-GOM2-2 field program was granted on Mar. 10, 2022.
- UT will complete a NEPA EQ for the dockside science location once confirmed by Helix.

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

Status: Complete (Milestones M5C, M5E)

- UT updated the UT-GOM2-2 Operations Plan to reflect changes made as a result of the September, 2022 BP5 Budget Period Extension / Continuation. The UT-GOM2-2 Operations Plan Rev. 2.2 is attached as Appendix A.
- Due to unknown amount and distribution schedule of the project’s FY23 Federal funding obligation, the UT-GOM2-2 field program scope has been reduced so that it can be accomplished with current

funding, under Task 16, '**Phase 5A'**. Phase 5A prioritizes pressure coring in the Orange sand in a single well, and is described in the UT-GOM2-2 Operations Plan Rev. 2.2. (Appendix A). The plan includes 'Optional Subtasks' that re-instate components of the original UT-GOM2-2 science objectives if sufficient funding is available in FY23. The expanded program subtasks would be accomplished under '**Phase 5B'**. The magnitude of the expanded scope will be adjusted to match the available funding, and will only performed upon formal authorization of Phase 5B by US DOE. Phase 5B prioritizes conventional coring in the shallow section of the hole to allow for characterization of the shallow microbial methane factory, temperature, pressure, and the composition and flux of fluids from the sediments into the ocean, spot pressure coring to characterize dissolved methane concentration with depth and other coarse-grained intervals of interest, and may result in the drilling of a second hole.

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.
- UT will update the Project Management Plan (PMP).

1.3.2 Task 10.0 – Core Analysis

- UT will simulate gas production using the UT Effective Stress Chamber using the new temperature capabilities. Similar to field conditions, these tests will maintain a constant total vertical stress under uniaxial strain conditions while samples are being dissociated. We will measure produced gas, lateral stress, compression and temperature throughout the entire test.
- Oregon State will continue working on improving DNA extraction techniques for UT-GOM2-2
- Ohio State with UT will continue developing reference hydrate saturation curves for UT-GOM2-2
- UT, Ohio State, UW, UNH, Oregon State, and Tufts will continue working on UT-GOM2-2 protocols and supply lists

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

- Task Complete

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

- Task Complete

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.
- UT will implement and test the new pump mode that corrects for equipment compressibility effects during uniaxial strain tests. This new version removes the deformation associated to the equipment, and thus, it uses a more accurate measurement of the sample length.

- UT will manufacture and implement the sediment trap modification in mPCATS to assist with preventing large quantities of loose sediment being introduced into the Effective Stress Chamber during testing.
- UT will obtain quotes for manufacturing additional quad-bases for pressure vessel storage and evaluate options for expedient manufacturing and material longevity when obtaining the quote.
- UT will obtain updated quotes for the pressure maintenance and pressure venting manifolds to ensure expedient delivery and cost reductions from the previous quotes.
- UT will continue to evaluate and refine the temperature measurement capabilities of the Effective Stress Chamber test section.
- UT will begin assembly of the mobile stand for the methane-charged water equipment to test for the mitigation of core degradation.

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

- Task complete.

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

- UT will submit a Revised Exploration Plan to BOEM, The Revised Exploration Plan will reflect updates to the drilling and activity schedule, well designations and well locations, vessel information, and air emissions information, as required by BOEM.
- UT submit the Permit to Conduct Geological or Geophysical Exploration for Mineral Resources for Mineral Resources or Scientific Research on the OCS (BOEM-0327 and BOEM-0329) to BOEM.
- Helix will continue to request quotes from various third-party subcontractors and UT will provide specification guidance to Helix regarding required services, materials, equipment, and personnel.
- UT will complete a NEPA Environmental Questionnaire for the dockside science location once it is confirmed by Helix.

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

- Future Task.

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.

Chen, X., and Espinoza, D. N., 2018a, Ostwald ripening changes the pore habit and spatial variability of clathrate hydrate: Fuel, v. 214, p. 614-622. https://doi.org/10.1016/j.fuel.2017.11.065

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

Chen, X. Y., and Espinoza, D. N., 2018b, Surface area controls gas hydrate dissociation kinetics in porous media: Fuel, v. 234, p. 358-363. https://doi.org/10.1016/j.fuel.2018.07.030

Chen, X.Y., Espinoza, D. N., Tisato, N., Flemings, P. B., in press, Gas Permeability, Pore Habit and Salinity Evolution during Methane Hydrate Dissociation in Sandy Sediments: Energy & Fuels, Manuscript ID: ef-2022-017204.R2

Cook, A. E., and Portnov, A., 2019, Gas hydrates in coarse-grained reservoirs interpreted from velocity pull up: Mississippi Fan, Gulf of Mexico: COMMENT: Geology, v. 47, no. 3, p. e457-e457. https://doi.org/10.1130/g45609c.1

Cook, A. E., and Sawyer, D. E., 2015, The mud-sand crossover on marine seismic data: Geophysics, v. 80, no. 6, p. A109-A114. https://doi.org/10.1190/geo2015-0291.1

Cook, A. E., and Waite, W. F., 2018, Archie's Saturation Exponent for Natural Gas Hydrate in Coarse-Grained Reservoirs, v. 123, no. 3, p. 2069-2089. https://doi.org/10.1002/2017jb015138

Daigle, H., Fang, Y., Phillips, S.C., Flemings, P.B., 2022, Pore structure of sediments from Green Canyon 955 determined by mercury intrusion: AAPG Bulletin, v. 106, no. 5, p. 1051-1069. https://doi.org/10.1306/02262120123

Darnell, K. N., and Flemings, P. B., 2015, Transient seafloor venting on continental slopes from warming-induced methane hydrate dissociation: Geophysical Research Letters, p. n/a-n/a. https://doi.org/10.1002/2015GL067012

Darnell, K. N., Flemings, P. B., and DiCarlo, D., 2019, Nitrogen-Driven Chromatographic Separation During Gas Injection Into Hydrate-Bearing Sediments: Water Resources Research. https://doi.org/10.1029/2018wr023414

Ewton, E., 2019, The effects of X-ray CT scanning on microbial communities in sediment coresHonors]: Oregon State University, 21 p.

Fang, Y., Flemings, P. B., Daigle, H., Phillips, S. C., Meazell, P. K., and You, K., 2020, Petrophysical properties of the Green Canyon block 955 hydrate reservoir inferred from reconstituted sediments: Implications for hydrate formation and production: AAPG Bulletin, v. 104, no. 9, p. 1997–2028, https://doi.org/10.1306/01062019165

Fang, Y., Flemings, P.B., Daigle, H., Phillips, S.C., O'Connel, J., 2022, Permeability of methane hydrate-bearing sandy silts in the deepwater Gulf of Mexico (Green Canyon block 955): AAPG Bulletin, v. 106, no. 5, p. 1071-1100. https://doi.org/10.1306/08102121001

Fang, Y., Flemings, P.B., Germaine, J.T., Daigle, H., Phillips, S.C., 2022, Compression behavior of hydrate-bearing sediments: AAPG Bulletin, v. 106, no. 5, p. 1101-1126. https://doi.org/10.1306/01132221002

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

Flemings, P. B., Phillips, S. C., Collett, T., Cook, A., Boswell, R., and Scientists, U.-G.-E., 2018, UT-GOM2-1 Hydrate Pressure Coring Expedition Summary, *in* Flemings, P. B., Phillips, S. C., Collett, T., Cook, A., Boswell, R., and Scientists, U.-G.-E., eds., UT-GOM2-1 Hydrate Pressure Coring Expedition Report: Austin, TX, University of Texas Institute for Geophysics.

Flemings, P.B., Cook, A.E., Collett, T., Boswell, R., 2022 Gas hydrates in Green Canyon Block 955, deep-water Gulf of Mexico: Part II, Insights and future challenges: AAPG Bulletin, v. 106, no. 5, p. 937-947. https://doi.org/10.1306/bltnintro030922

Hillman, J. I. T., Cook, A. E., Daigle, H., Nole, M., Malinverno, A., Meazell, K., and Flemings, P. B., 2017a, Gas hydrate reservoirs and gas migration mechanisms in the Terrebonne Basin, Gulf of Mexico: Marine and Petroleum Geology, v. 86, no. Supplement C, p. 1357-1373. https://doi.org/10.1016/j.marpetgeo.2017.07.029

Hillman, J. I. T., Cook, A. E., Sawyer, D. E., Küçük, H. M., and Goldberg, D. S., 2017b, The character and amplitude of 'discontinuous' bottom-simulating reflections in marine seismic data: Earth and Planetary Science Letters, v. 459, p. 157-169. https://doi.org/10.1016/j.epsl.2016.10.058

Johnson, J.E., MacLeod, D.R., Phillips, S.C., Purkey Phillips, M., Divins, D.L., 2022. Primary deposition and early diagenetic effects on the high saturation accumulation of gas hydrate in a silt dominated reservoir in the Gulf of Mexico. Marine Geology, Volume 444, 2022, 106718, https://doi.org/10.1016/j.margeo.2021.106718.

MacLeod, D.R., 2020. Characterization of a silty methane-hydrate reservoir in the Gulf of Mexico: Analysis of full sediment grain size distributions. M.S. Thesis, pp. 165, University of New Hampshire, Durham NH, U.S.A.

Majumdar, U., and Cook, A. E., 2018, The Volume of Gas Hydrate-Bound Gas in the Northern Gulf of Mexico: Geochemistry, Geophysics, Geosystems, v. 19, no. 11, p. 4313-4328. https://doi.org/10.1029/2018gc007865

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

Meazell, K., Flemings, P., Santra, M., and Johnson, J. E., 2020, Sedimentology and stratigraphy of a deepwater gas hydrate reservoir in the northern Gulf of Mexico: AAPG Bulletin, v. 104, no. 9, p. 1945–1969, https://doi.org/10.1306/05212019027

Meyer, D. W., 2018, Dynamics of gas flow and hydrate formation within the hydrate stability zone [Doctor of Philosophy: The University of Texas at Austin.

Meyer, D. W., Flemings, P. B., and DiCarlo, D., 2018a, Effect of Gas Flow Rate on Hydrate Formation Within the Hydrate Stability Zone: Journal of Geophysical Research-Solid Earth, v. 123, no. 8, p. 6263-6276. https://doi.org/10.1029/2018jb015878

Meyer, D. W., Flemings, P. B., DiCarlo, D., You, K. H., Phillips, S. C., and Kneafsey, T. J., 2018b, Experimental Investigation of Gas Flow and Hydrate Formation Within the Hydrate Stability Zone: Journal of Geophysical Research-Solid Earth, v. 123, no. 7, p. 5350-5371. https://doi.org/10.1029/2018jb015748

Moore, M., Phillips, S., Cook, A.E. and Darrah, T., (2020) Improved sampling technique to collect natural gas from hydrate-bearing pressure cores. Applied Geochemistry, Volume 122, November 2020, p. 104773, https://doi.org/10.1016/j.apgeochem.2020.104773.

Moore, M.T., Phillips, S.C., Cook, A.E., Darrah, T.H., 2022, Integrated geochemical approach to determine the source of methane in gas hydrate from Green Canyon Block 955 in the Gulf of Mexico: AAPG Bulletin, v. 106, no. 5, p. 949-980. https://doi.org/10.1306/05272120087

Oti, E.A., Cook, A.E., Phillips, S.C., Holland, M.E., 2022 Using X-ray Computed Tomography (XCT) to Estimate Hydrate Saturation in Sediment Cores from Green Canyon 955, northern Gulf of Mexico: AAPG Bulletin, v. 106, no. 5, p. 1127-1142. https://doi.org/10.1306/05272120051

Phillips, S. C., Flemings, P. B., Holland, M. E., Schulthiss, P. J., Waite, W. F., Jang, J., Petrou, E. G., and H., H., 2020, High concentration methane hydrate in a silt reservoir from the deep-water Gulf of Mexico: AAPG Bulletin, v. 104, no. 9, p. 1971–1995. https://doi.org/10.1306/01062018280

Phillips, S. C., Flemings, P. B., You, K., Meyer, D. W., and Dong, T., 2019, Investigation of in situ salinity and methane hydrate dissociation in coarse-grained sediments by slow, stepwise depressurization: Marine and Petroleum Geology, v. 109, p. 128-144. https://doi.org/10.1016/j.marpetgeo.2019.06.015

Portnov, A., Cook, A. E., Heidari, M., Sawyer, D. E., Santra, M., and Nikolinakou, M., 2020, Salt-driven evolution of a gas hydrate reservoir in Green Canyon, Gulf of Mexico: AAPG Bulletin, v. 104, no. 9, p. 1903–1919, http://dx.doi.org/10.1306/10151818125

Phillips, S.C., Flemings, P.B., You, K., Waite, W.F., 2022, Thermodynamic insights into the production of methane hydrate reservoirs from depressurization of pressure cores AAPG Bulletin, v. 106, no. 5, p. 1025-1049. https://doi.org/10.1306/08182120216

Portnov, A., Cook, A. E., Sawyer, D. E., Yang, C., Hillman, J. I. T., and Waite, W. F., 2019, Clustered BSRs: Evidence for gas hydrate-bearing turbidite complexes in folded regions, example from the Perdido Fold Belt, northern Gulf of Mexico: Earth and Planetary Science Letters, v. 528. https://doi.org/10.1016/j.epsl.2019.115843

Portnov, A., Santra, M., Cook., A.E., and Sawyer, D.E, (2020, accepted & online) The Jackalope gas hydrate system in the northeastern Gulf of Mexico. Journal of Marine and Petroleum Geology. https://doi.org/10.1016/j.marpetgeo.2019.08.036

Santra, M., Flemings, P., Meazell, K., and Scott, E., 2020, Evolution of Gas Hydrate-bearing Deepwater Channel-Levee System in Abyssal Gulf of Mexico – Levee Growth and Deformation: : AAPG Bulletin, v. 104, no. 9, p. 1921–1944, https://doi.org/10.1306/04251918177

Santra, M., Flemings, P.B., Heidari, M., You, K., 2022, Occurrence of High-Saturation Gas Hydrate in a Fault-Compartmentalized Anticline and the Role of Seal- Green Canyon, Abyssal Gulf of Mexico: AAPG Bulletin, v. 106, no. 5, p. 981-1003. https://doi.org/10.1306/08182120149

Sawyer, D. E., Mason, R. A., Cook, A. E., and Portnov, A., 2019, Submarine Landslides Induce Massive Waves in Subsea Brine Pools: Scientific Reports, v. 9, no. 1, p. 128. https://doi.org/10.1038/s41598-018-36781-7

Sheik, C. S., Reese, B. K., Twing, K. I., Sylvan, J. B., Grim, S. L., Schrenk, M. O., Sogin, M. L., and Colwell, F. S., 2018, Identification and Removal of Contaminant Sequences From Ribosomal Gene Databases: Lessons From the Census of Deep Life: Front Microbiol, v. 9, p. 840. https://doi.org/10.3389/fmicb.2018.00840

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

Smith, A. J., Flemings, P. B., Liu, X., and Darnell, K., 2014, The evolution of methane vents that pierce the hydrate stability zone in the world's oceans: Journal of Geophysical Research: Solid Earth, p. 2013JB010686. https://doi.org/10.1002/2013JB010686

Thomas, C., Phillips, S. C., Flemings, P. B., Santra, M., Hammon, H., Collett, T. S., Cook, A., Pettigrew, T., Mimitz, M., Holland, M., and Schultheiss, P., 2020, Pressure-coring operations during the University of Texas Hydrate Pressure Coring Expedition, UT-GOM2-1, in Green Canyon Block 955, northern Gulf of Mexico: AAPG Bulletin, v. 104, no. 9, p. 1877–1901. https://doi.org/10.1306/02262019036

Wei, L., Cook, A., Daigle, H., Malinverno, A., Nole, M., and You, K., 2019, Factors Controlling Short-Range Methane Migration of Gas Hydrate Accumulations in Thin Coarse-Grained Layers: Geochemistry, Geophysics, Geosystems, v. 20, no. 8, p. 3985-4000. https://doi.org/10.1029/2019gc008405

Wei, L., Cook, A.E., You, K., 2022, Methane migration mechanisms for the Green Canyon Block 955 gas hydrate reservoir, northern Gulf of Mexico: AAPG Bulletin, v. 106, no. 5, p. 1005-1023. https://doi.org/10.1306/06022120134

Yoneda, J., Jin, Y., Muraoka, M., Oshima, M., Suzuki, K., Waite, W.F., Flemings, P.B., 2022, Comprehensive pressure core analysis for hydrate-bearing sediments from Gulf of Mexico Green Canyon Block 955, including assessments of geomechanical viscous behavior and NMR permeability: AAPG Bulletin, v. 106, no. 5, p. 1143-1177. https://doi.org/10.1306/04272120204

You, K., Summa, L., Flemings, P., Santra, M., and Fang, Y., 2021, Three-Dimensional Free Gas Flow Focuses Basin Wide Microbial Methane to Concentrated Methane Hydrate Reservoirs in Geological System: Journal of Geophysical Research: Solid Earth, v. 126, no. 12, p. e2021JB022793. https://doi.org/https://doi.org/10.1029/2021JB022793

You, K., and Flemings, P. B., 2018, Methane hydrate formation in thick sandstones by free gas flow: Journal of Geophysical Research: Solid Earth, v. 123, p. 4582-4600. https://doi.org/10.1029/2018JB015683

You, K., Flemings, P. B., Malinverno, A., Collett, T. S., and Darnell, K., 2019, Mechanisms of Methane Hydrate Formation in Geological Systems: Reviews of Geophysics, v. 0, no. ja. https://doi.org/10.1029/2018rg000638

You, K., Kneafsey, T. J., Flemings, P. B., Polito, P., and Bryant, S. L., 2015, Salinity-buffered methane hydrate formation and dissociation in gas-rich systems: Journal of Geophysical Research: Solid Earth, v. 120, no. 2, p. 643-661. https://doi.org/10.1002/2014JB011190

You, K., Summa, L., Flemings, P. B., Santra, M., and Fang, Y., (2021), Three-dimensional free gas flow focuses basin-wide microbial methane to concentrated methane hydrate reservoirs in geological system, Journal of Geophysical Research: Solid Earth, 126, e2021JB022793.

You K., and Flemings, P. B., (2021), Methane hydrate formation and evolution during sedimentation, Journal of Geophysical Research: Solid Earth, 126, e2020JB021235.

2.2 Conference Presentations/Abstracts

Colwell, F., Kiel Reese, B., Mullis, M., Buser-Young, J., Glass, J.B., Waite, W., Jang, J., Dai, S., Phillips, S. 2020. Microbial Communities in Hydrate-Bearing Sediments Following Long-Term Pressure Preservation. Presented as a poster at 2020 Gordon Research Conference on Gas Hydrates

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

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

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

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

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

Chen X., Espinoza, D.N., Tisato, N., and Flemings, P.B., 2018, X-Ray Micro-CT Observation of Methane Hydrate Growth in Sandy Sediments. Presented at the AGU Fall Meeting 2018, Dec. 10–14, in Washington D.C.

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

Dong, T., Lin, J. -F., Flemings, P. B., Gu, J. T., Polito, P. J., O'Connell, J., 2018, Pore-Scale Methane Hydrate Formation under Pressure and Temperature Conditions of Natural Reservoirs. Presented to the AGU Fall Meeting 2018, Washington D.C., 10-14 December.

Ewton, E., Klasek, S., Peck, E., Wiest, J. Colwell F., 2019, The effects of X-ray computed tomography scanning on microbial communities in sediment cores. Poster presented at AGU Fall Meeting.

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

Espinoza D.N., Chen X., Luo J.S., Tisato N., Flemings P.B., 2010, X-Ray Micro-CT Observation of Methane Hydrate Growth and Dissociation in Sandy Sediments. Presented to the Engineering Mechanics Institute Conference 2019, Pasadena, CA, 19 June.

Fang, Y., et al., 2020, Petrophysical Properties of Hydrate-Bearing Siltstone from UT-GOM2-1 Pressure Cores. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

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

Fang, Y., Flemings, P.B., Daigle, H., O'Connell, J., Polito, P., 2018, Measure permeability of natural hydrate-bearing sediments using K0 permeameter. Presented at Gordon Research Conference on Gas Hydrate, Galveston, TX. Feb 24- Mar 02, 2018.

Flemings, P.B., et al., 2020 Pressure Coring a Gulf of Mexico Deep-Water Turbidite Gas Hydrate Reservoir: The UT-GOM2-1 Hydrate Pressure Coring Expedition. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

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

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

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

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

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

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

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

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

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

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

Johnson, J., et al., 2020, Grain Size, TOC, and TS in Gas Hydrate Bearing Turbidite Facies at Green Canyon Site 955, Gulf of Mexico. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

Johnson, J.E., Phillips, S.C., and Divins, D.L., 2018, Tracking AOM through TOC and Elemental S: Implications for Methane Charge in Gulf of Mexico Marine Sediments. Abstract OS13A-08 presented at 2018 Fall Meeting, AGU, San Francisco, Calif., 14-18 Dec. Oral Presentation

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

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

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

Liu, J. et al., 2018, Pore-scale CH4-C2H6 hydrate formation and dissociation under relevant pressure-temperature conditions of natural reservoirs. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS23D-2824

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

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

Meazell, K., and Flemings, P.B., 2021, Seal capacity and fluid expulsion in hydrate systems. Presented at IMAGE 2021, SEG/AAPG Annual Conference. Denver, Colorado. Theme 9: Hydrocarbons of the future.

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

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

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

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

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

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

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

Murphy, Z., et al., 2018, Three phase relative permeability of hydrate bearing sediments. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS23D-1647

Naim, F., Cook, A., Konwar, D. (2021) Estimating P-wave velocity and Bulk Density in Hydrate Systems using Machine Learning, in IMAGE 2021, SEG/AAPG Annual Conference. Denver, Colorado

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

Oti, E., Cook, A., Phillips, S., and Holland, M., 2019, Using X-ray Computed Tomography (XCT) to Estimate Hydrate Saturation in Sediment Cores from UT-GOM2-1 H005, Green Canyon 955 (Invited talk, U11C-17). Presented to the AGU Fall Meeting, San Francisco, CA.

Oti, E., Cook. A., Phillips, S., Holland, M., Flemings, P., 2018, Using X-ray computed tomography to estimate hydrate saturation in sediment cores from Green Canyon 955 Gulf of Mexico. Talk presented at the American Geophysical Union Fall Meeting, Washington D.C.

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

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

Phillips, S.C., et al., 2020, High Concentration Methane Hydrate in a Silt Reservoir from the Deep-Water Gulf of Mexico. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

Phillips, S.C., Formolo, M.J., Wang, D.T., Becker, S.P., and Eiler, J.M., 2020. Methane isotopologues in a high-concentration gas hydrate reservoir in the northern Gulf of Mexico. Goldschmidt Abstracts 2020. https://goldschmidtabstracts.info/2020/2080.pdf

Phillips, S.C., 2019, Pressure coring in marine sediments: Insights into gas hydrate systems and future directions. Presented to the GSA Annual Meeting 2019, Phoenix, Arizona, 22-25 September. https://gsa.confex.com/gsa/2019AM/meetingapp.cgi/Paper/338173

Phillips et al., 2018, High saturation of methane hydrate in a coarse-grained reservoir in the northern Gulf of Mexico from quantitative depressurization of pressure cores. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS23D-1654

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

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

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

Portnov, A., Cook, A. E., Frye, M. C., Palmes, S. L., Skopec, S., 2021, Prospecting for Gas Hydrate Using Public Geophysical Data in the Northern Gulf of Mexico. Presented at in IMAGE 2021, SEG/AAPG Annual Conference. Denver, Colorado. Theme 9: Hydrocarbons of the future.

Portnov A., et al., 2018, Underexplored gas hydrate reservoirs associated with salt diapirism and turbidite deposition in the Northern Gulf of Mexico. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS51F-1326

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

Santra, M., et al., 2020, Gas Hydrate in a Fault-Compartmentalized Anticline and the Role of Seal, Green Canyon, Abyssal Northern Gulf of Mexico. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

Santra, M., et al., 2018, Channel-levee hosted hydrate accumulation controlled by a faulted anticline: Green Canyon, Gulf of Mexico. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS51F-1324

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

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

Varona, G., Flemings, P.B., Santra, M., Meazell, K., 2021, Paleogeographic evolution of the Green Sand, WR313. Presented at in IMAGE 2021, SEG/AAPG Annual Conference. Denver, Colorado. Theme 9 Gas Hydrates and Helium Sourcing.

Wei, L. and Cook, A., 2019, Methane Migration Mechanisms and Hydrate Formation at GC955, Northern Gulf of Mexico. Abstract OS41B-1668 presented to the AGU Fall Meeting, San Francisco, CA.

Wei, L., Cook, A. and You, K., 2020, Methane Migration Mechanisms for the GC955 Gas Hydrate Reservoir, Northern Gulf of Mexico. Abstract OS029-0008. AGU 2020 Fall Meeting

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

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

You, K., M. Santra, L. Summa, and P.B. Flemings, 2020, Impact of focused free gas flow and microbial methanogenesis kinetics on the formation and evolution of geological gas hydrate system, Abstract presented at 2020 AGU Fall Meeting, 1-17 Dec, Virtual

You, K., et al. 2020, Impact of Coupled Free Gas Flow and Microbial Methanogenesis on the Formation and Evolution of Concentrated Hydrate Deposits. Presented at the AAPG virtual Conference, Oct 1, Theme 9: Analysis of Natural Gas Hydrate Systems I & II

You, K., Flemings, P. B., and Santra, M., 2018, Formation of lithology-dependent hydrate distribution by capillary-controlled gas flow sourced from faults. Poster presented at American Geophysical Union, Fall Meeting, Washington, D.C. OS31F-1864

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.

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

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

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

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

Flemings, P.B., Boswell, R., Collett, T.S., Cook, A. E., Divins, D., Frye, M., Guerin, G., Goldberg, D.S., Malinverno, A., Meazell, K., Morrison, J., Pettigrew, T., Philips, S.C., Santra, M., Sawyer, D., Shedd, W., Thomas, C., You, K. GOM2: Prospecting, Drilling and Sampling Coarse-Grained Hydrate Reservoirs in the Deepwater Gulf of Mexico. Proceeding of ICGH-9. Denver, Colorado: ICGH, 2017. http://www-udc.ig.utexas.edu/gom2/UT-GOM2-1%20Prospectus.pdf.

2.3.3 Expedition Report Chapters

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018. UT-GOM2-1 Hydrate Pressure Coring Expedition Summary. In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition, Austin, TX (University of Texas Institute for Geophysics, TX). https://dx.doi.org/10.2172/1647223.

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018. UT-GOM2-1 Hydrate Pressure Coring Expedition Methods. 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/10.2172/1647226

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018. UT-GOM2-1 Hydrate Pressure Coring Expedition Hole GC 955 H002. 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/10.2172/1648313

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018. UT-GOM2-1 Hydrate Pressure Coring Expedition Hole GC 955 H005. 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/10.2172/1648318

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.

Heber, R., Cook, A., Sheets, J., and Sawyer, D., 2020. Data Report: X-Ray Diffraction 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/10.2172/1648308, 27 p.

Johnson, J.E., MacLeod, D.R., Divins, D.L., 2020. Data Report: UT-GOM2-1 Sediment Grain Size Measurements at Site GC 955, Holes H002 and H005. 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/10.2172/1823030, 87 p.

Johnson, J.E., Divins, D.L., 2020, Data Report: UT-GOM2-1 Lithostratigraphic Core Description Logs at Site GC 955, Holes H002 and H005. 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/10.2172/1823034, 30 p.

Phillips, I.M., 2018. Data Report: X-Ray Powder Diffraction. 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/10.2172/1648320 14 p.

Purkey Phillips, M., 2020, Data Report: UT-GOM2-1 Biostratigraphy Report Green Canyon Block 955, Gulf of Mexico. In Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition: Austin, TX (University of Texas Institute for Geophysics, TX)., http://dx.doi.org/10.2172/1823039, 15 p.

Solomon, E.A., Phillips, S.C., 2021, Data Report: Pore Water Geochemistry at Green Canyon 955, deepwater Gulf of Mexico, In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, UT-GOM2-1 Hydrate Pressure Coring Expedition Report: Austin, TX (University of Texas Institute for Geophysics, TX), http://dx.doi.org/ 10.2172/1838142, 14 p

2.4 Processing of the UT-GOM2-2 Hydrate Coring Expedition

Volume contents will be published on the [UT-GOM2-2 Expedition Proceedings] website and on [OSTI.gov].

2.4.1 Prospectus

Peter Flemings, Carla Thomas, Tim Collett, Fredrick Colwell, Ann Cook, John Germaine, Melanie Holland, Jesse Houghton, Joel Johnson, Alberto Malinverno, Kevin Meazell, Tom Pettigrew, Steve Phillips, Alexey Portnov, Aaron Price, Manasij Santra, Peter Schultheiss, Evan Solomon, Kehua You, UT-GOM2-2 Prospectus: Science and Sample Distribution Plan, Austin, TX (University of Texas Institute for Geophysics, TX). http://dx.doi.org/10.2172/1827729, 141 p.

2.5 Websites

- Project Website:

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

- UT-GOM2-2 Expedition Website

https://ig.utexas.edu/energy/gom2-methane-hydrates-at-the-university-of-texas/gom2-2-expedition/

- 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

2.6 Technologies Or Techniques

Nothing to report.

2.7 Inventions, Patent Applications, and/or Licenses

Nothing to report.

3 CHANGES/PROBLEMS

3.1 Changes In Approach And Reasons For Change

UT will continue to coordinate efforts to plan and execute the UT-GOM2-2 expedition in 2023. See Section 3.2 and 3.3 for further discussion.

3.2 Actual Or Anticipated Problems Or Delays And Actions Or Plans To Resolve Them

In December, 2021, UT and US DOE determined that performing UT-GOM2-2 in 2022 was no longer viable, and made the decision to pursue a 2023 field program. It was subsequently recognized the amount and distribution schedule of the projects FY23 Federal funding obligation was uncertain.

In the BP5 Budget Period Transition/Extension, UT developed and finalized a financial and operational plan that will enable the project to execute a condensed UT-GOM2-2 field science program with existing funds, and maintain the ability to rapidly expand the program if the project receives additional funding in the FY23 Congressional appropriation.

The minimum, reduced-science, expedition will prioritize taking 10 pressure cores in the Orange sand and bounding muds in a single well, WR313 H002. If additional funding is provided in FY23, UT will expand the program with the following priorities:

- Conventional coring and expedition core analysis
- Spot pressure coring, pressure core analysis, and pressure coring other sands of interest
- Drilling a second hole, WR313 H003, recovering additional cores and adding subaward effort
- Adding additional cores and other coarse-grained hydrate-bearing intervals of interest.

3.3 Changes That Have A Significant Impact On Expenditures

The decision to defer UT-GOM2-2 from 2022 to 2023 impacted anticipated project costs. The BP5 Budget Period Transition/Continuation modified the project cost to reflect UT's best understanding of current offshore drilling costs at this time. Many of UT's service contracts are now locked-in contractually. Unkown variables that are still subject to change include Helix Well Ops third party subcontracts, such as supply vessels, helicopters, mud and drilling fluids, and associated fuel costs.

3.4 Change Of Primary Performance Site Location From That Originally Proposed

None.

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	$ 29,766,294	$ 426,667	$ 30,192,961	$ 2,072,269	$ 32,265,230	$ 598,900	$ 32,864,131
Non-Federal Share	$ 220,056	$ 23,547,000	$ 374,124	$ 23,921,124	$ 623,736	$ 24,544,860	$ 222,682	$ 24,767,542
Total Incurred Cost	$ 809,604	$ 53,313,294	$ 800,791	$ 54,114,085	$ 2,696,006	$ 56,810,091	$ 821,582	$ 57,631,673
Variance								
Federal Share	$ 1,897	$ (2,207,301)	$ (154,484)	$ (2,361,785)	$ (3,394,037)	$ (5,755,822)	$ 17,750	$ (5,738,072)
Non-Federal Share	$ 69,763	$ (324,255)	$ 225,493	$ (98,761)	$ (774,281)	$ (873,043)	$ 74,052	$ (798,991)
Total Variance	$ 71,661	$ (2,531,556)	$ 71,010	$ (2,460,546)	$ (4,168,318)	$ (6,628,864)	$ 91,801	$ (6,537,063)
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	$ 466,675	$ 33,330,806	$ -	$ 33,330,806	$ 543,438	$ 33,874,244	$ 3,743,308	$ 37,617,551
Non-Federal Share	$ 254,642	$ 25,022,184	$ 281,474	$ 25,303,658	$ 258,413	$ 25,562,071	$ 904,873	$ 26,466,945
Total Incurred Cost	$ 721,317	$ 58,352,990	$ 281,474	$ 58,634,464	$ 801,851	$ 59,436,315	$ 4,648,181	$ 64,084,496
Variance								
Federal Share	$ (3,967,208)	$ (9,705,280)	$ (749,973)	$ (10,455,253)	$ (19,730,651)	$ (30,185,904)	$ 3,032,471	$ (27,153,433)
Non-Federal Share	$ (445,590)	$ (1,244,581)	$ 163,033	$ (1,081,548)	$ (2,943,422)	$ (4,024,969)	$ 792,613	$ (3,232,356)
Total Variance	$ (4,412,798)	$ (10,949,860)	$ (586,940)	$ (11,536,800)	$ (22,674,073)	$ (34,210,873)	$ 3,825,084	$ (30,385,789)

6 BIBLIOGRAPHY

Flemings, P. B., 2021a, Y7Q1 Quarterly Research Performance Progress Report (Period ending 12/31/2020), Deepwater Methane Hydrate Characterization and Scientific Assessment, DOE Award No.: DE-FE0023919.

-, 2021b, Y7Q2 Quarterly Research Performance Progress Report (Period ending 3/31/2021), 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
APD	Application for Permit to Drill
APM	Application for Permit to Modify
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CHNS	Carbon, Hydrogen, Nitrogen, Sulfur
CPP	Complimentary Project Proposal
DNA	Deoxyribonucleic Acid
DOE	U.S. Department of Energy
GC	Green Canyon
GHSZ	Gas Hydrate Stability Zone
IODP	International Ocean Discovery Program
JGR	Journal of Geophysical Research
JIP	Joint Industry Project
LDEO	Lamont-Doherty Earth Observatory
LOD	Letter of Determination
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
NMR	Nuclear Magnetic Resonance
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
OCS	Outer Continental Shelf
OSTI	Office of Scientific and Technical Information
PCATS	Pressure Core Analysis and Transfer System
PCC	Pressure Core Center
PCTB	Pressure Core Tool with Ball Valve
PI	Principle Investigator
PM	Project Manager
PMP	Project Management Plan
PMRS	Pressure Maintenance and Relief System
QRPPR	Quarterly Research Performance and Progress Report
RBBC	Resedimented Boston Blue Clay
RPPR	Research Performance and Progress Report
RUE	Right-of-Use-and-Easement

SOPO	Statement of Project Objectives
UNH	University of New Hampshire
USCG	United States Coast Guard
USGS	United States Geological Survey
UT	University of Texas at Austin
UW	University of Washington
WR	Walker Ridge
XCT	X-ray Computed Tomography

National Energy Technology Laboratory

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

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

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

1450 Queen Avenue SW
Albany, OR 97321-2198

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

Visit the NETL website at:
www.netl.doe.gov

Customer Service Line:
1-800-553-7681

NATIONAL ENERGY TECHNOLOGY LABORATORY

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

APPENDIX A

UT-GOM2-2 Operations Plan

Rev. 2.2

UT-GOM2-2 OPERATIONS PLAN

Deepwater Methane Hydrate Characterization and Scientific Assessment

DOE Award No. DE-FE0023919

The University of Texas at Austin

U.S. Department of Energy

National Energy Technology Laboratory

Updated November 1, 2022

PREFACE

This document has been prepared by The University of Texas at Austin and the DE-FE0023919 project team. The purpose of this document is to define the technical and operational activities required to achieve the science goals of the UT-GOM2-2 Scientific Drilling Program. This document will be revised on an as-needed basis to update information, incorporate changes, and provide clarification on the UT-GOM2-2 Scientific Drilling Program prior to its execution.

Major revisions to the document will be tracked in the 'Record of Revisions' table provided below.

Record of Revisions

REV.	DATE	AUTHORS	DESCRIPTION
0.0	04/12/18	Flemings, Houghton, Thomas	Initial issuance following approval of CPP & scheduling of IODP Expedition 386.
1.0	10/01/19	Cook, Flemings, Houghton, Morrison, Phillips, Pettigrew, Polito, Portnov, Santra, Thomas	Major revisions throughout, including presumed use of drilling vessel other than *JR* and significantly revised field program focused on coring two existing LWD locations in Terrebonne Basin.
1.1	12/13/19	Cook, Flemings, Houghton, Morrison, Polito, Santra, Thomas	Minor edits throughout document based on technical input from Geotek and quality control review.
1.2	12/16/19	Santra, Houghton	Updated Mud Weight Plots on pages 31, 32.
1.3	12/20/19	Houghton	Minor edits and corrections throughout. Updated List of Acronyms.
1.4	7/3/20	Portnov, Santra, Cook, Thomas, Morrison	Hole locations edited to ~50 ft from original JIP location, tops tables and resulting text changes. Updated Coring Plan and container logistics.
2.0	12/11/20	Flemings, Morrison, Portnov, Santra, Pettigrew, Thomas, Cook, Houghton	Moderate revisions throughout to incorporate updates from Exploration Plan, Science and Sample Distribution Plan, and logistics planning. Figures and tables updated throughout with minor edits. Added discussion of H2S hazards.
2.1	10/11/21	Thomas, Houghton	Moderate revisions throughout to incorporate updates from the Science and Sample Distribution Plan Rev V2.to the schedule, coring program, and container logistics. Added Tufts under Project Organization
2.2	11/01/2022	Thomas, Portnov, Houghton	Moderate revisions throughout to incorporate updates moving the second well from G002 to H003.

Contents

Figures

Tables

Appendices

1 Executive Summary

The UT-GOM2-2 Scientific Drilling Program is part of the *Deepwater Methane Hydrate Characterization & Scientific Assessment Project* (DE-FE0023919), funded by the Department of Energy and advised by the United States Geological Survey (USGS) and the Bureau of Ocean Energy Management (BOEM). The objective of the 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 through the planning and execution of drilling, coring, logging, testing and analytical activities that assess marine methane hydrate deposits in the northern Gulf of Mexico.

This is the operational plan for the UT-GOM2-2 Scientific Drilling Program. The UT-GOM-2 expedition will be accomplished with a deepwater drilling/intervention vessel that is commercially contracted.

Two wells will be drilled in Walker Ridge Block 313 (WR313) in the northern Gulf of Mexico. The surface location of each well will be approximately 60 feet of a well previously drilled with logging while drilling (LWD) tools as part of the 2009 JIP II Methane Hydrates LWD program (Collett et al., 2009). Water depth at the well locations is 6,460 feet below sea level.

In the first well (H002), multiple pressure-cores will be obtained from hydrate-bearing targets (Red, Upper Blue, and/or Orange sands). The depth of the targets ranges from ~950 to 2,700 fbsf. In addition, conventional cores, intermittent spot pressure-cores, and temperature pressure measurements may be acquired throughout the borehole. Coring tools will be deployed through the drill string via slickline.

In the second well (H003), conventional cores, pressure cores, and temperature/ pressure measurements may also be obtained. The primary targets include mudline to ~385 fbsf and two hydrate-bearing sands (Red and Upper Blue sands). In addition, intermittent spot pressure-cores, temperature & pressure measurements, and conventional cores may be acquired. Coring tools will be deployed through the drill string via slickline.

The wells will be permanently abandoned at the conclusion of the program. There will be no pipelines or other facilities installed that would require decommissioning.

The Geotek pressure Core Analysis and Transfer System (PCATS) will be used onboard to perform characterization, cutting, and transfer of pressure cores. Sections of pressure cores will be selected for quantitative degassing and future analysis at UT and other institutions. Pressure cores will be demobilized via supply vessel. PCATS and quantitative degassing manifolds will be remobilized at the dock to complete the processing of any remaining pressure core not addressed onboard. All intact quantitatively degassed sections of core will be processed as conventional core as possible.

The Geotek MSCL-IR scanner will be used to scan conventional core as it reaches the rig floor. Pore water squeezing will be conducted on sections of conventional and depressurized core onboard to assess ephemeral properties. Pore water samples will also be preserved for additional analysis on shore. Conventional and depressurized whole round core samples will also be cut and preserved for moisture and density, geomechanical testing, other physical properties, headspace gas analysis, and microbiology. Dockside, whole round conventional and depressurized core will be scanned using the Geotek MSCL and CT imaging. After imaging, core will be split, photographed, and scanned using the Geotek, Geoscan camera, color spectrophotometry, magnetic susceptibility, and x-ray florescence scanner. A team of scientists will conduct conventional core analysis including smear slide preparation and microscopy, initial biostratigraphy, sediment weight and dry weights. Plugs of material will also be preserved for future analysis at various institutions.

The maximum scientific program will require approximately 8 weeks to complete (Table 1-1). Mobilization, requiring 3.8 days, involves transporting equipment and personnel to the drilling vessel and preparing for field science operations. The onboard drilling and science program will require a total of 27.5 days, followed by demobilization of personnel and equipment, requiring 3.2 days. A dockside core analysis program will then be initiated, requiring an estimated 14 days to complete. This is followed by approximately 3 days of final demobilization.

Table 1-1. UT-GOM2-2 Scientific Drilling Program Schedule.

No.	TASK	LOCATION	ESTIMATED DURATION (Days)	CUMULATIVE DURATION (Days)
1	Mobilization	Port of Embarkation	3.8	3.8
2	WR313 H002 Coring Program*	Walker Ridge 313	14.0	17.8
3	WR313 H003 Coring Program*	Walker Ridge 313	13.5	31.3
4	Stage 1 Demobilization	Walker Ridge 313	3.2	34.5
5	Dockside Core Processing	Port Fourchon, LA	14.0	48.5
6	Stage 2 Demobilization	Port Fourchon, LA	3.0	51.5
	* From _WR313-H002 MAXIMUM; includes pre-tour safety meeting and 20% non-productive time			

2 Science Objectives

The prioritized science objectives for the UT-GOM2-2 Scientific Drilling Program and the plans to meet them are as follows. For more information on the scientific rationale, please see the UT-GOM2-2 Prospectus: Science and Sample Distribution Plan.

2.1 Characterize the Orange sand and Upper Blue sand hydrate reservoirs and their bounding units.

We will meet Objective 1 by pressure coring through the Orange sand and bounding mud in the first hole, H002, and pressure coring a portion of the Blue sand in the second hole, H003. Pressure core analysis will be done on-board and at the dock. Conventional core analysis will be done on depressurized pressure cores. We will characterize the 1) hydrate concentration, dissolved methane concentration, and produced gas composition, 2) pore water dissolved solute concentration and composition, 3) lithofacies identification, grain size, and sorting, 3) permeability, 4) compressibility, 5) strength behavior, 6) sediment composition and age, 7) microbial communities and activity. We will illuminate the diffusion rate and direction of methane and other solutes diffusion by taking background cores 16.4, 49.2, and 148 ft (5, 15 and 45 m) above and 49.2 ft (15 m) below the orange sand.

2.2 High resolution geochemical and sedimentary profiles: understanding the hydrate system

A sedimentary profile with high resolution pore water, sedimentology, physical properties, microbiological, and mechanical properties sampling will be acquired. We will continuously core to 250 fbsf, spot conventional and pressure core to XCB refusal, and pressure core to total depth. We will derive the following:

1. Measure organic matter content and source indicators (total organic carbon, bulk organic $\delta^{13}C$, C/N ratios) with depth to constrain the amount of organic carbon available for microbial fermentation and methanogenesis, and determine if this organic carbon can drive sufficient in situ microbial methane production to form high saturation hydrate in the Orange sand and Upper Blue sand.
2. Observe abrupt transitions and general behavior of the pore water composition to infer fluid flow, hydrate formation/dissociation, and diagenesis.
3. Determine the age of the strata through nannofossil biostratigraphy in both holes.
4. Characterize the continuous record of lithologic properties including the reservoir seals.
5. Determine presence, numbers, and activities of key microbial communities responsible for methane generation and link these observations to pore-water, lithologic, and formation properties.

2.3 Measure the in-situ temperature and pressure profile

Formation temperature will be measured in two manners. We will measure pressure and temperature with a penetrometer. We will use the 'Temperature 2 Pressure' (T2P) probe. The tool is only compatible with PCTB-CS BHA. The PCTB-CS may be depth-limited and we have estimated the maximum depth to be approximately 1640 fbsf whereupon the lithology will be too indurated to recover good core using the PCTB-CS.

In addition, we will measure temperature while piston-coring using the IODP APC temperature sensor (APCT Tool Sheet (tamu.edu)). In this approach, two sensors embedded in the cutting shoe of the piston corer record the cutting shoe temperature while the piston-core is advanced, held in the formation for 10 minutes, and the inner core barrel is extracted. The in situ temperature is then inferred from the acquired temperature history. APCT temperature measurements will be made from the depth of our second APC core (31 feet) to the depth of our final APC core whereupon we will switch to XCB coring. This depth is currently estimated to be 258 fbsf (78.6 mbsf).

2.4 Characterize dissolved methane concentration and gas molecular composition with depth

We will meet Objective 3 by pressure coring over a range of depths in the muds surrounding the coarse-grained hydrate intervals to obtain a profile of dissolved methane and gas composition. The location of these pressure cores will be coordinated between the two holes. Initial dissolved methane concentrations from H002 will be used to predict concentrations in H003 and adjust coring points. Deeper pressure cores will focus on the interval between the Orange and Blue Sand to test the long-range transport model. The dissolved methane concentrations for WR313 H003, together with analyses from conventional coring, will focus on characterizing the microbial methane 'factory' and target an expected increase in dissolved methane from below the sulfate-methane transition (SMT) to the depth at which methane reaches maximum solubility. The depth of the SMT is commonly within the upper 20 m in methane-bearing continental margin sediments. The SMT at WR313 H003 is predicted to be at or shallower than 27 mbsf (98 fbsf) based on the shallowest depth of interpreted hydrate occurrence from LWD logs.

We will acquire a depth profile of dissolved gas concentration and the gas molecular/isotopic composition to characterize the gas source and the microbial methane production. Degassing experiments will be performed on longer intervals of high-quality core to be able to resolve changes in dissolved methane. Quantitative degassing of pressurized core sections will directly measure the volume of gas and methane produced, and will use this methane volume with core volume and porosity to calculate the dissolved methane concentration. The molecular (C1-C5) hydrocarbon composition of the hydrocarbons (C1-C5) of the produced gas will be measured. The isotopic composition of methane ($\delta^{13}C$ and δ^2H) and CO_2 ($\delta^{13}C$) will also be measured. We will also measure any atmospheric N_2 or O_2 contamination.

2.5 Reservoir characterization—other targets of interest

We will meet Objective 6 by pressure coring the Aqua and the Red sand Pressure core analysis will be done on-board and at the dock. Conventional core analysis will be done on depressurized pressure cores. We will characterize the 1) hydrate concentration, dissolved methane concentration, and produced gas composition, 2) pore water dissolved solute concentration and composition, 3) lithofacies identification, grain size, and sorting, 3) permeability, 4) compressibility, 5) strength behavior, 6) sediment composition and age, 7) microbial communities and activity.

3 Geologic Program

3.1 Introduction

The study area in Walker Ridge Block 313 (WR313) is located near the southern boundary of Terrebonne Basin (Figure 3-1). The Terrebonne Basin is an intraslope salt withdrawal minibasin in the Walker Ridge protraction area (Figure 3-1, Figure 3-2). The Terrebonne Basin is a salt-floored, salt-bounded, minibasin (Frye et al., 2012), with water depths ranging between 6000 ft and 6800 ft. The local seafloor topographic gradient at the proposed well sites vary between 2° and 3°.

One exploration well, WR313 001, was drilled in the 'Orion south' prospect in 2001 by Devon Energy (Figure 3-1). The WR313 G001, and WR313 H001 wells (Figure 3-1, Table 3-1, Table 3-2) were drilled during the 2009 Gas Hydrates Joint Industry Project Leg II (JIP II) LWD program (Boswell et al., 2012a; Boswell et al., 2012b; Shedd et al., 2010). Two major gas hydrate-bearing units, the Blue and Orange sands (Figure 3-4), were encountered during the 2009 JIP II drilling.

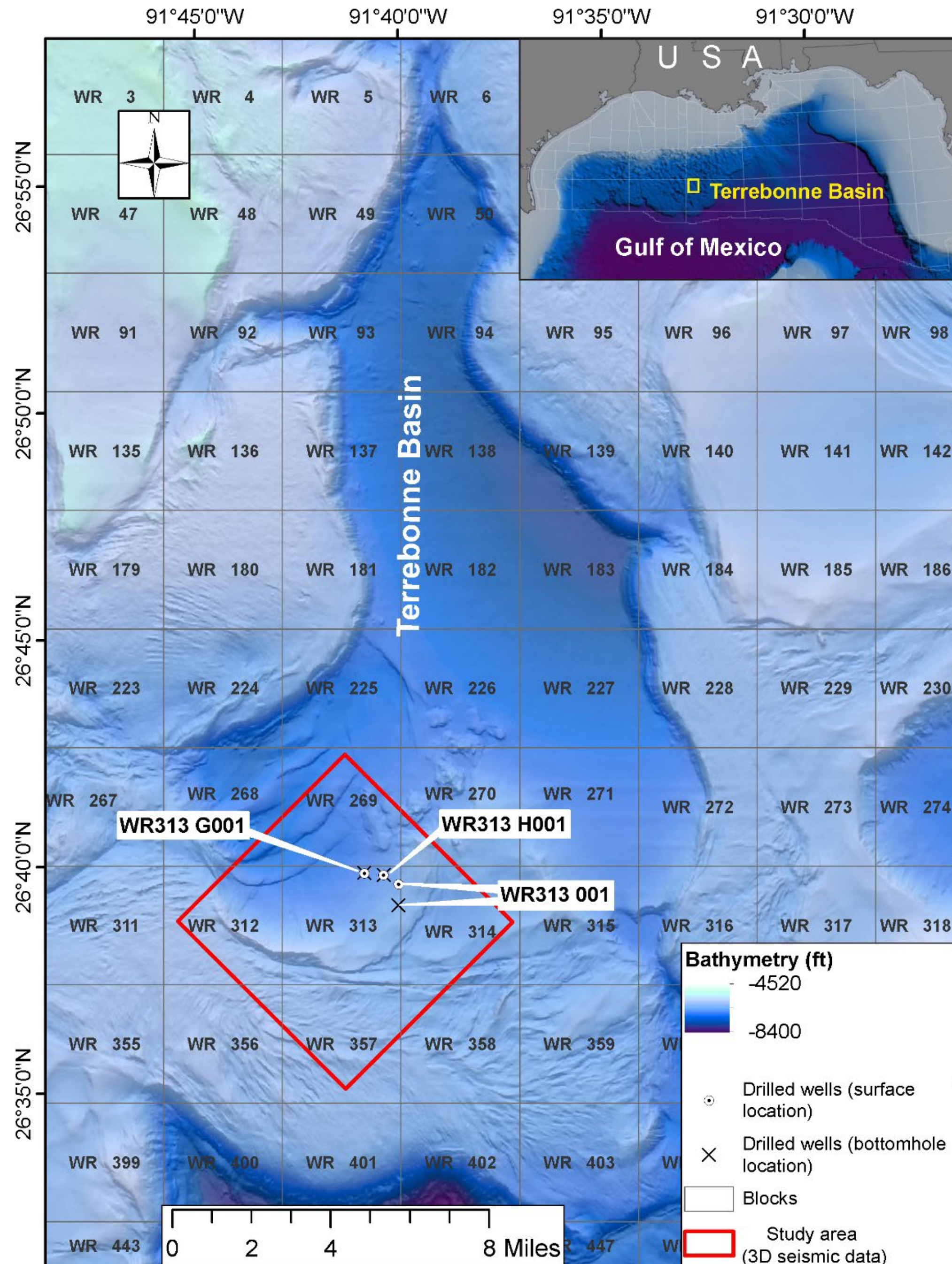


Figure 3-1. Shaded relief map of sea floor in the northwestern part of Walker Ridge Protraction Area showing Terrebonne Basin and existing wells in Walker Ridge Block 313 (WR313). Inset map shows the position of Terrebonne Basin in northern Gulf of Mexico. Bathymetry data are from BOEM Northern Gulf of Mexico Deepwater Bathymetry Grid from 3D Seismic (Kramer and Shedd, 2017).

Table 3-1. Existing wells - Locations in Walker Ridge Block 313.

Well Name	API Well Number	Surface Lat. (NAD27)	Surface Long. (NAD27)	X (NAD 27 UTM 15N US ft)	Y (NAD 27 UTM 15N US ft)	Bottom Lat. (NAD27)	Bottom Long. (NAD27)	X (NAD 27 UTM 15N US ft)	Y (NAD 27 UTM 15N US ft)
WR313 001	608124000700	26.659120	-91.669906	2074707	9675848	26.651294	-91.670086	2074674	9673003
WR313 G001	608124003900	26.663190	-91.683872	2070127	9677280	26.663308	-91.683837	2070138	9677323
WR313 H001	608124004000	26.662458	-91.676041	2072687	9677040	26.662498	-91.675882	2072739	9677055

Table 3-2. Existing wells – Well information.

Well Name	API Well Number	Total MD, RKB (ft)	Total TVD, RKB (ft)	Air Gap (ft)	Water Depth (ft)
WR313 001	608124000700	16,720	16,072	72	6,216
WR313 G001	608124003900	10,200	10,199	52	6,562
WR313 H001	608124004000	9,888	9,887	51	6,462

3.2 Proposed Well Locations

We will drill one to two locations in Walker Ridge Block 313: WR313 H002 and WR313 H003. WR313 H002 and WR313 H003 will be located approximately 60 ft from the existing well WR313 H001 and approximately 60 ft from each other.

Table 3-3. Planned well locations and depths. Geographic coordinates, projected coordinates, water depth, and planned total depth below seafloor are listed.

Proposed Locations	Latitude NAD27	Longitude NAD27	X NAD27 UTM15N	Y NAD27 UTM15N	X WGS84 UTM15N	Y WGS84 UTM15N	Water depth	Total depth below seafloor
	degree (N)	degree (W)	(ft)	(ft)	(m)	(m)	(ft)	(ft)
WR313 H002	26.662375	91.676210	2072632.0	9677009.4	631730.5	2949756.6	6460	3010
WR313 H003	26.662566	91.67619	2072637.9	9677078.7	631732.8	2949777.0	6460	2450

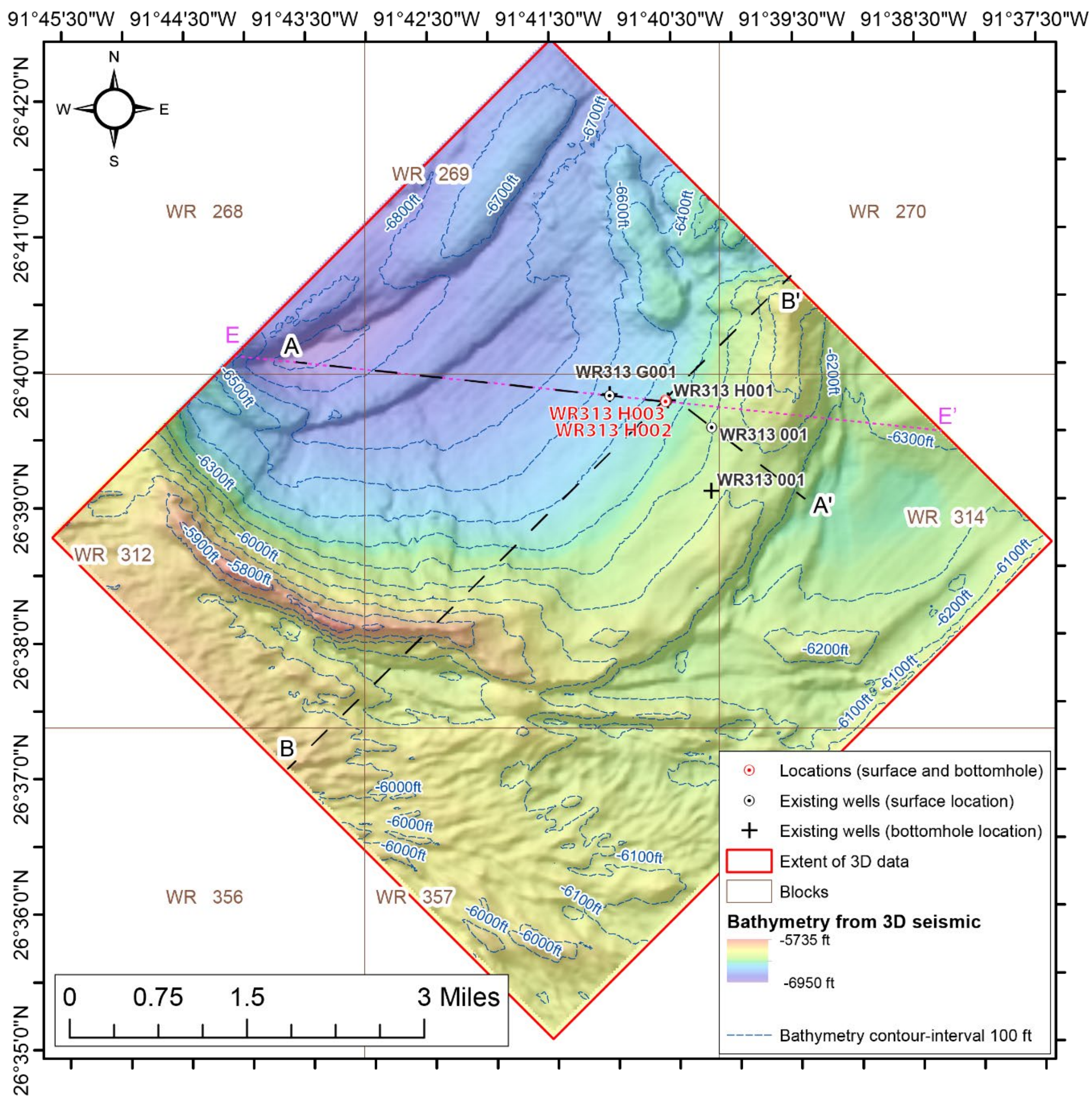


Figure 3-2. Bathymetry map of the study area based on 3D seismic data in southern Terrebonne Basin. The map shows existing wells and proposed locations in Walker Ridge Block 313 (WR313). 3D seismic data were used with permission of WesternGeco.

3.3 Top Hole Stratigraphy

The shallow sedimentary succession at WR313 consists of hemipelagic sediments, turbidites from channel-levee systems, and mass transport deposits. A discontinuous BSR is imaged in seismic data (Figure 3-4). This is interpreted as the base of gas hydrate stability zone.

Intervals with low gamma ray values that are interpreted as coarse-grained were found in both wells WR313 H001 and WR313 G001 at multiple levels, often with high gas hydrate saturations (S_h>70%) (Boswell et al., 2012a; Boswell et al., 2012b; Collett et al., 2009; Collett et al., 2010; Frye et al., 2012). In our interpretation (Figure 3-3, Table 3-4), we assume coarse-grained sediments are defined by low gamma-ray (API < 65), which distinguish them from higher gamma ray mud-rich sediments. Hydrate-bearing coarse-grained sediments have high resistivity and velocity coupled with low gamma ray (API < 65); because both the resistivity and velocity have corresponding increases (without increase in density) these intervals are most likely pore-filling hydrate (Table 3-4). Similarly, some thin mud intervals also have corresponding moderate increases in resistivity and velocity which we also interpret as pore-filling (Table 3-4). Water bearing sands have low resistivity (often lower than background), enlarged borehole size and low gamma ray (API < 65) (Table 3-4). Fracture-filling gas hydrates have also been observed at Terrebonne (Cook et al., 2014). These intervals are primarily marine mud and have increases in resistivity, fractures visible on resistivity image logs, and propagation resistivity curve separation (Cook et al., 2010). One notable hydrate-filled fracture interval is called the JIP unit, a several hundred meter thick mud unit that appears in both holes (Cook et al., 2014) (Figure 3-8 & Figure 3-9).

Table 3-4. Interpretation of sediment type, pore constituents, and fractures based on well log response.

Sediment Type	Approximate Gamma Ray (API)	Interpretation	Well Log Response
coarse-grained sediment (sand and coarse silt sized grains)	<65	pore-filling hydrate	corresponding moderate to high increase in resistivity and velocity above background, possible slight drop in density, caliper near bit size
		gas-bearing	increase in resistivity or background resistivity with a drop-in velocity, caliper measuring borehole enlargement
		water-bearing	resistivity and velocity at or slightly below background, drop in density, caliper measuring borehole enlargement
marine mud sediment (silt and clay sized grains)	>65	pore-filling hydrate	corresponding moderate increase in resistivity and velocity above background, possible slight drop in density, caliper near bit size
		fracture-filling hydrate	increase in resistivity, fractures visible on borehole images, propagation resistivity curve separation, little to no increase in velocity above background, caliper near bit size
		water-bearing	resistivity and velocity at background, caliper near bit size

The two major coarse-grained intervals encountered in WR313 H001 well, the Upper Blue sand and the Orange sand, are associated with two prominent seismic reflectors called the Blue Horizon and the Orange Horizon (Boswell et al., 2012a; Boswell et al., 2012b; Frye et al., 2012) (Figure 3-4, Figure 3-5). The hydrate-bearing Upper Blue sand in WR313 H001 is just above the interpreted Blue Horizon. The WR313 G001 well encountered hydrate-bearing coarse-grained sediments both above and below the Blue Horizon, the Upper Blue sand and Lower Blue sand, respectively. The Orange sand was intersected in both WR313 G001 and WR313 H001 wells. The WR313 H001 intersected a relatively thick coarse-grained package with high gas hydrate saturation at this level. However, the WR313 G001 encountered a thin, water-bearing, muddy/coarse package below the BSR at the Orange Horizon. An additional thin coarse-grained interval, the Kiwi sand (Hillman et al., 2017), was encountered in well WR313 G001 at the base of gas hydrate stability zone and contains both gas hydrate and a low saturation of gas (Figure 3-4).

The stratigraphic nomenclature used in this document is different from published studies in this area such as Boswell et al. (2012a), Boswell et al. (2012a), or Hillman et al. (2017). Each mapped stratigraphic surface was assigned a numerical designation; for example, the Orange Horizon is Horizon 0300 (Hrz 0300; see Figure 3-4 for the names and positions of stratigraphic surfaces). In addition to the stratigraphic surfaces, a surface was also generated connecting the discontinuous but locally strong BSR, which is interpreted to record the base of the gas hydrate stability zone (BHSZ) (Figure 3-4). The Orange Horizon/Hrz 0300, and Blue Horizon/Hrz 0400 are prominent reflectors in 3D seismic data and display a distinct phase reversal when they intersect the BSR. This phenomenon, which is a result of transition between gas hydrate (above) and free gas (below) within the pore spaces, guided our mapping strategy. Each of these three stratigraphic surfaces was traced as a seismic peak above the BSR, and following the phase reversal, traced as a seismic trough below the BSR (see Boswell et al. (2012b) for an explanation of mapping strategy).

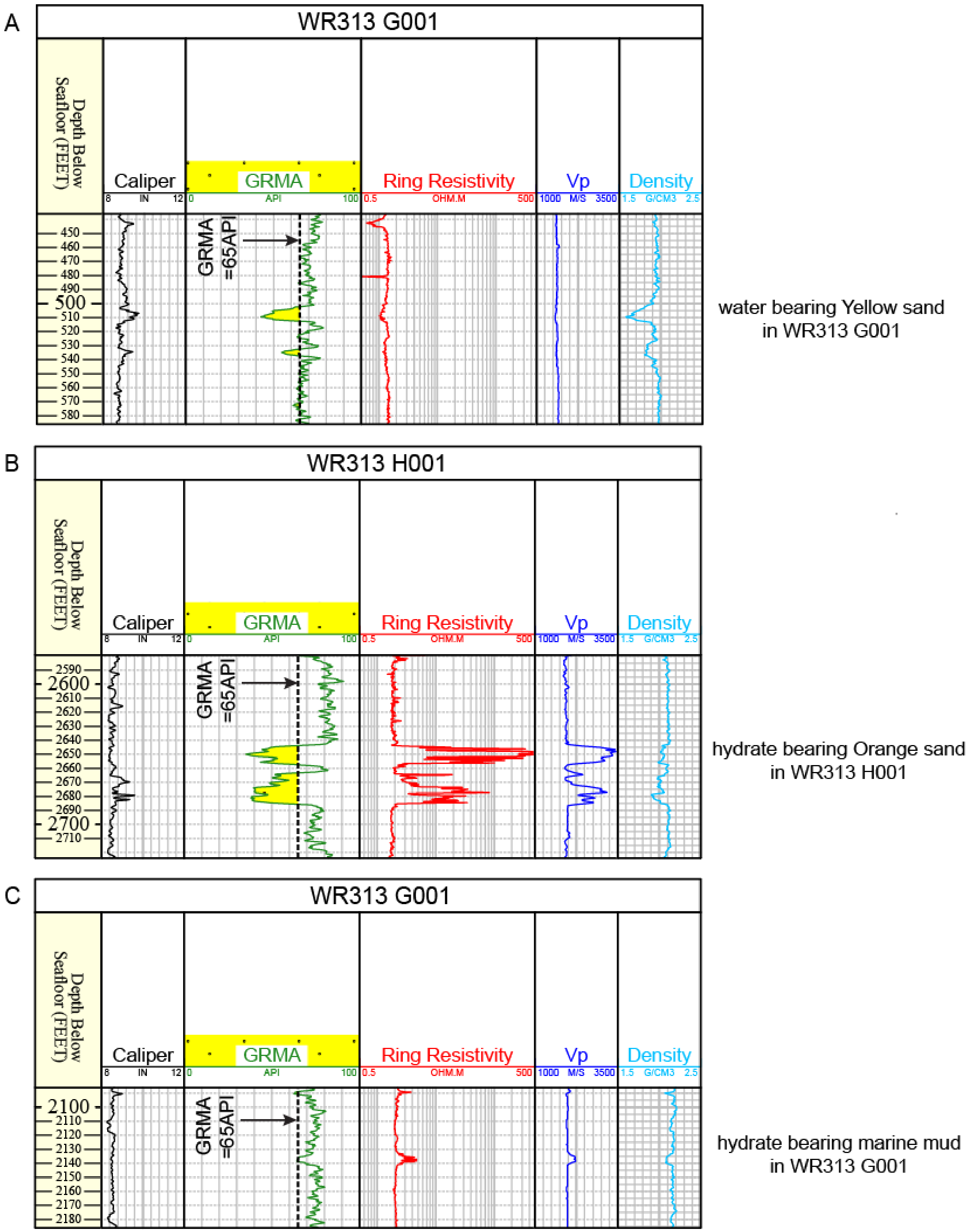


Figure 3-3. Identification of coarse-grained intervals (hydrate bearing or water bearing) and interpreted hydrate bearing marine mud from LWD data. A) Example of interpreted coarse-grained intervals with water showing low gamma ray (GRMA <65) values and low resistivity (lower than background); B) example of a hydrate bearing coarse-grained interval with low gamma ray

(GRMA<65), high resistivity, high p-wave velocity, and low density; C) example of an interpreted hydrate bearing marine mud interval with moderately low gamma ray values, moderately high resistivity, and moderately high p-wave velocity.

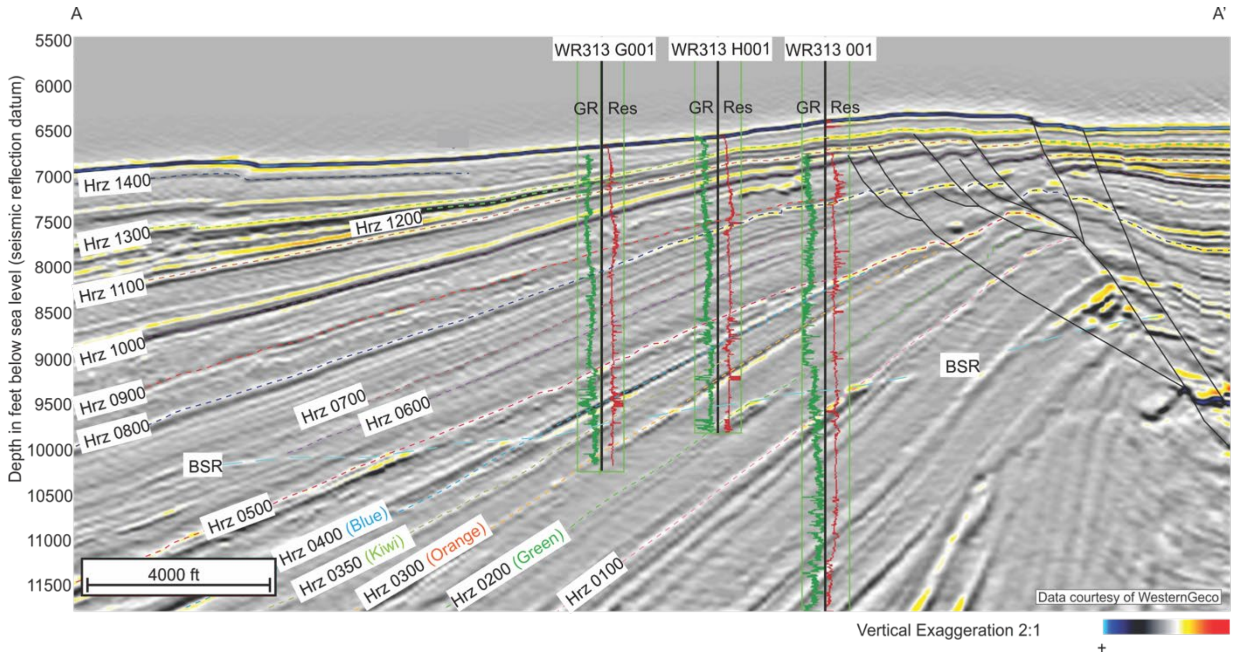


Figure 3-4. Seismic section AA' through existing wells in block WR313 (location in Figure 3-2), showing all interpreted stratigraphic horizons, BSR, and gamma ray (GR) and resistivity (Res) logs at existing wells. Stratigraphic nomenclature used for some previous studies in the area for relevant reservoir intervals (Boswell et al., 2012b; Frye et al., 2012; Hillman et al., 2017) are presented for comparison with nomenclature used in this study. Seismic data courtesy of WesternGeco.

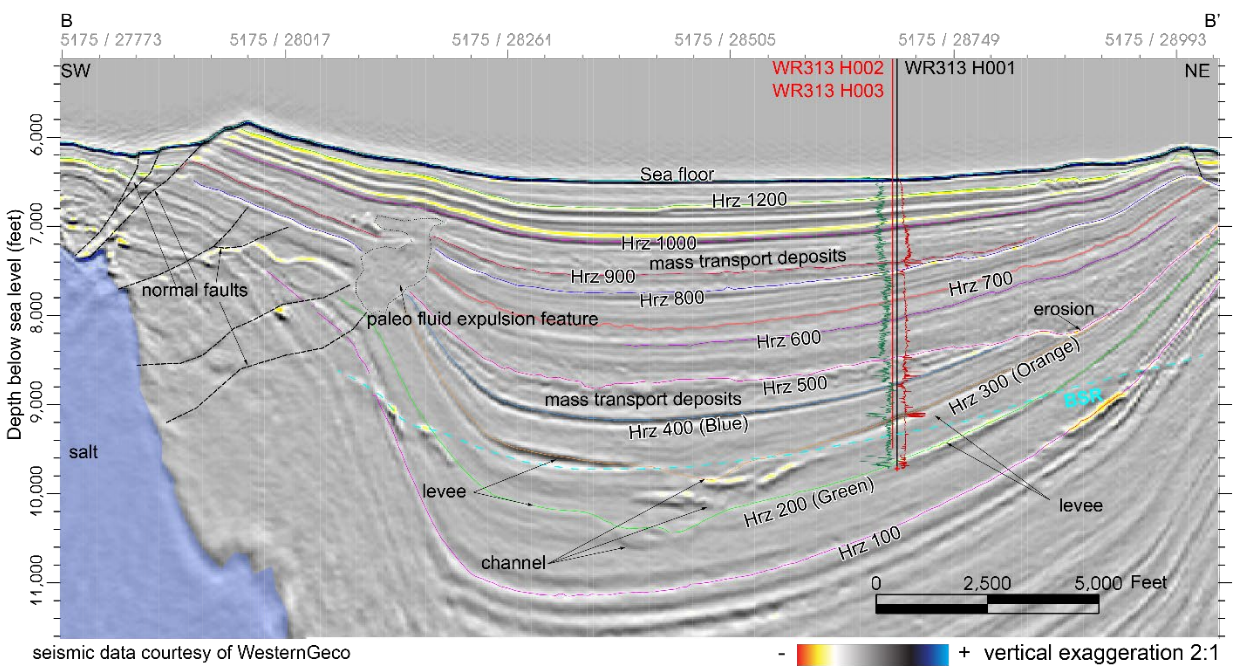


Figure 3-5. SW-NE oriented seismic section BB' (location in Figure 3-2) through well WR313 H001 showing major stratigraphic features in the study area. Resistivity (RES) and gamma ray (GR) logs are shown at WR313 H001 well. High resistivity indicates presence of gas hydrate. Seismic data courtesy of WesternGeco.

Five major lithostratigraphic units are identified based on seismic reflection character and log response from existing wells WR313 H001 and WR313 G001.

Unit 1 extends from seafloor to the depth of 773 fbsf in WR313 G001 and to 520 fbsf in WR313 H001. In the seismic data Unit 1 is imaged as sub-parallel reflections (Figure 3-4). In log character, it has a high gamma ray response indicating marine mud, with few relatively thin low-gamma-ray intervals. The base of Unit 1 is defined by Horizon 1000. Unit 1 is interpreted as fine-grained hemipelagic interval, with thin, coarse-grained layers, identified as the Aqua and Yellow sands (Table 3-5 & Table 3-6). In WR313 G001, part of this unit contains very low-concentration gas hydrate in near-vertical fractures, called the Mendenhall unit.

Unit 2 extends from the base of Unit 1 (marked by Horizon 1000) to 1316 fbsf at WR313 G001 and 1038 fbsf at WR313 H001; on the well logs, gas hydrate was identified in this interval in near-vertical fractures. The gamma ray in Unit 2 are slightly lower than overlying section. Based on discontinuous and chaotic seismic reflections of variable amplitude (Figure 3-4 & Figure 3-5), we interpret this section as mass transport deposits (MTD) possibly with a higher amount of silty material compared to hemipelagic deposits described in Unit 1.

Unit 3 underlies Unit 2 (base marked by Horizon 0800) and extends down to 2,412 fbsf at WR313 G001 and 2,000 fbsf at WR313 H001. In seismic data, Unit 3 is characterized by continuous parallel reflections of moderate amplitude (Figure 3-4 & Figure 3-5), while in the wells WR313 G001 and WR313 H001, the corresponding section shows high gamma ray that changes to slightly lower gamma ray in the lower part of Unit 3. The lower boundary of this unit is a prominent seismic reflector identified as Horizon 500. Unit 3 is interpreted as a hemipelagic mud-dominated section.

Unit 4 underlies Unit 3 and extends from Hrz 500 down beneath the Upper Blue sand interval to 2,796 fbsf at WR313 G001 and 2,285 fbsf at WR313 H001. Horizon 500 is a strong seismic reflector, which has the characteristics of an erosion surface (Figure 3-4 & Figure 3-5) and is associated with abrupt increase in gamma ray in both wells. The seismic reflection data within the lower-most section of Unit 4 (below Horizon 500) is characterized by discontinuous reflections with variable amplitude. This section has been interpreted as mass transport deposits (MTD), which may be silt-rich mud as indicated by moderately low gamma ray. Very thin low gamma-ray and low resistivity streaks within this zone indicate presence of thin water-bearing coarse-grained intervals. The hydrate-bearing Upper Blue sand interval (2180-2256 fbsf in WR313 H001, 2706-2779 fbsf in WR313 G001) is near the base of this interval. The Upper Blue sand is a prominent hydrate bearing interval in both WR313 H001 and WR313 G001.

Unit 5, which underlies Unit 4, includes three major coarse-grained intervals associated with Hrz 0400 (Lower Blue sand), Hrz 0300 (Orange sand), and Hrz 0200 (Green sand); as indicated by low gamma ray values recorded in wells WR313 G001 and WR313 H001. These three coarse-grained intervals are separated by intervals of marine mud with higher gamma ray values. High resistivity, high P-wave velocity (V_P) and low density in the Blue and Orange sand indicate the presence of pore-filling, high saturation gas hydrate (Table 3-4).

In both WR313 G001 and WR313 H001, the top of Unit 5 is at the prominent reflector marked as Horizon 0400 (2,796 fbsf in WR313 G001; 2,285 fbsf in WR313 H001). The Lower Blue sand interval (just below Horizon 0400) is present in WR313 G001 well but absent or of poor quality in WR313 H001 well. Frye et al. (2012) interpreted that the Blue sand represented mud-rich intra-slope ponded submarine fan complex, with both sand sheets and leveed channels. Seismic amplitude distribution at Horizon 0400 (Blue Horizon) suggests channel and sheet-like coarse-grained deposits (Figure 3-6). The Blue sand is followed by a predominantly high gamma-ray (interpreted as mud) interval in both wells, which extends down to the top of the next major coarse-grained interval that starts just above Horizon 0300 (3370 and 2642 fbsf in WR313 G001 and WR313 H001 respectively).

In WR313 G001 a thin low gamma-ray interval can be identified at 3042-3063 fbsf, which contains both gas hydrate and low saturation gas (Hillman et al., 2017). This thin sand interval coincides with a discontinuous but locally prominent reflector, mapped as Horizon 0350 in this study and previously described as the Kiwi sand (Hillman et al., 2017).

The low gamma ray interval associated with Horizon 0300 (Orange sand) is gas hydrate bearing with high gas hydrate saturation in WR313 H001 but water-bearing and mud rich in WR313 G001 (alternatively, the Orange sand is completely missing in WR313 G001). The Orange sand as encountered in wells WR313 H001, was interpreted as coarse-grained levee deposits associated with a submarine channel (Frye et al., 2012). A NNE-SSW oriented channel, and coarse-grained levee deposits on its both flanks can be identified on an amplitude map at Horizon 0300 (Figure 3-7).

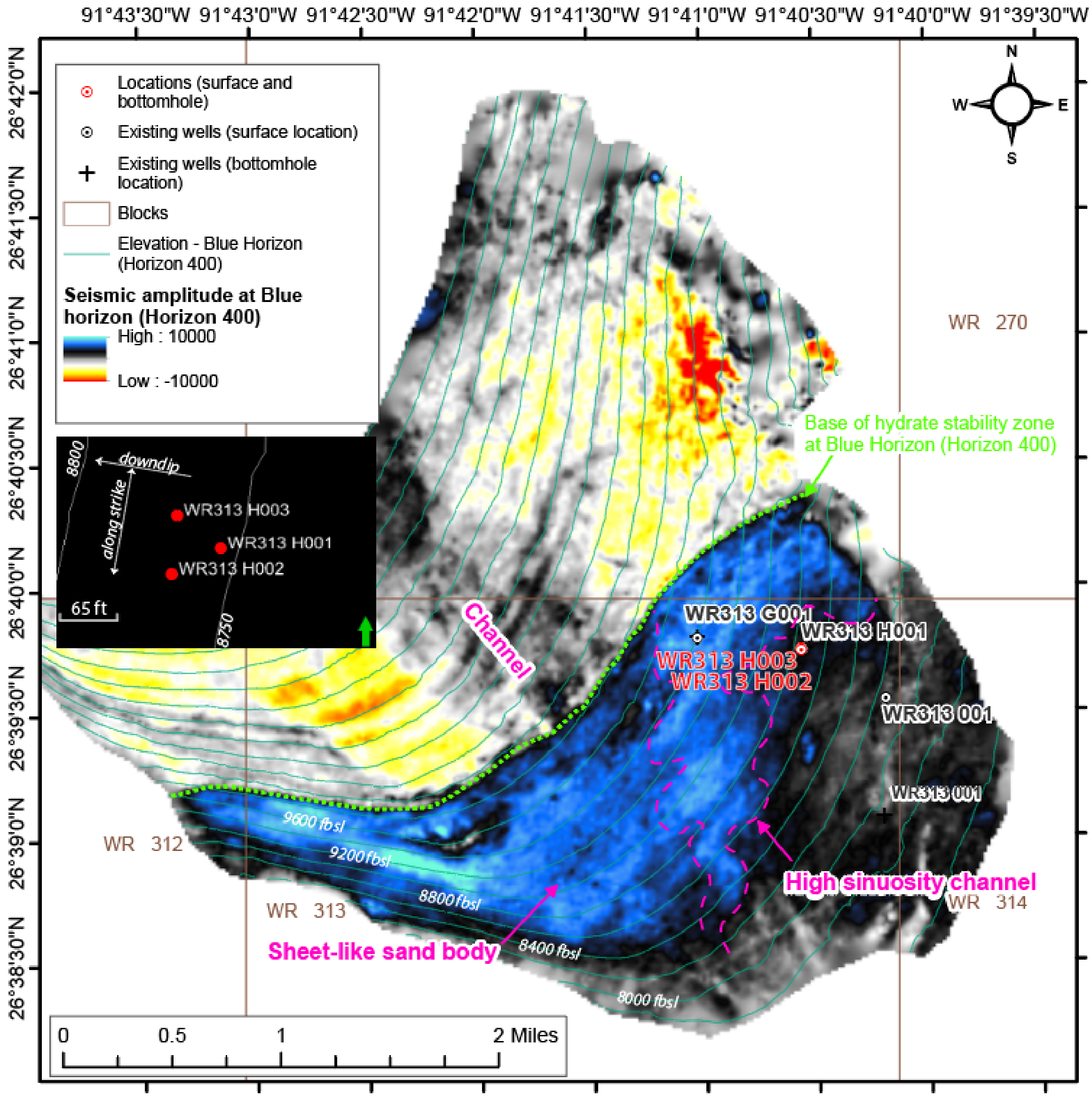


Figure 3-6. Instantaneous amplitude map extracted at Horizon 0400 (Blue Horizon) showing geological interpretation for the Blue sand – the upper of the two hydrate bearing target intervals. Maps generated from 3D seismic data used with permission of WesternGeco.

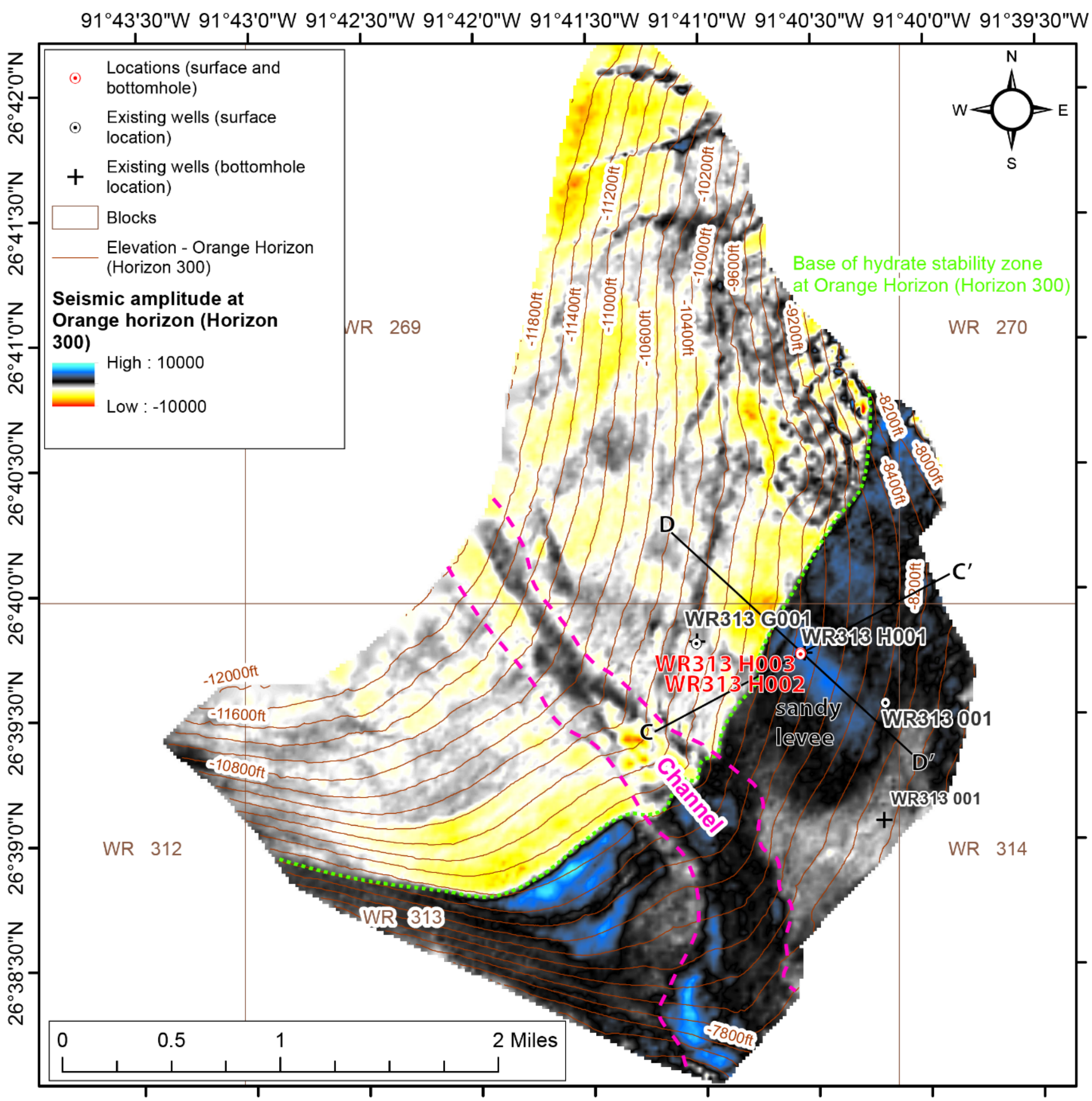


Figure 3-7. Instantaneous amplitude map extracted at Horizon 0300 (Orange Horizon) showing geological interpretation for the Orange sand – the lower of the two hydrate bearing target intervals. The well WR313 H001 and the proposed locations WR313 H002 and WR313 H003 target gas hydrate-bearing sandy levee deposits showing strong positive amplitude response (blue color). Maps generated from 3D seismic data used with permission of WesternGeco.

3.4 Top Hole Prognosis

3.4.1 Identification and projection of tops from existing well data

Major boundaries were identified in WR313 H001, including tops and bases of coarse-grained units and hydrate-bearing marine mud units. These were tied to the seismic data to identify corresponding seismic reflections. The seismic reflections were then projected to the proposed locations. The WR313 H002 and WR313 H003 wells are located ~60 feet from the original location WR313 H001. We estimated the tops depth at the new wells by examining the difference in seismic depths between the existent well location and the projected location. We identified the depth of the events in the new wells by adding or subtracting the difference in seismic depth to the tops mapped in the known well (Table 3-5 and Table 3-6). The proposed wells are planned generally downdip from WR313 H001 and along strike relatively to each other (see Figure 3-6 inset), which means the tops depths in the proposed wells are identical.

3.4.2 WR313 H002 and WR313 H003

WR313 H002 is located ~62 ft to the SW from the well WR313 H001, and WR313 H003 is located ~62 ft to the NW from the well WR3113 H001 (Table 3-3 and Figure 3-2, Figure 3-6 inset). WR313 H001 was drilled previously without incident (Collett et al., 2009). Top-hole prognoses for WR313 H002 and WR313 H003 are identical and are shown in Figure 3-8, Figure 3-9 and Table 3-5, Table 3-6. The seafloor at WR313 H002 and WR313 H002 is projected to be at 6460 feet below sea level (fbsl). We infer we will encounter similar lithology and horizon depths as at the WR313 H001 well.

Unit 1 (0-524.4 fbsf) is composed of mud interlayered with thin coarse-grained layers. Within this mud interval, there are two intervals containing coarse-grained sediments, identified as the Aqua sand (203.0-265.5 fbsf, with a total of 12 ft of sand) and the Yellow sand (336.4-347.4 fbsf, with a total of 9.5 ft of sand) (Table 3-5). Both coarse-grained layers likely water-saturated however, the Aqua sand might contain a low concentration of gas hydrate in a ~1.5 ft thick interval. These intervals correlate with seismic reflections that are continuous between wells; the Aqua Sand has positive polarity and the Yellow sand has negative polarity. In the WR313 H001 well, Unit 1 was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore were reported.

Unit 2 (524.4-1041.2 fbsf) is composed of mud with hydrate in near-vertical fractures and is called the JIP mud unit. The interval is interpreted as a mass transport deposit and is more compacted or de-watered than the overlying mud. The Red sand, an 8 ft thick coarse-grained layer is present in this interval at 957.8-965.8 fbsf (Table 3-5) and has hydrate at high saturation. The Red sand does not connect between the drilled wells WR313 H001 and WR313 G001. The Red sand is associated with a mappable seismic reflection (Horizon 0800), however, reflection characteristics are laterally variable. In the WR313 H001 well, this unit was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore were reported.

Unit 3 (1041.2 -2000 fbsf) is predominantly mud with one interval containing water-bearing thin coarse-grained layers (1098.6-1101.6 fbsf) and two thin marine muds containing pore-filling hydrate (1717.6-1723.6 fbsf and 1838-1852 fbsf) (Table 3-5).

Unit 4 (2000-2292.1fbsf) is a muddy mass transport deposit, with two coarser intervals. The upper interval is a thinly-bedded hydrate-bearing coarse-grained interval (2015.3-2041.3 fbsf, total thickness of coarse-grained sediments is 12 ft). The lower interval is part of our key reservoirs for coring: the hydrate-bearing, thinly bedded Upper Blue sand interval (2187-2263 fbsf, total thickness of coarse-grained layers is 13 feet).

Unit 5 (beginning at 2292.1) is predominantly mud but contains one hydrate bearing thin pore-filling mud interval (2586.3-2588.3 fbsf) and the Orange sand (2649.9-2693.9, total thickness of coarse-grained sediments is 39 ft), which is a thick hydrate-bearing reservoir and the primary coring target in WR313 H002. The BHSZ is likely to be encountered at WR313 H002 and WR313 H003 at approximately 2900 fbsf, however, there is no indication of this event on the well logs or seismic at the proposed locations.

The total depth of WR313 H002 and WR313 H003 wells will be 3010 fbsf and it will lie within Unit 5. Based on interpolation of the BSR from nearby locations, the base of the hydrate stability zone is interpreted to be at 2900 fbsf. Thus, the well will cross the base of the hydrate stability zone. However, Unit 5 is composed of marine muds and no hydrate or free gas is expected in this interval as was demonstrated by the adjacent WR313 H001 well.

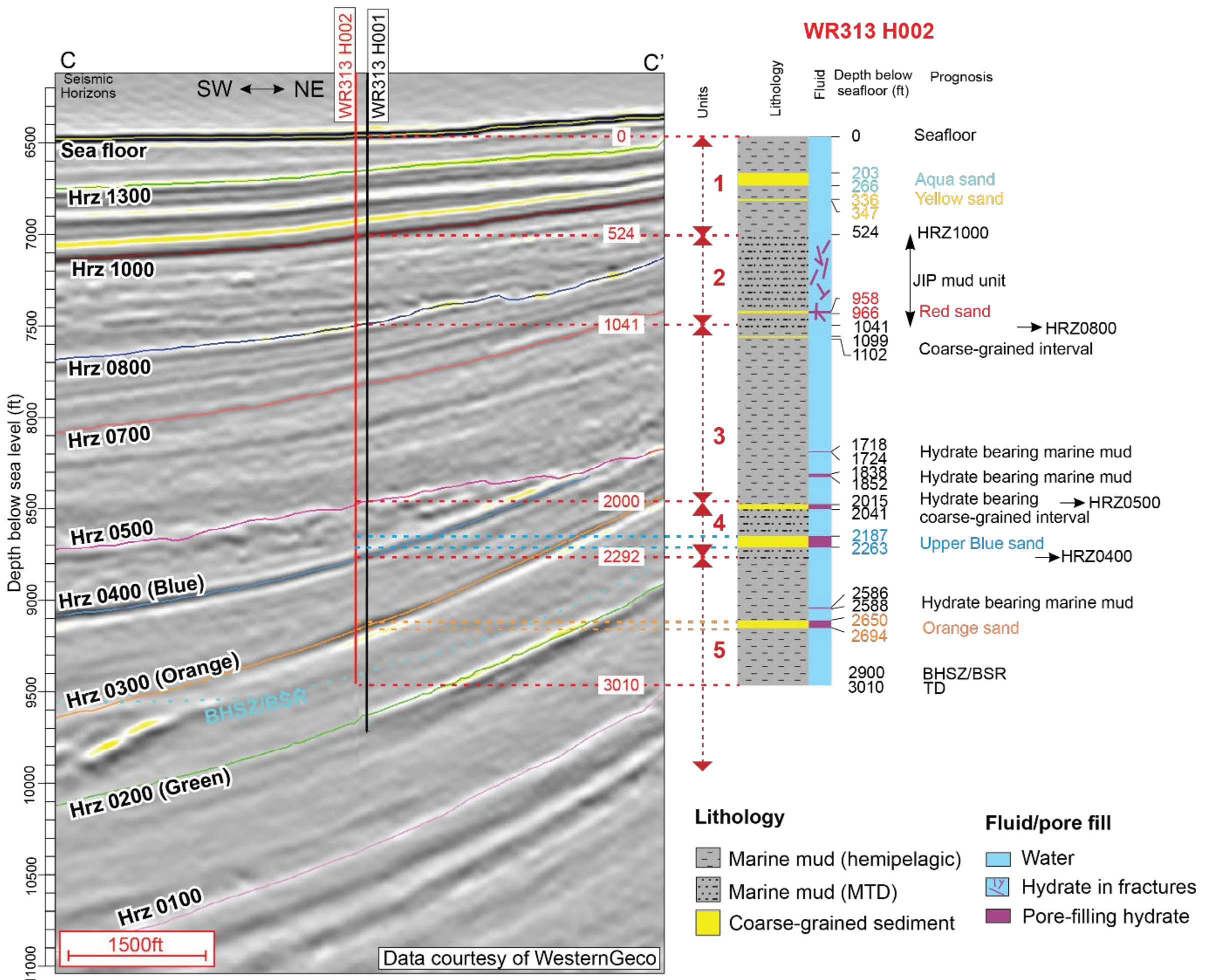


Figure 3-8. Seismic cross section CC' through Location WR313 H002 with interpreted lithology , hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked next to lithology column in red; The line of section is located in Figure 3-7.

Table 3-5. Projected tops for the proposed location WR313 H002 (Table 3-3).

			Water depth (ft)	Drilled Footage (fbsf)	Total depth (fbsl)
WR313 H002			6,460.0	3,010.0	9,470.0
Events, Sands & Units			**WR313 H001**	**WR313 H002**	
			Depth (fbsf)	Projected Depth (fbsf)	Projected Depth (fbsl)
Seafloor			-	-	6,460.0
water bearing **Aqua sand**	Top	**Unit 1**	201.5	203.0	6,663.0
	Base		264.0	265.5	6,725.5
water bearing **Yellow sand**	Top		333.0	336.4	6,796.4
	Base		344.0	347.4	6,807.4
Horizon 1000			520.0	524.4	6,984.4
JIP mud unit with low concentration hydrate	Top	**Unit 2**	520.0	524.4	6,984.4
hydrate bearing **Red sand**	Top		958.0	957.8	7,417.8
	Base		966.0	965.8	7,425.8
JIP mud unit with low concentration hydrate	Base		1,038.0	1,041.2	7,501.2
Horizon 0800			1,038.0	1,041.2	7,501.2
water bearing coarse-grained interval	Top	**Unit 3**	1,096.0	1,098.6	7,558.6
	Base		1,100.0	1,101.6	7,561.6
hydrate bearing marine mud	Top		1,716.0	1,717.6	8,177.6
	Base		1,722.0	1,723.6	8,183.6
hydrate bearing marine mud	Top		1,832.0	1,838.0	8,298.0
	Base		1,846.0	1,852.0	8,312.0
Horizon 0500			2,000.0	2,000.0	8,460.0
hydrate bearing coarse-grained interval	Top	**Unit 4**	2,017.0	2,015.3	8,475.3
	Base		2,042.0	2,041.3	8,501.3
hydrate bearing **Upper Blue sand**	Top		2,180.0	2,187.0	8,647.0
	Base		2,256.0	2,263.0	8,723.0
Horizon 400			2,285.0	2,292.1	8,752.1
hydrate bearing marine mud	Top	**Unit 5**	2,578.0	2,586.3	9,046.3
	Base		2,580.0	2,588.3	9,048.3
hydrate bearing **Orange sand**	Top		2,642.0	2,649.9	9,109.9
	Base		2,686.0	2,693.9	9,153.9
Interpreted base of hydrate stability			2,935.0	2,935.0	9,395.0
WR313 H002 TD				3,010.0	9,470.0

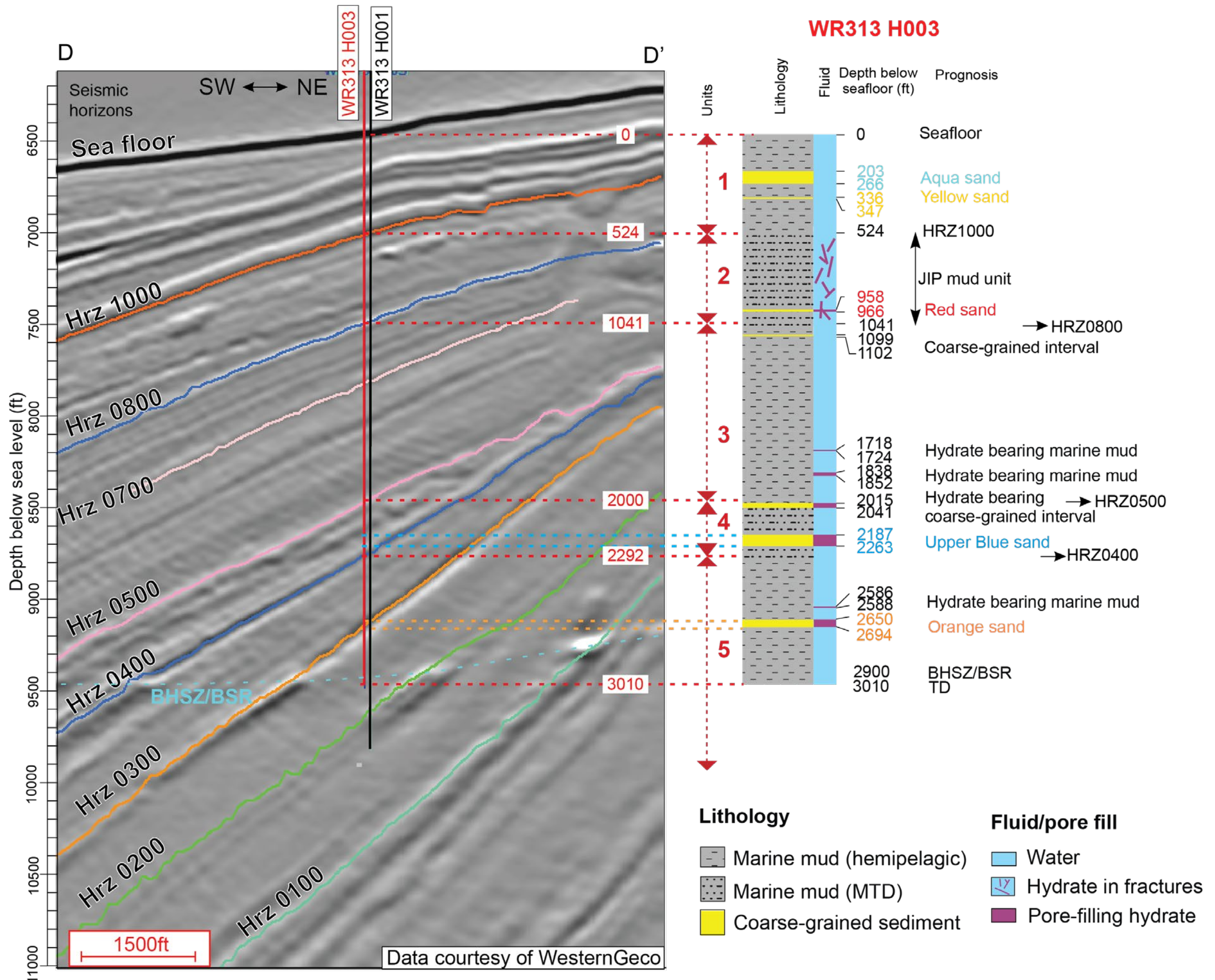


Figure 3-9. Seismic cross section DD' through Location WR313 H003 with interpreted lithology , hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked on lithology column in red; the line of section is located in Figure 3-7.

Table 3-6. Projected tops for the proposed location WR313 H003 (Table 3-3).

			Water depth (ft)	Drilled Footage (fbsf)	Total depth (fbsl)
WR313 H003			6,460.0	2,450	8,910
Events, Sands & Units			**WR313 H001**	**WR313 H003**	
			Depth (fbsf)	Projected Depth (fbsf)	Projected Depth (fbsl)
Seafloor			-	-	6,460.0
water bearing **Aqua sand**	Top	Unit 1	201.5	203.0	6,663.0
water bearing **Aqua sand**	Base	Unit 1	264.0	265.5	6,725.5
water bearing **Yellow sand**	Top	Unit 1	333.0	336.4	6,796.4
water bearing **Yellow sand**	Base	Unit 1	344.0	347.4	6,807.4
Horizon 1000			520.0	524.4	6,984.4
JIP mud unit with low concentration hydrate	Top	Unit 2	520.0	524.4	6,984.4
hydrate bearing **Red sand**	Top	Unit 2	958.0	957.8	7,417.8
hydrate bearing **Red sand**	Base	Unit 2	966.0	965.8	7,425.8
JIP mud unit with low concentration hydrate	Base	Unit 2	1,038.0	1,041.2	7,501.2
Horizon 0800			1,038.0	1,041.2	7,501.2
water bearing coarse-grained interval	Top	Unit 3	1,096.0	1,098.6	7,558.6
water bearing coarse-grained interval	Base	Unit 3	1,100.0	1,101.6	7,561.6
hydrate bearing marine mud	Top	Unit 3	1,716.0	1,717.6	8,177.6
hydrate bearing marine mud	Base	Unit 3	1,722.0	1,723.6	8,183.6
hydrate bearing marine mud	Top	Unit 3	1,832.0	1,838.0	8,298.0
hydrate bearing marine mud	Base	Unit 3	1,846.0	1,852.0	8,312.0
Horizon 0500			2,000.0	2,000.0	8,460.0
hydrate bearing coarse-grained interval	Top	Unit 4	2,017.0	2,015.3	8,475.3
hydrate bearing coarse-grained interval	Base	Unit 4	2,042.0	2,041.3	8,501.3
hydrate bearing **Upper Blue sand**	Top	Unit 4	2,180.0	2,187.0	8,647.0
hydrate bearing **Upper Blue sand**	Base	Unit 4	2,256.0	2,263.0	8,723.0
Horizon 400			2,285.0	2,292.1	8,752.1
WR313 H003 TD				2,450.0	8,910.0

3.5 Borehole Temperature and Hydrate Stability Field

In-situ temperatures and the methane hydrate stability-boundary have been estimated for the proposed WR313 locations (Figure 3-10). The in-situ temperatures were estimated based on the following assumptions: 1) the base of the hydrate stability zone at three-phase equilibrium 2) seawater salinity of 35 ppt, 3) pore pressure gradient of 0.465 psi/ft, 4) seafloor temperature of 4.0 °C or 39.2 °F (Boyer et al., 2018), and 5) temperature increasing linearly with depth from the seafloor. The base of the hydrate stability zone at the well locations was estimated using the BSR identified and mapped in 3D seismic data, and tied-to the depth of the Kiwi sand in existing well WR313 G001 (Table 3-6).

The predicted in situ temperature at WR313 G001 and WR313 H001 wells are shown as blue dashed line and green dashed line respectively (Figure 3-10). At the WR313 G001 well, we estimate the temperature at the base of the hydrate stability zone to be 72.1°F (22.3°C) and the gradient to be 10.7° F/1000 ft (5.9°C/1000 ft). At the WR313 H001 well, we estimate the temperature at the base of the hydrate stability zone to be 71.7°F (22.0 °C) and the gradient to be 11.0°F/1000 ft (6.1°C/1000 ft). The recorded temperature at WR313 G001 and WR313 H001 wells (blue and green lines respectively in Figure 3-10) show that flushing of the cooler drilling fluid brings down the borehole temperature considerably below the in-situ temperature, making the borehole more stable for hydrates.

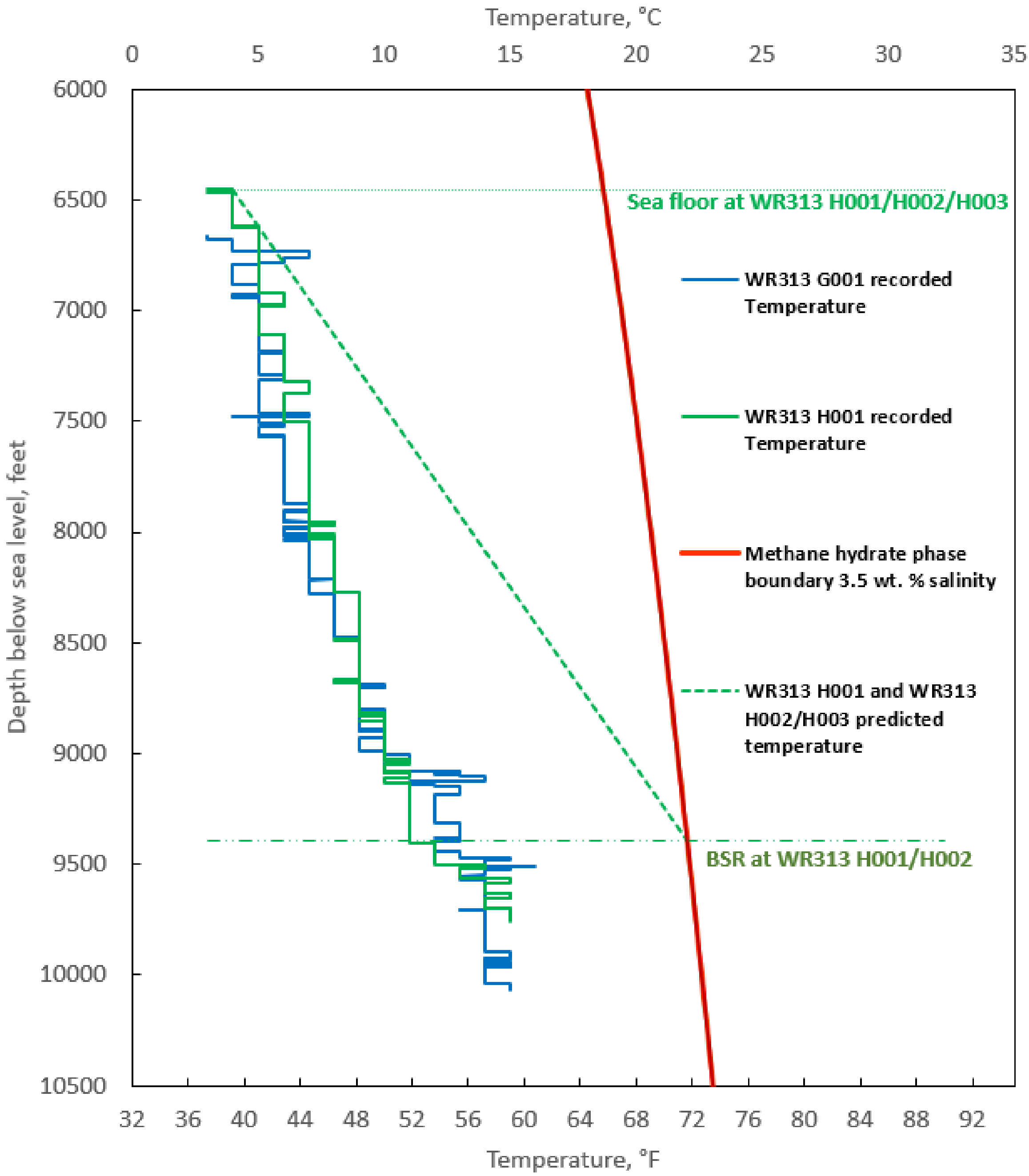


Figure 3-10. Estimated thermal gradient for WR313 G001 (blue dashed line) and WR313 H001 (green dashed line), in comparison with recorded borehole temperature (solid blue and green lines). Methane hydrate is stable on the left side of the hydrate stability phase boundary plotted in red. Horizontal lines represent interpreted base of hydrate stability zone in the wells, which intersect the corresponding predicted in situ temperature profiles at the hydrate stability phase boundary.

3.6 Pore Pressure Plots

3.6.1 Methodology

Based on seismic interpretation and offset well information from WR313 H001, the formations penetrated at the proposed locations are expected to be normally pressured. Figure 3-11 illustrates the well paths for the planned WR313 H002 and H003 wells. This diagram emphasizes the location of the wells relative to significant hydrate reservoirs (the Blue, Orange, and Green sand). Although the Green sand is interpreted to be a significant hydrate-bearing reservoir, we will not be able to penetrate it in the hydrate-bearing section based on our decision to locate our wells at the previously drilled WR313 H001 (Figure 3-11). Within these reservoirs, we interpreted a gas leg to be present down dip from the hydrate-bearing zones (red zones, Figure 3-11). No gas leg is interpreted to be present in the Purple sand, and we have not included it in the diagram. The wells, which were all drilled in these locations previously without incident, are designed to avoid encountering free gas beneath the hydrate stability zone by penetrating the sands in the hydrate bearing intervals (green zones, Figure 3-11). Where we will penetrate the Blue and the Orange sand (Figure 3-11), we are at least 1,000 feet laterally away from the gas leg.

We generated pore pressure and fracture gradient plots for WR313 H002 (Figure 3-12) and WR313 H003 (Figure 3-13). The plots are based on the following assumptions. 1) The overburden stress (σ_v) was generated by integrating the density log from the LWD data acquired in WR313 H001. In zones where there were washouts and the density values recorded values near the density of water, density values were interpolated from the overlying and underlying zones to more effectively determine the overburden. 2) Pore water pressure was assumed to be hydrostatic (u_h) because there was no evidence of any elevated pore pressures during previous drilling of these wells. Hydrostatic pore pressure (u_h) is expressed with a pore pressure gradient of 8.95 ppg, or seawater gradient of 0.465 psi/ft. 3) The least principle stress (σ_{hmin}) was estimated using Equation 3-1.

Equation 3-1

$$\sigma_{hmin} = K * (\sigma_v - u_h) + u_h$$

Equation 3-1 is commonly used to model the fracture gradient (Eaton, 1969). K is termed the effective stress ratio and is equal to the ratio of the horizontal effective stress to the vertical effective stress. It is commonly used to model least principal stress in sedimentary basins. It is commonly observed in deepwater wells that in the shallow section (e.g. 1,000 feet below mud line), K values can approach 1.0. An upper bound of K = 0.9 and a lower bound of K = 0.7 is assumed (green dashed line and orange dashed line in Figure 3-12 and Figure 3-13).

The WR313 H002 well penetrates both the Orange and Blue sands in the hydrate-bearing interval (Figure 3-11). The WR313 H001 well at this location was drilled without incident with 10.5 PPG mud. We will drill with 10.5 PPG mud below 1600' ("mud program" in Figure 3-12). There is a gas leg in the Orange and Blue sands that is offset from the drilling location (e.g., Figure 3-11). Direct experience (two wells were drilled in this area) and observations of very low permeability in hydrate bearing intervals support that we will not observe these gas pressures at the location where the wells penetrate the hydrate-bearing interval.

The WR313 H003 well penetrates only the Blue sands in the hydrate-bearing interval. We illustrate a pore pressure plot of this well in Figure 3-13. The WR313 H001 well at this location was drilled without incident with 10.5 PPG mud. We will drill with 10.5 PPG mud below 1600' ('mud program', Figure 3-13).

There is a gas leg in the Orange and Blue sands that is offset from the drilling location (e.g., Figure 3-11). Direct experience (two wells were drilled in this area) and observations of very low permeability in hydrate bearing intervals support that we will not observe these gas pressures at the location where the wells penetrate the hydrate-bearing interval.

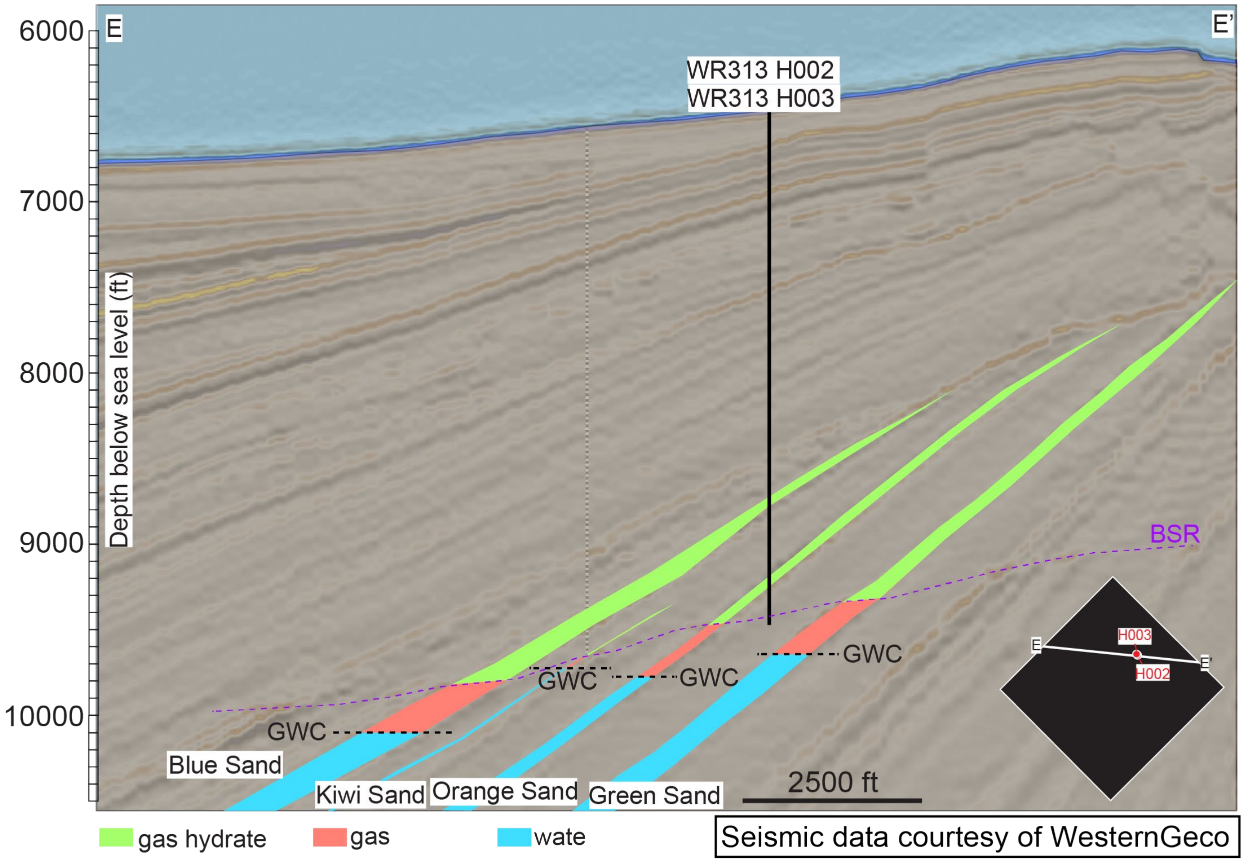


Figure 3-11. Seismic section EE' through proposed wells, showing hydrate-bearing sands, hydrate-gas contacts, and gas-water contacts.

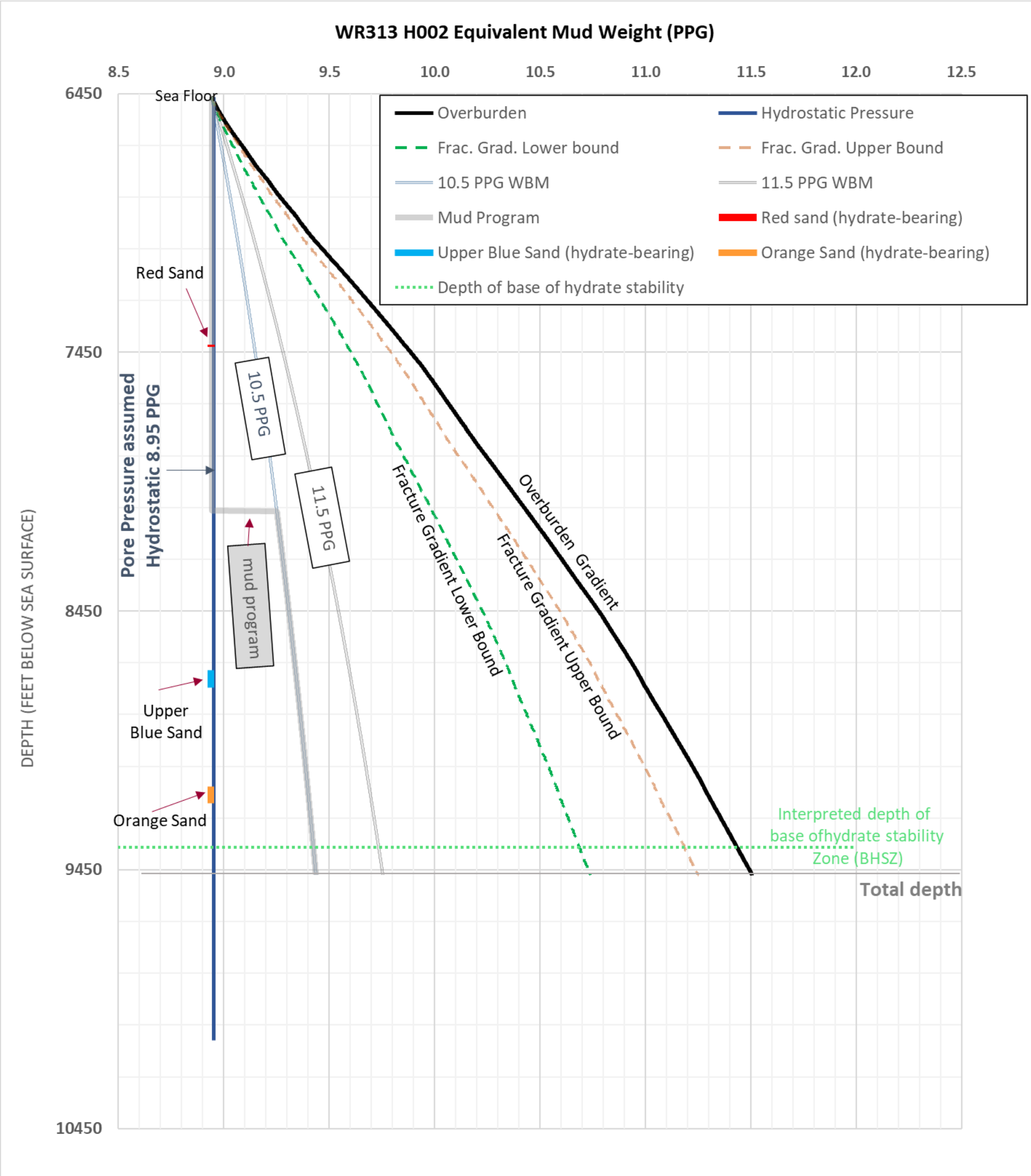


Figure 3-12. Equivalent mud weight plot for the planned WR313 H002.

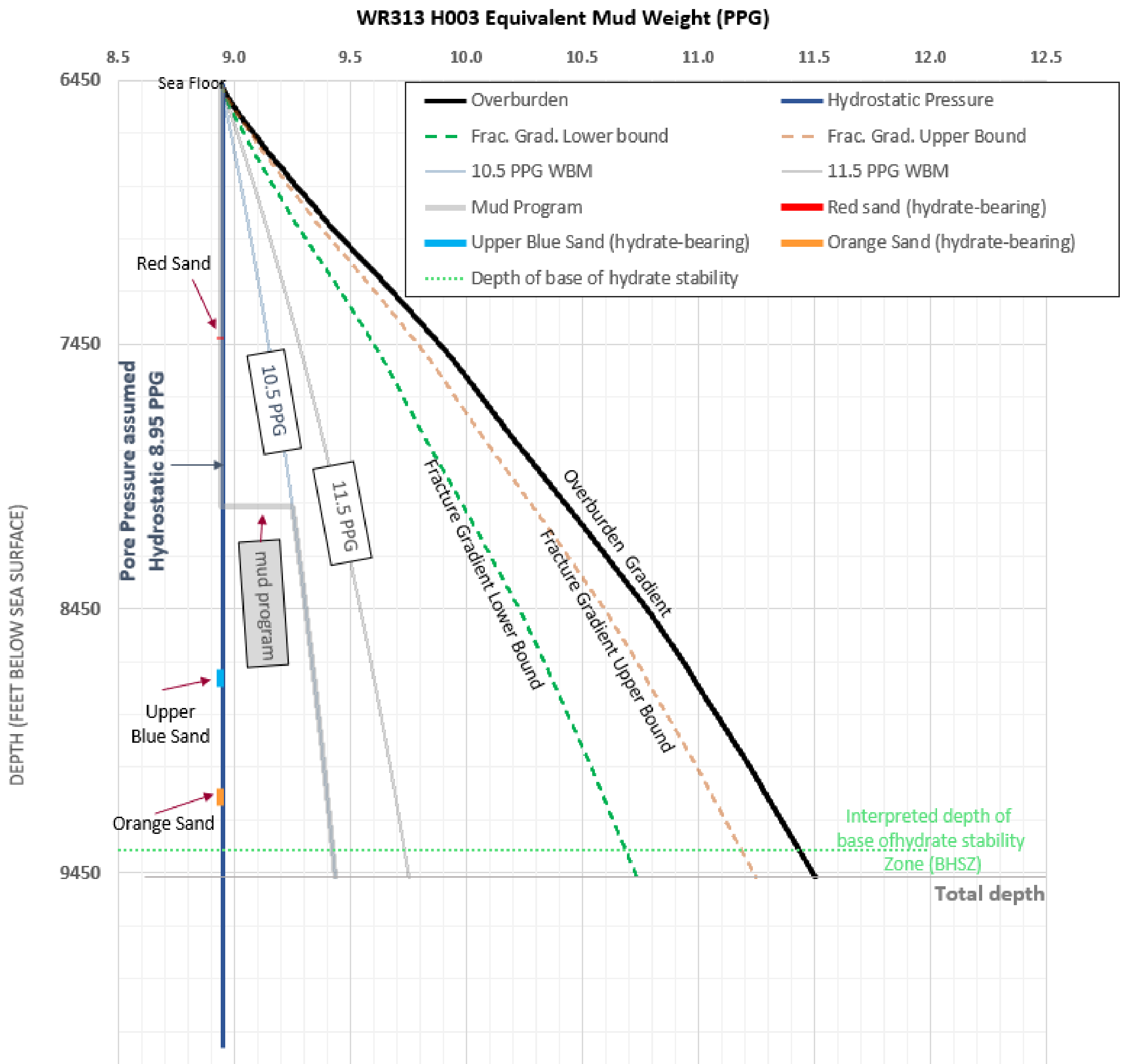


Figure 3-13. Equivalent mud weight plot for planned WR313 H003

3.6.2 Previous drilling

From the Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Logging-While-Drilling Operations and Challenges (Collett et al., 2009) and the IADC Drilling Reports for WR313 H well:

WR313 H001 was drilled during Gulf of Mexico JIP Leg II from Q4000 (April 29-May 1, 2009) using LWD technology. The seafloor was tagged at 6,501 ft md RKB (includes 52 ft air gap). A dual diameter BHA, with a 6-3/4" drill bit followed by an 8-1/2" hole opener, was used to drill from mudline to total depth at 9,886 ft md RKB (3,385 fbsf). The well spud protocol, developed to maintain good borehole conditions at the top of the hole, was followed: The first ~60 ft of the hole was drilled while circulating between 200-250 gpm of seawater and a rate of rotation of about 10-50 rpm. From 6,561 to 6,671 ft md RKB (60 - 170 fbsf), the pump rate was slowly increased to ~250 gpm and the bit-rotation was increased to 50 rpm; after which point the drilling parameters were increased to 350 gpm and ~70 to 110 rpm. At 6,841 md RKB (340 fbsf), the pump rate was increased to 385 gpm to facilitate MWD directional surveys. From 6,501-8,501 ft md RKB (0-2,000 fbsf), the hole was drilled using seawater with WBM sweeps pumped very few stands. Fracture filling gas hydrate was encountered at 7,050-7,400 ft md RKB (549-899 fbsf). At 8,501 ft md RKB (2,000 fbsf), the instantaneous ROP was decreased to ~160 ft/hr in preparation for drilling the target zone of interest and the drilling fluid was changed to 10.5 ppg WBM. The controlled ROP of ~160 ft/hr and use of 10.5 ppg WBM continued for the remainder of the well. The primary target, consisting of two hydrate-bearing sand lobes (~15 ft and ~21 ft gross thickness), was encountered at ~9,096 ft md RKB (2,595 fbsf). After reaching the total depth of 9,886 ft md RKB (3,385 fbsf), the hole was circulated with 10.5 ppg drilling fluid, followed by displacement to 12 ppg WBM for abandonment.

Additional information on the drilling history can be found in the Gas Hydrate Joint Industry Project Leg II operational summary (Collett et al., 2009).

4 Drilling Program

The UT-GOM2-2 Scientific Drilling Program calls for penetrating several potential hydrate bearing sands throughout the boreholes. Cores, both unpressurized conventional and pressurized, will be acquired at various depths throughout the boreholes. Based on drilling results from the 2009 JIP II Methane Hydrate LWD program, anticipated typical drilling/coring operations are as follows.

1. Drill/core to the top of the uppermost hydrate bearing zone with the potential to flow, or a maximum depth of 8103 fbsl (1640 fbsf), while circulating sea water and pumping 10.5 ppg high viscosity mud sweeps as required for hole cleaning.
2. Prior to penetrating the uppermost hydrate zone with the potential to flow, or a maximum depth of 8103 fbsl (1640 fbsf), begin continuous circulation of 10.5 ppg water-based mud for better hole cleaning, increased hole stability, and to counterbalance any overpressure from gas or water that may be present, and pumping 10.5 ppg high viscosity mud sweeps as required for hole cleaning.
3. At total depth (TD), displace borehole to 11.5 ppg high viscosity pad mud to support the cement plug from TD to approximately 150 feet above the upper most hydrate bearing zone with the potential to flow.
4. Emplace a cement plug beginning approximately 150 feet above the uppermost hydrate bearing zone with the potential to flow and extending upward for 500 feet.
5. Displace borehole with 11.0 ppg mud from top of cement plug to seafloor.
6. All boreholes will be visually observed via ROV continuously from spud to abandonment with an electronic video made and archived.
7. H_2S precautions will be taken when retrieving cores above sulfate-methane transition (SMT) (0 to approximately 65 fbsf) and within the SMT zone in WR313 H003, as H_2S may be entrained in the cores.
8. Neither well will have circulation back to surface while drilling/coring through the shallow interval above the SMT. Walker Ridge 313 has been classified as H_2S absent per email from Thomas Bjerstedt, Minerals Management Service (MMS), dated 4/3/2008.

4.1 Coring Bits

Two types of 9-7/8 in (250.8 mm) diameter Polycrystalline Diamond Compact (PDC) coring bits will be used. The first type is referred to as a face bit. The face bit has an opening through the bit face equal to the core diameter. The face bit not only drills the borehole but also trims the core prior to it entering the core barrel (Figure 4-1). The second type is referred to as a cutting shoe bit. The cutting shoe bit has a hole through the bit face large enough to allow the core barrel to extend through the bit face (Figure 4-1). The cutting shoe bit drills the borehole while a cutting shoe attached to the bottom of the core barrel trims the core prior to it entering the core barrel.

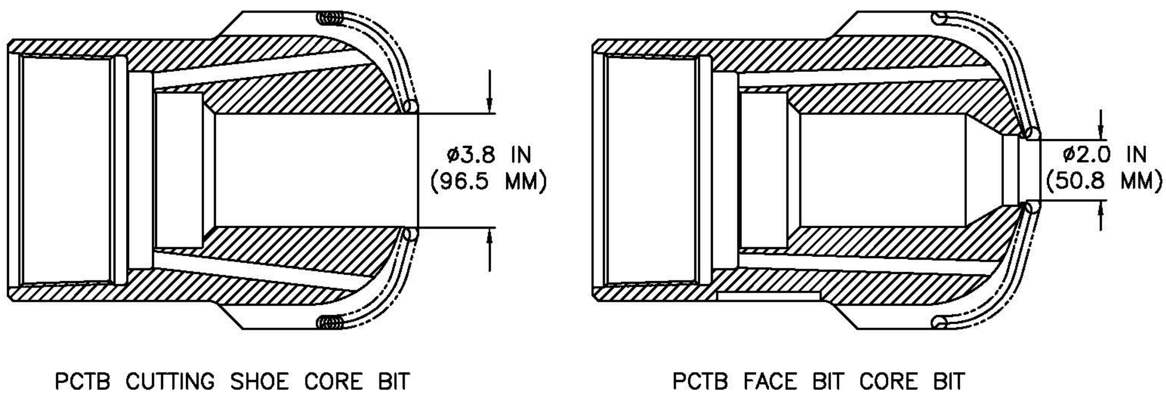


Figure 4-1. PCTB Coring Bit Configurations (Flemings et al., 2018)

4.2 Center Bit

For drilling ahead in either coring bit configuration, a center bit is deployed via slickline which fills the hole through the coring bit face. The bottom end of the center bit incorporates PDC cutters so as to extend the coring bit cutting structure across the entire bit face.

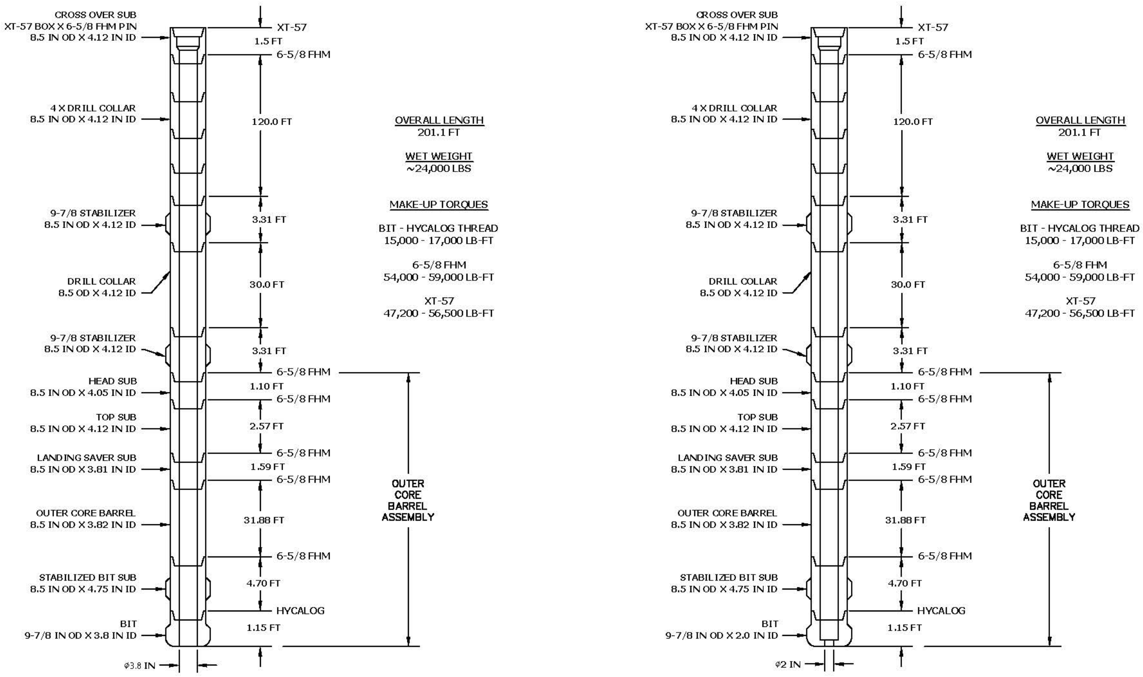
4.3 Drill String

A cleaned, rattled, and rabbited (gauge-checked) drill string with a minimum 4-1/8 inch (104.8 mm) internal diameter is required to pass the coring tools which are deployed via slickline through the drill string. A 5-7/8 in, 28.3 ppf (adjusted weight), S-135 drill string with XT-57 connections (minimum drift diameter of 4.125 inches) will be used.

4.4 Bottom Hole Assembly

Two different bottom hole assemblies (BHA) referred to as the face bit BHA and cutting shoe BHA will be employed (Figure 4-2). As with the drill string, the BHA must have a minimum 4-1/8 inch (104.8 mm) internal diameter to pass the coring tools. The BHA provides weight and stiffness for drilling as well as a means for landing and latching the coring tools. The BHA is composed of custom 8-1/2 inch (215.9 mm) outside diameter by 4-1/8 inch (104.8 mm) inside diameter by 30 feet (9.1 m) long drill collars. Various subs for landing and latching the coring tools and attaching the coring bits are also included in the BHA. The face bit BHA and cutting shoe BHA are identical except for the type of coring bit attached. Both

BHAs will have flapper valves installed to prevent back flow into the drill string when a coring tool or center bit is not in place.



PCTB CUTTING SHOE CONFIGURATION BHA SCHEMATIC

PCTB FACE BIT CONFIGURATION BHA SCHEMATIC

Figure 4-2. Drilling/Coring Bottom Hole Assemblies Configurations (Flemings et al., 2018).

4.5 Coring Tools

Several different types of coring tools will be employed as identified below. All of the coring tools are deployed via slickline and the compatibility of all tools with the PCTB-FB and PCTB-CS BHA’s is outlined in Table 4-1.

Table 4-1. BHA to tool compatibility chart.

Coring Tools Compatibility Chart

Tool	Geotek PCTB-CS BHA	Geotek PCTB-FB BHA	IODP (USIO) APC/XCB BHA	IODP (USIO) RCB BHA	IODP (Japan) APC/XCB BHA	IODP (Japan) RCB BHA	Notes
APC (IODP USIO)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
XCB (IODP USIO)	No	No	Yes	No	No	No	Requires conversion to bottom drive to be compatible with PCTB-CS and IODP (Japan) APC/XCB BHA.
RCB (IODP USIO)	No	No	No	Yes	No	No	Requires conversion to bottom drive to be compatible with PCTB-FB and IODP (Japan) RCB BHA.
APC (IODP Japan)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
XCB (IODP Japan)	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
RCB (IODP Japan)	No	Yes	No	No	No	Yes	Geotek space out confirmation required.
GAPC (Geotek)	Yes	No	Yes	No	Yes	No	Geotek space out confirmation required.
GXCB (Geotek)	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
GRCB (Geotek)	No	No	No	No	No	Yes	May be compatible with PCTB-FB BHA in future.
PCTB-FB	No	Yes	No	No	No	Yes	Geotek space out confirmation required.
PCTB-CS	Yes	No	No	No	Yes	No	Geotek space out confirmation required.
T2P	Yes	No	Yes	No	Yes	No	T2P OD too large to pass through RCB/face bit.

GAPC: The Geotek Advanced Piston Corer is used to recover soft sediment cores unpressurized and requires the use of a cutting shoe BHA. Once the GAPC is landed in the BHA the drill string is pressurized until shear pins in the GAPC shear resulting in the GAPC core barrel being thrust through the coring bit and 31 feet (9.5 m) into the formation. After extraction of the GAPC the borehole is drilled down 31 feet (9.5 m) to undisturbed sediments (Figure 4-3). The GAPC will be fitted with the IODP APC temperature sensor (APCT Tool Sheet (tamu.edu).

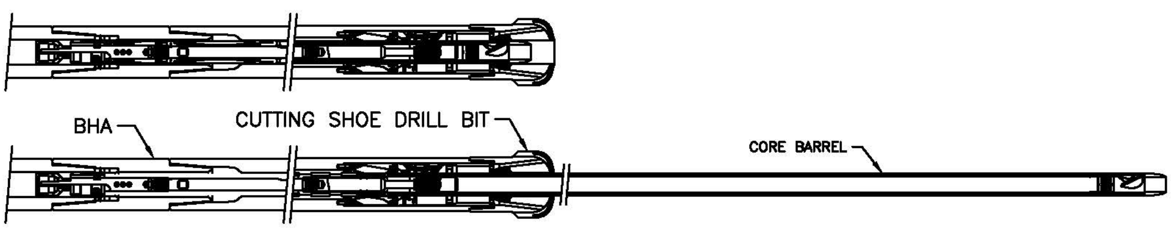


Figure 4-3. Geotek Advanced Piston Corer.

GXCB: The Geotek eXtended Core Barrel is used to recover semi-indurated sediment core samples unpressurized and requires the use of a cutting shoe BHA. Once landed and latched in the BHA the GXCB rotates with the BHA while the borehole is advanced 31 feet (9.5 m) while capturing the core (Figure 4-4).

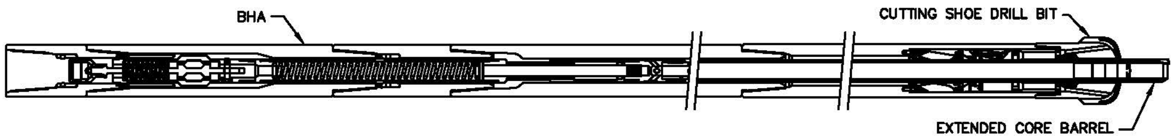


Figure 4-4. Geotek eXtended Core Barrel.

PCTB-FB: The Pressure Coring Tool with Ball Valve in the face bit configuration is used to recover pressurized core samples and requires the use of the PCTB-FB BHA. Once landed and latched in the BHA the borehole can be advanced up to 10 feet (3 m) while capturing the core. Upon recovery of the PCTB-FB, the ball valve is closed and the pressure chamber is sealed. The PCTB-FB is then recovered with the core maintained at near in situ pressure. (Figure 4-5, A and B)

PCTB-CS: The Pressure Coring Tool with Ball Valve in the cutting shoe configuration is used to recover pressurized hydrate core samples and requires the use of the PCTB-CS BHA. Once landed and latched in the BHA the borehole can be advanced up to 10 feet (3 m) while capturing the core. Upon recovery of the PCTB-CS, the ball valve is closed and the pressure chamber is sealed. The PCTB-CS is then recovered with the core maintained at near in situ pressure. (Figure 4-5, C and D)

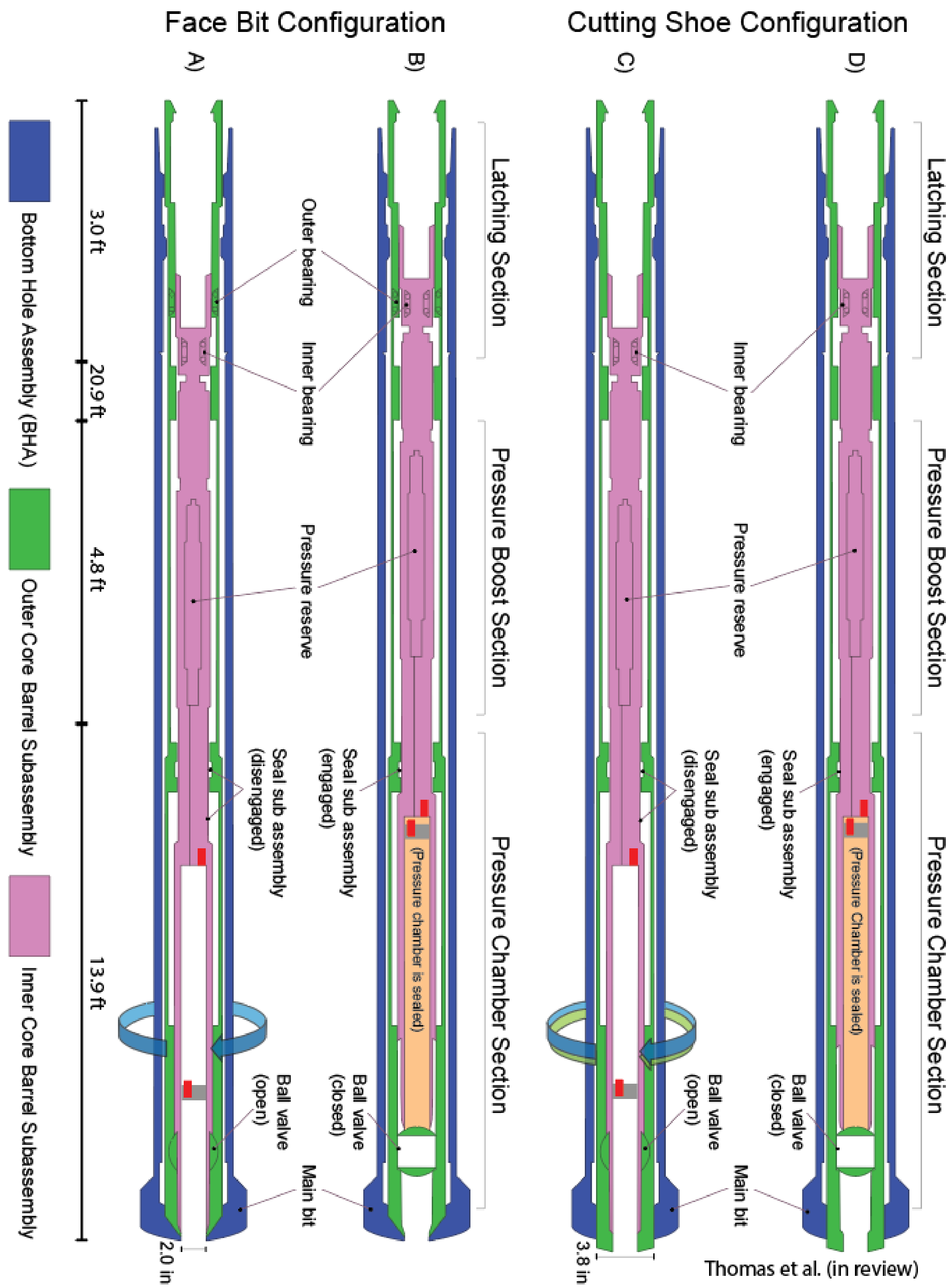


Figure 4-5. Pressure Coring Tool (PCTB) schematic Configurations. (A) PCTB-FB configuration during coring. In this configuration, the Outer (green) and Inner (pink) Core Barrel Subassembly move independently from each other and from the BHA. The blue arrow indicates direction of BHA rotation. (B) PCTB-FB during core retrieval. (C) PCTB-CS configuration during coring. In this configuration, only the Inner Core Barrel Subassembly moves independently from the BHA and the Outer Core Barrel Subassembly is locked to the BHA. The blue arrow indicates direction of BHA rotation and green arrow indicates that the Outer Core Barrel Subassembly rotates with the BHA. (D) PCTB-CS configuration during core retrieval. To initiate core retrieval the inner core barrel subassembly (in pink) is pulled up relative to the outer core barrel subassembly (in green). The locations of the Data Storage Tags are shown in red. The lower tag resides within a portion of the tool that moves up as the core fills the liner

referred to as the rabbit. A third tag (not shown) is located in the pulling tool. The ratio of the width and length of the tool is not to scale; see scales (Thomas et al., 2020).

4.6 Slickline

A slickline is required for deployment of the coring tools, center bits, and survey tool. The slickline to be used is a 5/16 in (8 mm) diameter braided wireline with a safe working load capacity of 10,530 pounds. The slickline will be deployed through the top drive equipped with a line wiper such that any flow up the drill string can be controlled during coring operations. A third party slickline unit and appropriate operators will be supplied.

4.7 Borehole Inclination/Azimuth Surveys

All boreholes will be surveyed at least every 1000 feet of penetration and at total depth, for inclination and azimuth, using a third-party surveyor and gyroscopic survey tool deployed on slickline.

4.8 Rig Position Survey

Rig position surveys using a certified surveyor will be conducted prior to spudding to ensure proper location of the boreholes.

4.9 Site Surveys

Seafloor "as found" surveys will be conducted using an ROV at each location prior to spudding the boreholes to document condition of seafloor and to identify if any archaeological resources or obstructions are encountered. After abandonment, an "as left" site survey will be conducted using an ROV at each location and a clearance report will be prepared verifying that the site is clear of obstructions. All survey data will be archived electronically.

5 Mud Program

The UT-GOM2-2 Scientific Drilling Program operations will be carried out riserless resulting in all mud pumped out of the boreholes settling on the seafloor.

16 ppg water-based drilling mud will be delivered to the vessel via work boat. The 16 ppg working drilling mud will then be diluted onboard the vessel with water to achieve the desired weight. Chemicals will be added to the mud during the mixing process to achieve the desired viscosity and properties. A description of the various types of drilling mud anticipated to be used during the UT-GOM2-2 Scientific Drilling Program is given below.

5.1 Working Mud

16 ppg water-based mud will be delivered to the vessel via work boats and stored on board. The 16 ppg mud will be diluted with water to achieve the desired weight. Chemicals will be added to the mud during mixing process to achieve the desired viscosity and properties.

5.2 Kill Mud

600 barrels (2x deepest hole volume) of 13.0 ppg mud will be held in reserve in the event that flow from a borehole occurs and heavy mud is required to stop the flow.

5.3 Drilling and Coring Mud

10.5 ppg mud will be continuously circulated while drilling and coring beginning prior to penetrating the upper most hydrate zone.

5.4 Sweep Mud

10.5 ppg high viscosity mud will be mixed and stored for use in cleaning the borehole as required.

5.5 Pad Mud

11.5 ppg high viscosity pad mud, sufficient to support the planned cement column, will be mixed and used to displace the bottom of the borehole up to the depth at which the cement plug will be emplaced.

5.6 Abandonment Mud

11 ppg mud will be mixed and used to displace the borehole from the top of the cement plug to the sea floor.

6 Coring Program

The coring program is dependent on the FY'23 level of funding.

6.1 Coring Plan Overview

At WR313, we will acquire pressure cores at WR313 H002 and H003 using the PCTB-FB and PCTB bottom hole assembly (BHA), twinning the WR313 H001 location. Pressure cores will be acquired in the Orange sand, Blue sand, Red sand and at select locations to characterize the background mud. At WR313 H003, we will acquire conventional cores and in situ pressure/temperature measurements (Table 6-1) using the APC, XCB, and penetrometer with the PCTB-CS BHA. We may collect pressure cores in the Aqua and Yellow sand.

6.1.1 WR313 H002

Pressure cores will be acquired using the PCTB-FB tool. A center bit will be used to drill the borehole where pressure cores are not being taken.
Continuous pressure-cores will be acquired in the Red sand (3 cores, complete interval), the Upper Blue sand (3 cores, partial interval), and the Orange sand (11 cores, complete interval). Intermittent spot pressure-core pairs may be acquired throughout the borehole to develop a dissolved methane profile and above / below the base of hydrate stability. A total of 24 pressure cores are planned in this well. Additional pressure cores may be taken if time and resources permit. (Table 6-1, Figure 6-1).

6.1.2 WR313 H003

Using the Geotek Advanced Piston Corer (G-APC) tool, conventional-core will be taken from the seafloor to a depth where the APC Corer can no longer be used ~ 200 fbsf. H_2S precautions will be taken per BSEE requirements when retrieving conventional core taken from surface to the Sulfate-Methane Transition at ~65 fbsf. Once the G-APC can no longer be used, conventional-core will be taken using the Geotek eXtended Core Barrel (G-XCB) to a depth of ~565 fbsf. PCTB-CS spot pressure cores will be acquired throughout the borehole from just below the Sulfate-Methane Transition (SMT) to 850 fbsf, followed immediately by a temperature and pressure penetrometer deployment (T2P). Lower, PCTB-CS pressure core will be acquired in the Red sand (3 cores, complete interval) followed immediately by a temperature and pressure penetrometer deployment (T2P). Pressure cores will be acquired in the Upper Blue sand (9 cores, partial interval), followed by a single spot pressure core at total depth.

A total of 21 pressure cores are planned in this well. Additional pressure cores may be taken if time and resources permit (Table 6-1, Figure 6-1).

Table 6-1. WR313 H002 and WR313 H003 preliminary coring plan . Each pressure core can have a maximum length of 10 ft.; each conventional core can have a maximum length of 31 ft.

<table>
<tr><th>LOCATION</th><th>CORE TYPE</th><th>CORING INTERVAL (fbsf)</th><th>BHA</th><th>CORING TOOL</th><th>NOTES</th></tr>
<tr><td rowspan="4">WR313 H002</td><td rowspan="4">Pressure Core</td><td rowspan="4">379-3010</td><td rowspan="4">PCTB-FB</td><td rowspan="4">PCTB-FB</td><td>7 spot pressure-cores</td></tr>
<tr><td>3 pressure-cores across the Red sand and bounding mud</td></tr>
<tr><td>3 pressure-cores in Upper Blue sand</td></tr>
<tr><td>11 pressure-cores across the Orange sand and bounding mud</td></tr>
<tr><td rowspan="5">WR313 H003</td><td rowspan="2">Con-ventional Core</td><td>0-205</td><td rowspan="5">PCTB-CS</td><td>G-APC</td><td>Conventional core with G-APC and 2 pressure cores with PCTB-CS</td></tr>
<tr><td>205-565</td><td>G-XCB</td><td>Conventional core with G-XCB and 5 pressure cores with PCTB-CS</td></tr>
<tr><td rowspan="3">Pressure Core</td><td>815-850</td><td rowspan="3">PCTB-CS</td><td>One Conventional core with G-XCB and one spot pressure core with PCTB-CS</td></tr>
<tr><td rowspan="2">945-2450</td><td>3 pressure-cores across the Red sand and bounding mud</td></tr>
<tr><td>9 pressure-cores in Upper Blue sand, and one below</td></tr>
</table>

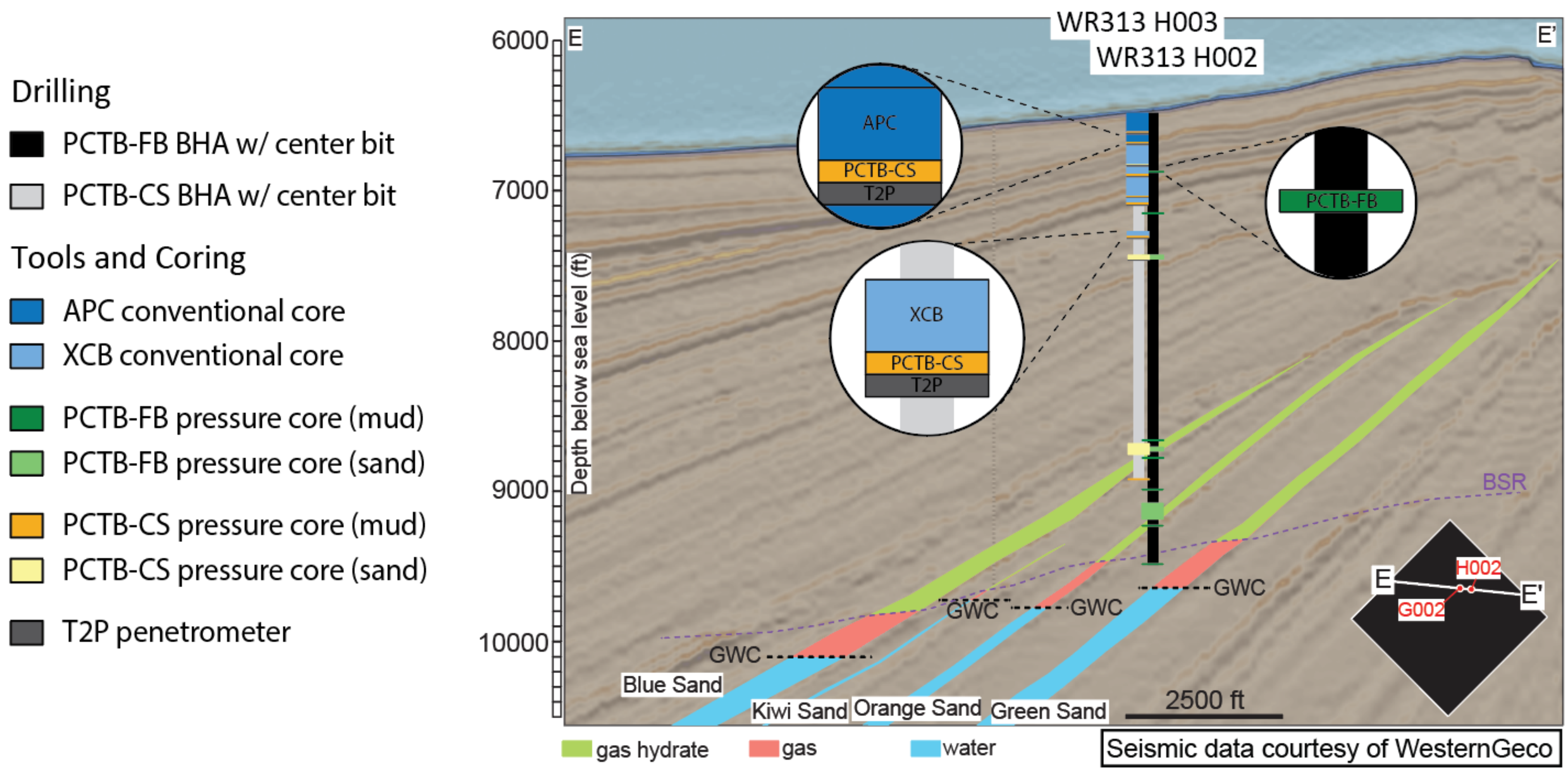


Figure 6-1. UT-GOM2-2 drilling and coring plan for WR313 H002 and WR313 H003. Not to scale.

The total length of pressure core recovered for WR313 H002 and WR313 H003, assuming 100% successful coring runs and 100% recovery with no fall-in, is 440 ft (134 m).

The total length of conventional core recovered for WR313 H002 and WR313 H003, assuming 100% successful coring runs and 100% recovery is 515 ft (113.7 m). This is the expected amount of core that will be logged using the Geotek IR and MSCL scanners. Table 6-2 outlines the various estimates of pressure and conventional core considering core type.

Table 6-2. Estimated total amount of pressure and conventional core based on core type, quality, pressure coring run success (core is sealed and held at a pressure within the hydrate stability zone) and core recovery (% of core barrel fill). Note that the amount of conventional core to process will increase assuming failed pressure coring runs produce depressurized core that can be treated as conventional core.

	Total Pressure Core		Total Conventional Core	
	ft	m	ft	m
TOTAL 2 HOLES (100% PC success, 100% recovery)	450	137	515	157
TOTAL 2 HOLES (70% PC success, 100% recovery)	315	96	650	198
TOTAL 2 HOLES (70% PC success, 80% recovery)	252	77	520	158

6.2 On-board Core Analysis

The UT-GOM2-2 core analysis program will focus on analysis of both pressurized and conventional cores. On-board core analyses are summarized in Table 6-3 Details of the core analysis will be provided in the UT-GOM2-2 Science and Sample Distribution Plan.

Table 6-3. Summary of sample type, analysis type, with required laboratory space, equipment.

Sample Type	Analysis	Where: Container or Lab	Equipment
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8	PCATS, PCATS water tank, supplies
Pressure core	Quantitative degassing w/ gas sampling	R17	3 degassing stations, SC130 storage racks, copper tubes, stainless steel tubes, other supplies
Gas samples	Hydrocarbons	Core Receiving	GC, computers, supplies
Whole round conventional core	Thermal imaging		MSCL-IR
Whole round core	Void gas collection; Cut whole round core into sections for pore water, microbiology, moisture and density, and physical properties; headspace gas sampling		Cutting tools and supplies
Whole round core	sediment strength		hand vane and pocket penetrometers
Microbiology whole rounds	Extracting sediment for Microbiology	Core Processing	Cutting tools and supplies, N2 bag, -80 C Freezer, Whirl paks, etc.
Pore Water whole rounds	Pore Water Squeezing	Pore Water Lab	4 squeezers and 2 glove bags
Pore Water	Time sensitive salinity and alkalinity		alkalinity titrator, refractometer, sampling bottles and preservation agents, freezer

6.2.1 Pressure Core Processing Flow

As time allows, pressure cores will be transferred to PCATS where they will get a "Quick scan" (1 cm resolution with 0-degree X-ray image) and/or a "Full scan" (0.5 cm resolution with 0- and 90-degree X-ray images) with CT imaging. Geotek will provide a recommendation, based on the Science Plan, for which sections should receive 3D imaging and which lengths will be cut. This recommendation will be reviewed by UT, with solicitation from others, and UT will make the final decision. When time is available, pressure cores from storage will be returned to PCATS for continued scanning, imaging, cutting, and transfer. There is limited time available for shipboard processing of pressure cores, so some of this subsampling and analysis will be done On-Board and the remainder will be completed at the dock (See Schedule).

6.2.1.1 PCATS: Quick Scan Analysis

During the quick scan, cores will be logged (velocity, density) with 1 to 5 cm resolution and single scan 2D x-ray image will be taken. Then that core will be transferred to temporary storage in order to make PCATS available for the next core on deck. Fifteen temporary storage chambers capable of handling 10' long pressure cores will be available.

6.2.1.2 PCATS: Full –Scan Analysis, Cutting, and Transfer

Because pressure core should not be directly depressurized within the longer temporary storage chambers, all core that is stored in the temporary storage chambers must be cut into shorter sections in PCATS.

First, we will run full scans to obtain more accurate data with a higher sampling frequency (gamma density and P-wave data at a 0.5 cm resolution, 0- and 90-degree X-ray images) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, sections of the core can be subsampled for quantitative degassing analysis. PCATS scans will allow the scientists to choose particular lithologies or zones within which to calculate dissolved methane in the pore water, hydrate concentration, and sample the resultant gasses. Thirdly, optimal 3.3’ (1.0 m) subsections will be transferred to UT.

6.2.1.3 Quantitative degassing

Sections cut for degassing will be quantitatively degassed on board. Gases will be preserved and/or analyzed on-board, and the remaining core material will be treated as conventional core (see below).

6.2.2 Conventional Core Processing Flow

Conventional cores will be IR-scanned and then cut into sections to be stored until dockside analysis. Some whole round sections will be cut for pore water squeezing, and ephemeral properties measured (alkalinity, pH, and salinity) on-board. Whole round sections will also be sampled and preserved for microbiology, moisture and density, and physical property measurements. Void gas samples will be collected. Sediment will be collected for headspace gas analysis. Hand vane and pocket penetrometers will be used as an initial estimate of sediment strength.

6.3 Dockside Core Analysis

The UT-GOM2-2 core analysis program is designed to meet the science objectives and will include the analysis of both pressurized and conventional core.

Table 6-4 shows the analyses planned, the core sample type required, in which container the analysis will be either be performed or samples for analysis on-shore will be preserved, the required equipment, and the required staff (count per shift).

Table 6-4. Planned Analyses including sample type, analysis, location, and required equipment.

Sample Type	Analysis	Where: Container or Lab	Equipment
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8	PCATS, PCATS water tank, supplies
Pressure core	Quantitative degassing w/ gas sampling	R17	3 degassing stations, SC130 storage racks, copper tubes, stainless steel tubes, other supplies
Gas samples	Hydrocarbons	Core Receiving	GC, computers, supplies
Whole core sections	Whole core logging, CT scanning	MSCL	MSCL-S, CT scanner
Whole core sections	Cut whole round core into sections for pore water, microbiology, moisture and density, mechanical and physical properties	Core Receiving	Cutting tools and supplies
Whole core sections	Thermal conductivity and Vane Strength		Thermal conductivity probe, Table Vane
Pore water whole rounds	Pore Water Squeezing	Pore Water	4 squeezers and glove bags, alkalinity titrator, refractometer, sampling bottles and preservation agents
Pore Water	Sample reservation for geochemistry		Sampling bottles and preservation agents, freezer
Split core	Core splitting	Split Core	core cutters and supplies
Split core scanning	Linescan images, color reflectance scans, X-ray fluorescence (core scanning), near IR scan	MSCL Container	Split Core scanner
Split core	Visual description, and smear slide description	Geotek 40 ft Whole Core Processing Laboratory	Core splitter
Split core	Sample preservation for sedimentology (CHNS, TOC, grain size, isotopes), biostratigraphy, minerology, etc	TBD	sampling supplies

6.3.1 Dockside Pressure Core Processing Flow

Any cores that were not processed on-board will be processed at the dock using 'Full scan' analysis, CT imaging, cutting, and transfer. Geotek will provide a recommendation based on the Science Plan for which sections should receive 3D imaging and which lengths will be cut. This recommendation will be reviewed by UT, with solicitation from others, and UT will make the final decision. All remaining pressure cores will be fully processed.

6.3.1.1 PCATS: Quick Scan Analysis

During the quick scan, cores will be logged (velocity, density) with 1 to 5 cm resolution and single scan 2D x-ray image will be taken.

6.3.1.2 PCATS: Full –Scan Analysis, Cutting, and Transfer

We will run full scans to obtain more accurate data with a higher sampling frequency (gamma density and P-wave data at a 0.5 cm resolution, 0- and 90-degree X-ray images) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, sections of the core can be subsampled for quantitative degassing analysis. The PCATS scans will allow the scientists to choose particular lithologies or zones within which to calculate dissolved methane in the pore water, hydrate concentration, and sample the resultant gasses. Thirdly, optimal 3.3’ (1.0 m) subsections can be chosen from the storage chambers and transferred UT.

6.3.1.3 Quantitative degassing

Sections cut for degassing will be quantitatively degassed on board. Gases will be preserved and /or analyzed at the dock, and the remaining core material will be treated as conventional core (see below).

6.3.2 Conventional Core Processing Flow

Conventional cores will be CT-scanned, logged using the MSCL-S. Whole round samples of core will be cut for mechanical measurements. Thermal conductivity and sediment strength will also be measured. The remaining core will be split into archival and working halves. Split core will be scanned (magnetic susceptibility, photo-scan, X-ray fluorescence, and color reflectance) and photographed. Sedimentology and Biostratigraphy Smear slides will be prepared and assessed. Discrete sediment samples will be collected for CHNS, TOC, grain size distribution, X-ray powder diffraction, and rock magnetism. Authigenic carbonate and sulfide will be collected if present. Additional samples for moisture and density and X-ray diffraction may be collected.

7 Plugging and Abandonment

The plugging and abandonment procedure employed will adhere to all applicable regulations for plugging and abandoning a borehole in the Gulf of Mexico. Several alternate compliances will be required, similar to the alternate compliances required for UT-GOM2-1. The final procedure will be reviewed by a third party registered professional engineer and all applicable regulatory bodies prior to initiating.

The preliminary Plugging and Abandonment Plan calls for emplacing a cement plug in the borehole beginning at approximately 150 feet above the upper most hydrate bearing zone with the potential to flow and extending upward for a minimum of 500 feet. Emplacement of the cement plug above the hydrate bearing zone, rather than across the zone, was chosen to prevent possible disassociation of the gas hydrate, due to the heat of hydration produced by the curing cement, that may lead to degradation of the cement plug integrity (Figure 7-1).

Prior to emplacement of the cement, the drill bit will be positioned near the bottom of the borehole, a cement liner inserted in the BHA, and the borehole displaced with an 11.5 ppg high viscosity (~100 lb/100 ft^2) mud from total depth to approximately 150 feet above the upper most hydrate bearing zone with the potential to flow. The drill bit will then be raised to approximately 150 feet above the upper most hydrate bearing zone with the potential to flow where sufficient 16.4 ppg Class H cement to fill 500 feet of the borehole plus 100 percent annular volume excess to account for any cement loss and borehole washouts will be pumped. The drill bit will then be carefully raised clear of the seafloor and flushed with seawater while waiting for the cement to cure.

After sufficient cement curing time as elapsed, the drill bit will be lowered in the borehole until the top of the cement plug is encounter. To confirm the top and integrity of the cement plug, 15,000 pounds weight on bit will be applied to the top of the cement plug. After confirming the top and integrity of the cement plug, the borehole will be displaced to 11 ppg WBM and then the drill string will be recovered in preparation for abandonment of the borehole.

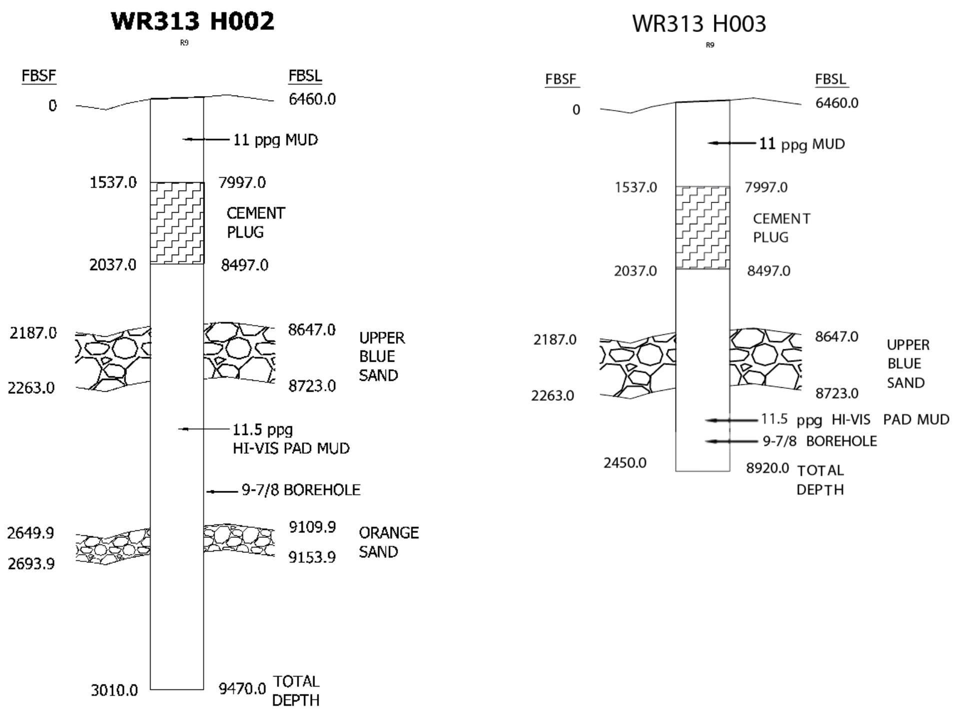


Figure 7-1. Plug and abandon cement plug emplacement hole schematics.

8 Schedule

8.1 UT-GOM2-2 Hydrate Expedition Schedule

The UT-GOM2-2 Scientific Drilling Program is scheduled to commence during in spring of 2023. Mobilization, requiring 3.8 days, involves transporting the equipment from the port of embarkation to the vessel via work boats, loading the equipment onboard the vessel, and making all equipment ready for operations. Drilling and coring operations at sea require ~30 days to complete (Table 8-1, Table 8-2).

Demobilization, requiring 3.2 days, involves offloading all equipment from the vessel to work boats and transporting it to the port of debarkation. Once in the port of debarkation, most of the equipment will be shipped back to its origin while the remaining equipment will be used in port for shore-based core preliminary analysis. Shore based core preliminary analysis will take 14 days to complete, after which all remaining equipment will be shipped back to its origin. The cores will then be shipped to various institutions for further analysis.

Total time to complete all operations is approximately 7.5 weeks.

Table 8-1. UT-GOM2-2 Scientific Drilling Program Overview

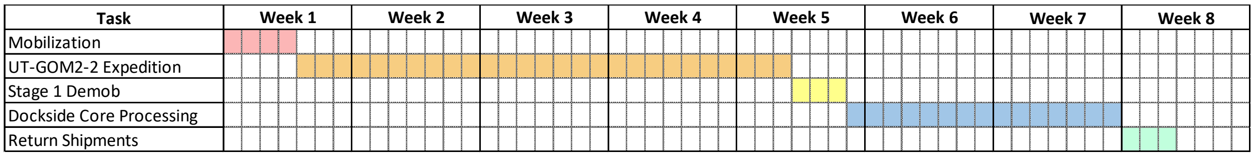


Table 8-2. UT-GOM2-2 Scientific Drilling Program Offshore Operations Schedule

Task	On Site Operations Time incl 20% NPT (days)	Mob-Demob Time (days)	16 ppg mud pumped (bbl)***	Cement Usage (sks)
Rig mobilization (on location WR313-H002)		3.75		
WR313-H002 coring operations. Transit to WR313-H003.	14.0		7,572	545
WR313-H003 coring operations	13.5		4,055	545
Rig demobilization (on location WR313-H003)		3.2		
Subtotals:	**27.5**	**6.99**	**11,627**	**1,090**
Total Expedition Time incl 20% NPT:	**34.5**			

8.2 Core Processing Schedule

8.2.1 PCATS pressure core acquisition time

The time to acquire one core using the PCTB can range from 3-6 hours. The assumed average rate is 5 hours.

8.2.2 Pressure Core Processing Time

Quick-scanning and transfer from the PCTB pressure chamber to temporary storage, in Geotek SC_{350} chambers, takes 3.5 hours for a single 10' (3.1 m) pressure core. We assume that PCATS quick-scanning will be able keep up with the PCTB coring even during continuous coring operations. During intermittent pressure coring, there is sometimes enough time to completely process a pressure core in PCATS before the next one shows up.

There are four PCTB pressure chambers (autoclaves) and each pressure chamber must be emptied and cleaned before it is needed again at the rig floor. There are 15 SC_{350} chambers each of which must be emptied and cleaned before it is needed again at PCATS. 35-41 SC_{120} and 3-4 SC_{30} pressure chambers will be available for storage and quantitative degassing.

Full-scanning can take up to 11 hours to for each 10' pressure core in PCATS depending on the number of cuts that will be made under pressure.

9 Risk Management

Risks are broken into 6 categories: Environmental, Personnel and Equipment, Meeting Science Objectives, Weather, Vessel Selection, and Cost Inflation.

9.1 Environmental

1. Release of fluids at the seafloor
    a. In any riserless offshore drilling operation, there is the risk of the release of wellbore fluids to the water column if hydrostatic control is not maintained. There are two possible types of borehole fluid flows at the Walker Ridge 313 locations: 1) water flows and 2) gas flows.
    b. Uncontrolled shallow flows can result in drilling delays or loss of well site.
    c. The risk of these events is minimized in the following manner:
        i. Avoid potential flow zones. Use seismic and previous well data to select surface locations and to design well paths that minimize the possibility of drilling into shallow formations with the potential of flowing fluids.
        ii. Maintain hydrostatic control. Use appropriately weighted drilling fluids during drilling and in response to flow events to slow/stop the flow of fluids. Minimize lost circulation.
        iii. Maintain visual observation of the wellbore returns at the seafloor via ROV camera for early detection of flow.
        iv. Review of offset well data.
2. Release of pollutants from the rig
    a. Spills can occur during transit (collision) or during transfer between rig & supply vessel. Spills of diesel fuel or other chemicals from the rig /supply vessel can also occur while on location.
    b. Any releases of diesel are expected to evaporate and biodegrade within a few days.
    c. Most chemicals used during the project will be either non-toxic or used in small quantities. Any spills are expected to have temporary localized impacts on water quality.
3. Operational discharges
    a. Will be regulated as per the NPDES General Permit GMG290000.
    b. Are expected to only have short-term localized degradation of marine water quality.
4. Emissions impact on air quality
    a. Emissions from routine activities are not expected to affect onshore air quality due to prevailing atmospheric conditions, emission heights, emission rates, distance of emissions from the coastline.
    b. There are no plans for burning or flaring during this project.
5. Impact on marine life
    a. Minimal to none expected.
6. Dissociation of gas hydrates
    a. Hydrate dissociation can be either gradual or instantaneous when hydrates are heated or depressurized.
    b. While drilling the boreholes, fluids cooler than the formation temperature will be introduced, which will act to further stabilize the hydrate zone.
    c. Drilling-fluid weight will be controlled to maintain a positive pressure on the formation.

d. During P&A, the cement abandonment plug will be set above the hydrate zone to minimize destabilization concerns due to the cement heat of hydration while the plug sets.

9.2 Personnel and Equipment

1. During Drilling
    a. Drilling involves dynamic use of heavy equipment, often under pressure, in a challenging and changing environment. There is risk to personnel and equipment inherit in this environment. Risks are mitigated by equipment & program design, preventative maintenance & inspections, strict adherence to procedure, job safety analyses, personnel competency & supervision, high quality safety culture, and use of a unified Safety Management System.
    b. Loss of drill string during drilling or coring. The drill string can be dropped or become stuck in the borehole resulting in loss of the bottom-hole assembly (BHA) and part of the drill string. Mitigation includes drill string inspection prior to project commencement, operating within drill string & BHA design limitations, following good drilling practices and preventative equipment maintenance.
    c. Loss of drill string due to geological event: It is possible, although very rare, that a submarine mass movement (e.g. landslide) could occur resulting in the loss of the drill string. Loss of equipment due to landslides is extremely rare. This risk is mitigated through location selection to avoid potential geological events.
2. While Handling High Pressured Samples
    a. We will be recovering, transferring, and storing samples that are at significant pore pressures (up to 35 MPa).
    b. The risk is mitigated in the following manner:
        i. All pressure vessels are equipped with pressure release safety valves.
        ii. Pressure cores will be transported by vehicle in ‘over-pack’ containers, a US DOT approved approach to transport of pressurized material.
        iii. Strict adherence to proper procedure in the presence of pressurized containers.
        iv. Hold pre-job safety discussions.
        v. Assure that personnel involved have been trained in the safe handling of pressurized samples.
3. While handling cores taken above and within the SMT zone in WR313 H003
    a. Release of H_2S at the rig floor /core processing areas is not likely from H_2S entrained in cores taken above and in the SMT in WR313 H003.
    b. Still the risks are mitigated in the following manner:
        i. Strict adherence to proper procedure in the presence of cores potentially entrained with H_2S in WR313 H003.
        ii. Assure that personnel involved have been trained in H_2S awareness and core-handling H_2S protocols.

9.3 Meeting Science Objectives

1. Table 9-1 lists the identified highest risks to not meeting the science objectives. Probability and Impact on meeting the science objectives were given a rating of 1 (lowest) to 3 (highest). Risk

Rating is the product of the numerical values given to Probability and Impact. Risk Ratings correlate to the Risk Level as follows: 1-3 = Low, 4-6 = Med, 7-9 = High.

Table 9-1 Identified highest risks for meeting the Science objectives . A full list of all the identified risks and risk assessment for all the proposed objectives can be found at UT-GOM2-2_Risk_Analysis_2019-08-12.

UT-GOM2-2 Scientific Drilling Plan Identified Failures	Probability Rating	Impact Rating	Risk Rating	Risk Level
A1. Failure of the vessel operator to work with/understand requirements for pressure coring	1	3	3	Low
A2. Failure of the PCTB-FB to seal within the HSZ, tool error	1	3	3	Low
A4. Failure of the PCTB-CS to seal within the HSZ	2	1	2	Low
A6. Pressure Cores above 150-200m might not be good	2	1	2	Low
B2. G-RCB jams in the PCTB-FB BHA	2	2	4	Med
B6. Failure of the Geotek coring tool (G-RCB) to hold core	1	2	2	Low
E1. PCATS failure	1	3	3	Low
E2. Failure of any equipment on-board needed for ephemeral measurements	1	2	2	Low
E3. Failure of the T2P	2	2	4	Med
F0. Failure to secure a vessel	1	3	3	Low
F1. Failure to Secure Dockside rental space	1	2	2	Low
F2. Failure to Secure a location for conventional Core Analysis (e.g. Port Fourchon)	1	2	2	Low
H2. Bioactivity too low for any microbiology analyses	2	1	2	Low

9.4 Adverse Weather Conditions

1. During coring, bit bounce must be minimized/eliminated to allow successful recovery of the cored material. If the core bit lifts up off bottom before the core is completely cut; the core catcher will likely close on the core, making it impossible for more core to enter the inner tube. Keeping the bit on bottom is complicated by use of a floating drilling vessel which heaves in response to the sea state and other environmental conditions.
2. The maximum sea state for backloading and transporting pressured cores is 4 feet w/ wave heights up to 8.2 feet.
3. The risk is mitigated in the following manner:
    a. Use active heave systems on the drilling vessel while coring
    b. Schedule project to avoid hurricane season & minimize time during height of winter storm-season. The ideal weather window for coring activities in the Gulf of Mexico is April-May.

10 Drilling Vessel

A fit-for-purpose oil-industry deepwater drilling or intervention vessel has been contracted for 2023, the Helix *Q-4000*. Specific vessel requirements can be found in Appendix A.

11 Personnel

11.1 Project Organization

The UT-GOM2-2 Scientific Drilling Program will be managed by the University of Texas Institute for Geophysics (UTIG), an Organized Research Unit recognized by the University of Texas at Austin (UT).

UTIG will manage and oversee all operations and analytical activities to ensure that project science objectives are accomplished.

There are six sub-recipient universities on this project: Ohio State University (Ohio State), Oregon State University (Oregon State), University of New Hampshire (UNH), University of Washington (UW), Tufts University, and Lamont-Doherty Earth Observatory at Columbia University (LDEO). Sub-recipients will participate in the UT-GOM2-2 Scientific Drilling Program to varying degrees according to their statements of work.

UT will contract subcontractors to fulfill various roles in the UT-GOM2-2 Scientific Drilling Program, including Pettigrew Engineering, Geotek, and Helix.

A project organization chart for the UT-GOM2-2 Scientific Drilling Program and core analysis activities is shown in Figure 11-1.

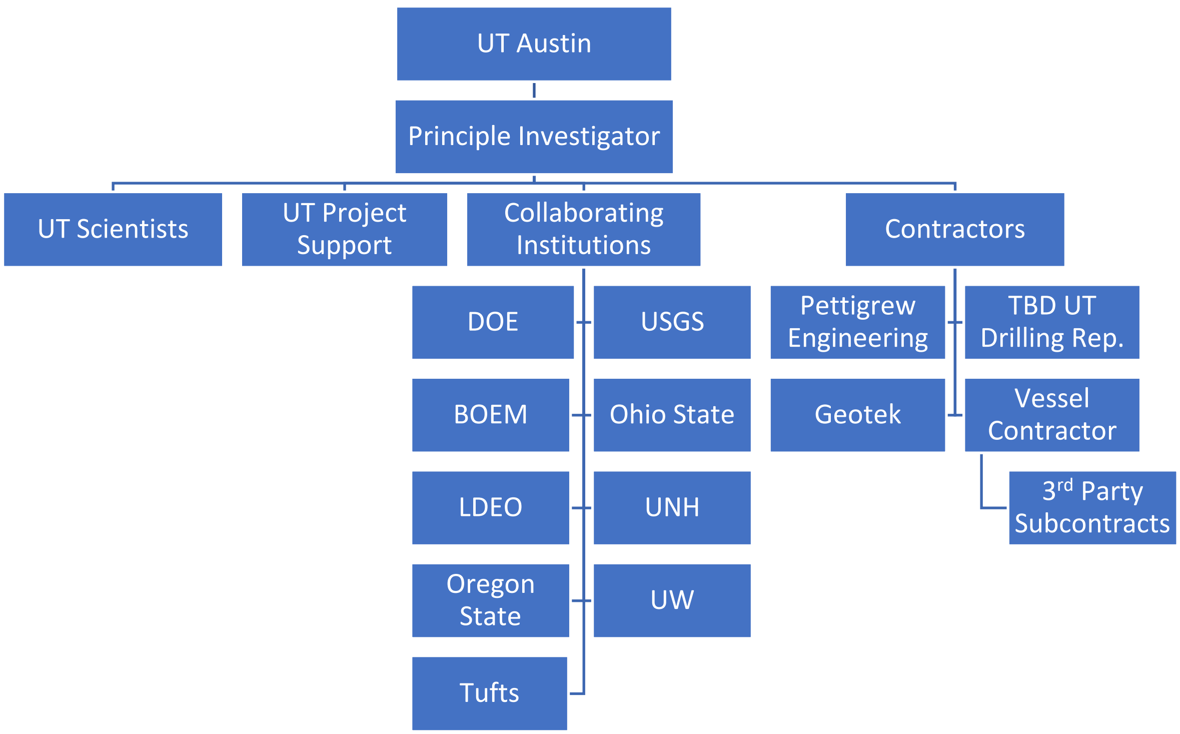


Figure 11-1. Personnel organization chart.

11.2 UT-GOM2-2 Scientific Drilling Program Personnel – Onboard

The roles, maximum number of persons, and anticipated institutions required to fulfill the UT-GOM2-2 Scientific Drilling Program, are shown in Table 11-1.

Table 11-1. UT-GOM2-2 onboard personnel

UT-GOM2-2 ONBOARD PERSONNEL			
ROLE / TASK	***PERSONS H002***	***PERSONS H003***	***INSTITUTION***
Company Man,Well Control /Safety Offi	2	2	TBD
Chief Scientist	1	1	UT
Staff Scientist	1	1	UT
Operations Reporting	1	1	USGS
Drilling Data and Core Log Integration	2	2	Ohio State
Pore Water Geochemistry	2	4	UW, others
Quantitative Degassing	4	4	UT, Geotek
Whole Core Processing	2	4	Oregon State, Ohio State
Pressure Coring/PCATS	12	12	Geotek, others
T2P	0	1	UT
Photography, Videography	2	0	TBD
TOTAL	**30**	**32**	

11.3 UT-GOM2-2 Scientific Drilling Program Personnel – Dockside Core Processing

The roles, number of persons, and anticipated institutions required to fulfill the UT-GOM2-2 dockside core analysis program, is shown in Table 11-2

Table 11-2. Dockside core analysis program personnel.

DOCKSIDE CORE ANALYSIS PROGRAM PERSONNEL		
ROLE / TASK	***PERSONS***	***INSTITUTION***
Chief Scientist	1	UT
Staff Scientist	1	UT
Pore Water Geochemistry	2	UW, others
Quantitative Degassing	4	UTIG, others
Whole Core Processing	2	Oregon State, Ohio State
Core Description	2	UNH
Biostratigraphy	1	UT
Physical Properties	1	UT, others
Whole Core Logging	2	Geotek
Core Splitting and Split Core Logging	2	Geotek
PCATS	4	Geotek
Degassing and Core Transfers	4	Geotek
TOTAL	**26**	

12 Permitting

Because the depth of penetration below the sea floor will be greater than 500 ft in each well, the wells will be considered "deep stratigraphic tests" per BOEM definition and permitted as such.

The UT-GOM2-2 Scientific Drilling Program will be drilled under the following permits and permissions:

- BOEM 'Right of Use & Easement'
- BOEM 'Exploration Plan' including Coastal Zone Management 'Federal-Consistency Certification'
- BOEM 'Permit to Conduct Geological or Geophysical Exploration for Mineral Resources or Scientific Research on the Outer Continental Shelf (BOEM-0327)'
- BSEE 'Permit to Drill' (BSEE-0123)
- NPDES General Permit for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico (GMG290000).
- NEPA Categorical Exclusion Designation

13 Logistics

13.1 Designated Port and Heliport / Boat and Helicopter Services

Providers of shore base/dockside and helicopter services are yet to be selected. Based on the area of the project operations. The heliport will most likely be based in Houma, Louisiana.

13.2 Mobilization / Demobilization Plans

UT will work with the Rig Contractor, Geotek, and Shore Base management to create Rig Mobilization and Demobilization logistics plans.

The Rig Mobilization Plan to include:

- Activities & Timeline
- Identification of Responsible Party
- Manifest
- Dimensions & weights of equipment to be transported to rig
- Equipment shipment-to-shore transport notes
- Dock requirements (cranes, fork lifts, power, staging area, personnel)
- Supply Boats (vessel selection, sea-fastening requirements, service hook up, order for loading and unloading, and deck layout of containers on the supply boat)
- Deck Layout of the containers on the rig
- Personnel (numbers and departure schedule)

The UT Drilling Representative and Rig Contractor will coordinate shore base logistics to ensure equipment arrives at the proper time and in the proper manner.

The Rig Demobilization Plan to include:

- Objectives of plan
- Activities & Timeline
- Identification of Responsible Party
- Manifest

- Dimensions & weights of equipment to be transported from rig
- Rig cranage required
- Dock requirements (cranes, fork lifts, power, staging area, container laydown area, personnel)
- Supply Boats (vessel selection, sea-fastening requirements, service hook up, order for back loading and unloading, and deck layout of containers on the supply boat)
- Dockside Geotek Site Plan (order of hook up at the dock and deck layout of the containers at the dock, power generators, fuel bowsers, etc.)
- Personnel (numbers and departure schedule)

13.3 Customs

UT, Geotek, and 3rd party members subcontracted by UT will work through UT with the Rig Contractor to ensure all personnel and equipment are properly documented and abide by US customs laws. Third party services subcontracted by the Rig Contractor will coordinate same through the Rig Contractor.

13.4 Trucking/Transport/Shipping

Arrangement for trucking of containers and equipment to/from the Shore Base facility will be the responsibility of the equipment owner/subcontractor. Prior to trucking; containers & contents will be properly secured for shipment and for offshore lifting. Loose equipment and materials are to be secured and transported in an offshore-rated basket. Mud materials are to be shrink-wrapped and palletized to protect materials during transport & storage. UT equipment and tools not stored in a container (e.g. BHA components) will be secured and transported in an offshore-rated basket. Third-party services subcontracted by the Rig Contractor will coordinate trucking delivery with the Rig Contractor, with input from the UT Drilling Representative. Return of containers, baskets, etc. will occur in a manner similar to delivery. All lifting elements (containers, slings, pad-eyes, etc.) will maintain current inspection and certification for offshore lifting (DNV) for the duration of the expedition.

13.5 Shore Base Support

Shipment of supplies and equipment will be coordinated between the Rig Contractor and the Shore Base Dispatcher with input from the UT Drilling Representative.

13.6 Supply Vessels and Crew Boats

Supply vessels and crew boats will be contracted by the logistics management provider (most likely the Rig Contractor) as required during execution.

13.7 Supplies and Equipment

13.7.1 Equipment

Sourcing and mobilization of 3rd party equipment subcontracted by the Rig Contractor will be handled by the 3rd party and the Rig Contractor with input from the UT Drilling Representative and UT.

All Geotek container/van logistics will be handled by Geotek; this includes but is not limited to shipping from UK, customs, storage, inspection, marking, and security. Geotek will also be responsible for the shipment and delivery of the PCTB storage van and heavy tools van should they not be returned to UT after the Land Test. Timing for mobilization will be developed in conjunction with Rig Contractor, UT Drilling Representative, UT, and Geotek.

UT will be responsible for:

- PCTB storage van and heavy tools van if these two containers/vans are stored at UT prior to the deployment.
- Vans and equipment related to whole round core sampling
- Shipment of all UT-supplied materials required by science team onboard the vessel during the expedition (e.g. RAID storage devices, printer, office supplies, etc.).
- Supplies and equipment related to Pore Water sampling; including providing a safe container lab with fridge, freezer (tbd, power, water, and drainage) for the pore water sampling work.

All UT equipment removed from a container while onboard will be stamped/stenciled/painted with "Property of UT." All non-UT equipment and materials shall be stamped/stenciled/painted with the owner's name as per Title 30 CFR 250.300 (c).

13.7.2 Baskets & Containers

Five 20-ft baskets will be required for pipe, collars, Geotek chillers, and Geotek cold shuck.

Pressure core operations and analysis will require a total of 4 containers - a 40-ft container for the PCTB, a 40+20 ft container for PCATS operations, and a 20-ft container for pressure core storage and degassing.

Conventional core operations will require an additional 5 containers on-board. Geotek will provide a 20-ft size container for conventional coring tools (which needs to be placed next to the PCTB Tools Van) and a 40-ft container for MSCL-IR for cutting core into 1.5 m sections (which will be repurposed during demobilization to the dock for core splitting and curation). UT will provide a 20-ft container for whole round core (for microbiology, pore water, and physical properties) sampling; and a 20-ft container for porewater squeezing and analysis. Geotek will provide a 20-ft container for conventional core storage and additional pressure core storage.

A 20-30 ft container will be required for onboard science party office space. This container will require a minimum of 40' linear feet of countertop space for users and workstations, 10 chairs, outlets for up to 10 computers/laptops operated at the same time, full network capabilities (either wired or wireless) that is both reliable and with internet access. It will need reliable climate control with ambient noise level in a range that is safe without hearing protection.

A 20-ft container may be required for vessel contracted Mud Engineering.

Expected basket & container requirements for the coring operations are summarized in Table 13-1 below.

Table 13-1. Name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up, and required hook-up

Name	Type	Description	Reuse or New	Required Vessel Hook-up	Notes	Activities	Mobilization/ demobilization
Narrow Pipe	40' basket	6 collars	Same as GOM2-1	None	Only required for supply boat transfer		Only required for supply boat transfer
Wide Pipe 1	40' basket	Collars and BHA subs	Same as GOM2-1	None	Only required for supply boat transfer		Only required for supply boat transfer
Wide Pipe 2	40' basket	Collars and BHA subs	Same as GOM2-1	None	Work basket	Sub storage	Onboard, via supply boat
Cold Shuck	20' basket	Cold Shuck, and cold bath, small chiller transport	Same as GOM2-1	None	Only required for supply boat transfer		Only required for supply boat transfer
Chiller Frame	20' Frame	Geotek large glycol chillers	Same as GOM2-1	Power 480 V 3 phase 60 amp, water (1" feed), air (1: feed), network/internet	Will be used as a distribution point for some other units, with good layout planning; may be above or below PCATS 11		Onboard, via supply boat, remobilize dockside
PCTB Van	40' container	PCTB coring	Same as GOM2-1	Power (480 V 3 phase 60 amp), Water, Air, Network/Internet	Minimum laydown area 10x 20'; under hoist that extends from PCTB Van	PC pressure checks, Some PCTB assembly, autoclave extraction, collect loose sediment	Onboard, via supply boat
CC Tools	20' container	Conventional Coring	NEW DNV	None	Required laydown area 10' x 60' to allow APC laydown and extraction of core; must be in-line with Core Receiving Lab	Geotek-APX/XCB handling, parts and supplies	Onboard, via supply boat
PCATS11	40' container	PCATS Analysis	Same as GOM2-1	Waste water drain	Attached to PCATS 8	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2-1	None	Attached to PCATS 11	Autoclave and PC storage handling, pressure core storage	Onboard, via supply boat, remobilize dockside
R17	20' container	Pressure Core storage and degassing	Same as GOM2-1	None		Pressure Core Storage, quantitative degassing	Onboard, via supply boat, remobilize dockside
Core Storage	20' container	Pressure and Conventional Core Storage	NEW DNV reefer	None	*Or within crane access, level walking access preferred	Pressure Core Storage, Conventional core storage racks, and core transport	Onboard, via supply boat, then dockside
Core Receiving Lab	40' container	Geotek Whole Core Processing Laboratory	NEW DNV	Power, water, air	Use same laydown area as CC Tools	MSCL-IR scanning, Void gas sampling, core sectioning, headspace gas sampling, sediment strength, Gas Chromatography, Data Processing	Onboard, via supply boat, remobilize dockside
Core Processing Lab	20' container	Microbiology, Headspace gas	Same as GOM2-1	Power (480v 3-phase), water, drain/sediment waste trap		Microbiology sub sampling, headspace gas processing	Onboard, via supply boat, remobilize dockside
Pore Water Lab	20' container	Pore Water Laboratory	NEW	Power, network, internet, intranet, desks		Pore water, squeezing, analysis, and storage	Onboard, via supply boat, remobilize dockside
3rd Party Conex	20' container	UT Office Space	Same as GOM2-1	None	TBD if required	Writing, Data Analysis	Onboard, via supply boat, remobilization dockside
T2P	Laydown Area	Wireline Pressure and Temperature Probe	NEW	Power (220 single phase)	Required laydown area 10 x 10 ft	T2P and PDT assembly	Onboard, via supply boat, remobilize dockside, possibly inside another container
Mud Engr Lab	20' container	Lab for Mud Engineer	Same as GOM2-1	Power, water, drain, vent, internet, desk	TBD if required	Mud checks, reports	Onboard, via supply boat

13.7.3 Personnel

13.7.3.1 Training

All personnel, prior to arriving on the vessel, will have completed all training and certifications required by their company and the Rig Contractor (e.g. Well Control, HUET, Rig Pass). The science team, Geotek, and the UT Drilling Representative(s) shall provide a copy of training/certification documentation and passport to UT the Project Manager prior arriving at the heliport for travel to the rig.

13.7.3.2 Travel to Heliport
Travel of all science team members to/from the heliport will be coordinated by UT. Travel of Rig Contractor, Geotek, and third-party personnel will be the responsibility of the company involved.

13.7.3.3 Travel to/from Rig
Transport of personnel between the heliport/shore-based facility and the rig will be coordinated between the UT Drilling Representative and the Rig Contractor. Transport of personnel will be primarily by helicopter. Helicopter trips will be scheduled/coordinated at maximum efficiency to reduce costs. At times, travel on crew boats or supply vessels may be required.

13.7.3.4 Passports / USCG Letter of Determination
All personnel will have a valid passport. Non-US citizens will also be required to have a USCG Letter of Determination allowing permission to work on the Outer Continental Shelf.

13.7.3.5 Rig Pass cards
Documentation denoting completion of the Rig Pass training program to be supplied by all personnel to the Rig Contractor, as required.

13.7.3.6 Luggage limits
All personnel will limit the size and weight of luggage under the assumption that they be transiting via helicopter.

13.7.3.7 Safety Management System
All personnel on-board the vessel will follow the Rig Contractor's Safety Management System. A bridging document will be prepared to identify and clarify which procedures/policies to follow if there are differences in policy between the Rig Contractor and UT. The highest standard will be followed.

13.7.3.8 Incident Notification
UT will prepare an Incident Notification document with flow chart and call list of contact names/numbers for Regulatory Agencies, UT Management, Geotek, UT Drilling Representative(s), and Science Team. BSEE notifiable incidents include: Fatalities, injuries that require evacuation, loss of well control, fires and explosions, spills > 1 bbl, reportable releases of hydrogen sulfide, collisions (equipment damage greater than $25,000), incidents involving crane or personnel/material handling operations, and incidents involving damage or disable safety systems or equipment including firefighting systems.

13.7.3.9 Shifts
All personnel will work a 12-hour shift. Shifts for the science team and Geotek will be coordinated prior to deployment. Rig Contractor and Third-Party Supervisors typically work a 6-6 shift (6 am to 6 pm or 6 pm to 6 am); with vessel and third-party crews working a 12-12 shift (noon to midnight or midnight to noon). The UT Drilling Representative(s), Principal investigator, and staff scientist will most likely work a 6-6 shift with the science team and Geotek will working on a 12-12 shift.

13.8 Demobilization from Rig

13.8.1 Materials and Equipment

13.8.1.1 Disembarking Materials and Equipment
The Rig Contractor will work with third party services, Geotek, and the UT Drilling Representative to ensure all supplies and equipment are removed from the vessel and delivered to the Shore Base. Prior

to backloading any Geotek equipment, Geotek will lead and UT will support a complete inventory of all Geotek equipment. Geotek to provide supervisory oversight while their equipment is being backloaded to the demobilization vessel. Third party providers are responsible for securing and supervising the backloading of their equipment. A list of cement and mud products to be returned is to be provided to the UT Drilling Representative prior to the third-party representative leaving the drilling vessel. The UT Drilling Representative is responsible for inventory, securing and backloading of all UT owned equipment including new equipment purchased for the project such as adapters & subs.

13.8.1.2 Equipment left onboard

Should equipment be accidently left onboard the drilling vessel; UT will work with the Rig Contractor to ensure timely delivery to the Shore Base.

13.8.1.3 New Equipment

Any newly acquired UT-owned equipment (e.g. BHA subs delivered from factory directly to Rig Contractor) will be properly catalogued and prepared for demobilization along with existing equipment.

13.8.1.4 Waste

The Rig Contractor will backload mud and cement waste and coordinate disposal in an accredited onshore disposal site. The Rig Contractor will also coordinate the cleaning of the bulk tanks on the demobilization vessel after equipment and waste has been removed.

13.8.2 Personnel

13.8.2.1 Science Team and Third Party

Transport of personnel to the heliport will be coordinated between the UT Drilling Representative and the Rig Contractor. Helicopter flights will be scheduled/coordinated at maximum efficiency to reduce costs.

13.8.2.2 Pressure Core Observers

Geotek will elect two personnel to accompany the pressure cores on the demobilization vessel to ensure proper temperature and pressure is maintained in the transport containers at all times.

13.9 Remobilization Dockside

Pressure and conventional core processing will continue dockside in a dedicated area within the Shore Base. The processing area will be set-up using a number of containers demobilized from the rig. Additional containers and equipment will be mobilized to the processing area to complete the site.

13.9.1 Geotek Site Plan

Dockside container layout & hook-up will be as per the Geotek Site Plan (see Figure 13-1below for example plan). Geotek will be responsible for coordinating the order of hook up & deck layout of the containers at the dock. Hook-up includes appropriate dunnage, inclement weather engineering controls, power generators, fuel bowsers, air, water, etc.

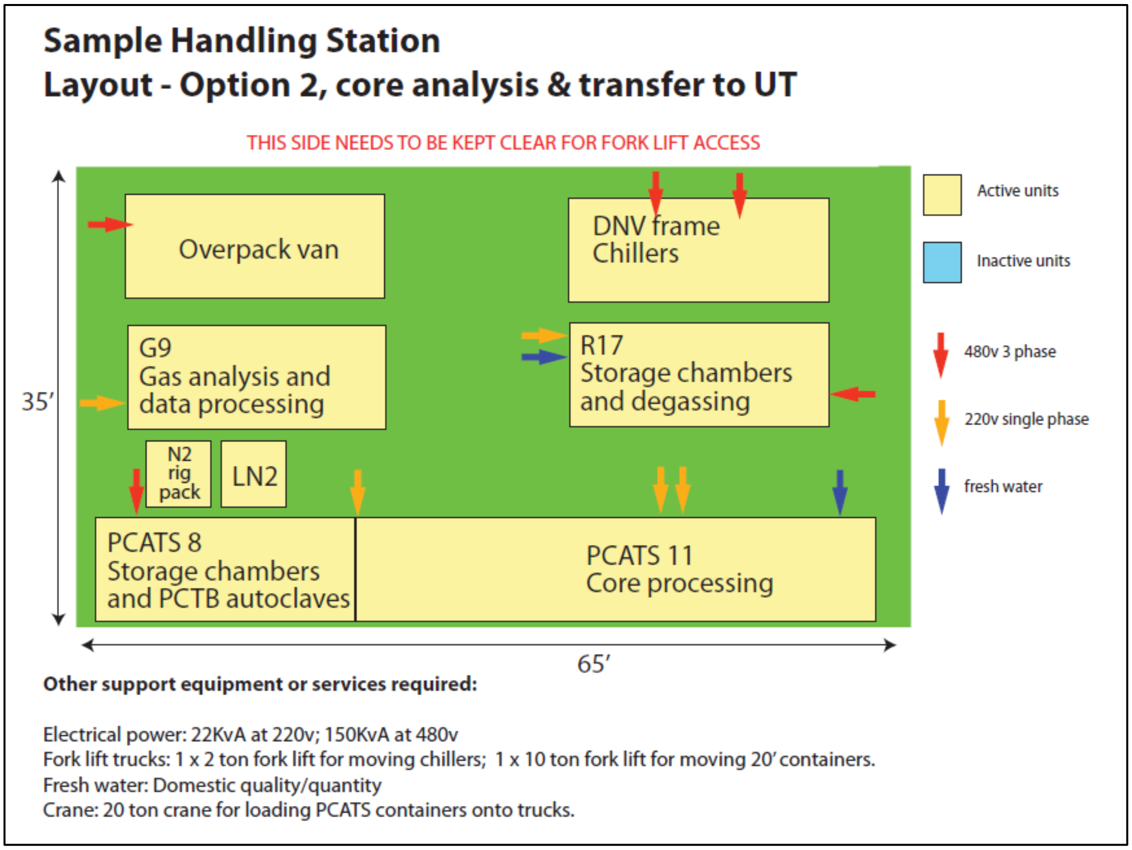


Figure 13-1. Example of Geotek Site Plan

13.9.2 Dockside Containers

Pressure core operations and analysis will require 3 containers to be remobilized dockside. Geotek will have a 40+20-ft container (for PCATS operations and storage chamber storage), and a 20-ft container for pressure core storage and degassing). The Geotek 40-ft trailer for the PCTB will be transferred to a TBD location for cleaning and preparation for long term storage.

Conventional core operations will require 6 containers, 4 remobilized and 2 new. Geotek will provide a new (not from the vessel) 20-ft trailer for MSCL scanning and CT imaging. The Geotek 40-ft container for whole core receiving and 20-ft container for core storage will be remobilized. UT’s 20-ft container for whole round sampling will need to be remobilized dockside (TBD). UT’s pore water container for pore water analysis will need to be remobilized dockside. Geotek will provide a 40-ft container for split core scanning, layout, and analysis. This 40-ft container will be fitted with an exterior covered lay down area for core splitting.

The UT 20-ft Office will need to be brought to the dock or remobilized dockside if it was needed on-board (TBD).

All containers require dunnage, which will be provided by the Shore Base Operator (contracted through the Rig Contractor). PCATS and the mud lab require drainage to a stillage. The Shore Base Operator will provide the stillage.

A reefer truck with the Geotek overpack system, two power generators, and a fuel bowser will be mobilized dockside.

Expected container requirements for the dockside core-processing operations are summarized in Table 13-2 below.

Table 13-2. Dockside Container - name, type and size, container description, comparison to the previous expedition, container activities, mobilization location, and required hook-up

Name	Type	Description	Reuse or New	Required demobilization supply boat Hook-up	Required Dockside Hook-up	Activities	Mobilization/ demobilization
PCATS11	40' container	PCATS Analysis	Same as GOM2-1	None	Power (2 - 220v single-phase), water, air, Network/Internet, timber supports	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2-1	Power	Power (480v 3-phase, 220v single-phase), air, timber supports	Autoclave and PC storage handling, pressure core storage	Onboard, via supply boat, remobilize dockside
R17	20' container	Pressure Core storage and degassing	Same as GOM2-1	Power	Power (480v 3-phase, 220v single-phase), water, air	Pressure Core Storage, quantitative degassing, gas sampling	Onboard, via supply boat, remobilize dockside
Core Storage	20' container	Pressure and Conventional Core Storage	NEW	Power	Power (480v 3-phase, 220v single-phase), water, air	Pressure and Conventional core storage racks, and core transport	Onboard, via supply boat, send to Stratum Reservoir, then dockside, then archival halves to storage facility
Core Receiving Lab	40' container	Geotek Whole Core Processing Laboratory	NEW DNV	Power	Power, air	Core splitting, gas chromatography, data analysis	Onboard via supply boat, remobilize dockside
Core Processing Lab	20' container	Microbiology, headspace gas	Same as GOM2-1	TBD	Power (480v 3-phase), water, drain	Microbiology sub sampling, headspace gas processing	Onboard, via supply boat, remobilize dockside
Pore Water Lab	20' container	Pore Water Laboratory	NEW	TBD	Power (480v 3-phase), water, drain	Pore Water Squeezing, Analysis, and storage	Onboard, via supply boat, remobilize dockside
3rd Party Conex	20' container	UT Office Space	Same as GOM2-1	None	Power, network, internet, desk	Writing, Data Analysis	Onboard, via supply boat, remobilization dockside is TBD
MSCL /X-ray	20' container	Core Scanning, Core imaging	NEW	NA	Power, water, air	Conventional Whole core scanning	Dockside only
Split Core Lab	40' container with 'tent'	Split Core Analysis	NEW	NA	Power, water, air	Split core scanning, layout, M&D weights, smear slide prep and sample preservation	Dockside only
Overpack	40' Reefer Truck	Overpack reefer truck	Same as GOM2-1	NA	None	Pressure Core Transport over land	Dockside only
Gen1		Power Generator #1	Same as GOM2-1	NA	None	NA	Dockside only
Gen2		Power Generator #2	Same as GOM2-1	NA	None	NA	Dockside only
Fuel		Fuel Bowser	Same as GOM2-1	NA	None	NA	Dockside only

13.10 Dockside Core Processing

13.10.1 Samples and Cores

Detailed movement and processing of samples and cores will be as outlined in the UT-GOM2-2 Science and Distribution Plan.

13.10.2 Reporting

UT will provide a daily update to the UT-GOM2-2 Advisory Team with additional updates as required. UT will maintain close contact with GOM2 project manager, program manager, and IT support team.

13.10.3 Personnel

13.10.3.1 Room and Board

UT personnel will coordinate room and board for the onshore/dockside science team. Third party members (e.g. Geotek) will be responsible for coordinating their own accommodations.

13.10.3.2 Shifts

Shift duration and timing will be decided by PI, staff scientist, and Geotek leads.

13.10.3.3 Supplies and Equipment

Shipment of supplies and equipment will be coordinated between UT, Geotek, and the Dockside Dispatcher.

13.10.3.4 Safety Management System

All personnel dockside will follow the port safety procedures. A bridging document will be prepared to identify and clarify which procedures/policies to follow if there are differences in policy between the Vessel Operator and UT. The highest standard will be followed.

13.10.3.5 Incident Notification

UT will prepare an Incident Notification document with flow chart and call list of contact names/numbers for Regulatory Agencies, UT Management, Geotek, and Science Team.

13.11 Demobilization from Dockside

Demobilization will be coordinated by Geotek, UT, and the Port Management. Exact division of responsibility will be agreed upon prior to departure but is dependent on yet to be decided factors, e.g. dockside location.

14 List of Acronyms

Table 14-1. List of Acronyms

ACRONYM	DEFINITION
°C	degrees Celsius
3D	3-Dimensional
APC	Advanced Piston Corer
API	American Petroleum Institute radioactivity unit
bbl	barrel
BHA	Bottom Hole Assembly
BHSZ	Base of Hydrate Stability Zone
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Bottom Simulating Reflector
cm	centimeter
CPP	Complimentary Project Proposal
CT	Computed Tomography
DNA	Deoxyribonucleic Acid
DNV	De Norske Veritas AS
DOE	Department of Energy
DOT	Department of Transportation
fbsf	feet below sea floor
fbsl	feet below sea level
ft	feet
ft^2	square feet
g/cm3	gram per cubic centimeter
GAPC	Geotek Advanced Piston Corer
GC	Gas Chromatography
GHSZ	Gas Hydrate Stability Zone
GR	Gamma Ray
GRMA	Gamma Ray, Average
GWC	gas-water contact
GXCB	Geotek eXtended Core Barrel
HRZ	Horizon
HUET	Helicopter Underwater Escape Training
IEU	Internal-External Upset
IR	Infrared
JIP	Joint Industry Project
JR	JOIDES Resolution
LA	Louisiana
lb	pounds
LDEO	Lamont-Doherty Earth Observatory
LWD	Logging While Drilling
m	meter
m/s	meter per second
MD	Measured Depth

ACRONYM	DEFINITION
mm	millimeter
MODU	Mobile Offshore Drilling Unit
MSCL	Multi-Sensor Core Logger
msl	mean sea level
MTD	Mass Transport Deposits
NAD	North American Datum
NE	Northeast
NEPA	National Environmental Policy Act
NNE	North-Northeast
NPDES	National Pollutant Discharge Elimination System
PC	Pressure Core
PC	Pressure Core
PCATS	Pressure Core Analysis and Transfer System
PCTB	Pressure Coring Tool with Ball-Valve
PCTB-CS	Pressure Coring Tool with Ball-Valve - Cutting Shoe
PCTB-FB	Pressure Coring Tool with Ball-Valve - Face Bit
PDC	Polycrystalline Diamond Compact
PI	Principle Investigator
PPG	Pounds Per Gallon
psi	pounds per square inch
psi/ft	pounds per square inch, per foot
RAID	Redundant Array of Independent Disks
RES	Resistivity
RKB	Rotary Kelly Bushing (depth reference point)
RNA	Ribonucleic Acid
ROP	Rate of Penetration
ROV	Remotely Operated Vehicle
S_h	Hydrate Saturation (expressed as a % of pore volume)
sks	sacks
SMT	Sulfate-Methane Transition
SSW	South-Southwest
SW	Southwest
T2P	Temperature to Pressure Probe
TBD	To Be Determined
TD	Total Depth
TVD	Total Vertical Depth
UNH	University of New Hampshire
US	The United States of America
USCG	United States Coast Guard
USGS	United States Geological Survey
UT	The University of Texas at Austin
UTIG	The University of Texas at Austin Institute for Geophysics
UTM	Universal Transverse Mercator
UW	University of Washington
V_p	P-Wave Velocity

ACRONYM	DEFINITION
WBM	Water Based Mud
WR	Walker Ridge
XCB	eXtended Core Barrel
XCT	X-ray Computed Tomography

15 References

Boswell, R., Collett, T. S., Frye, M., Shedd, W., McConnell, D. R., and Shelander, D., 2012a, Subsurface gas hydrates in the northern Gulf of Mexico: Marine and Petroleum Geology, v. 34, no. 1, p. 4-30.

Boswell, R., Frye, M., Shelander, D., Shedd, W., McConnell, D. R., and Cook, A., 2012b, Architecture of gas-hydrate-bearing sands from Walker Ridge 313, Green Canyon 955, and Alaminos Canyon 21: Northern deepwater Gulf of Mexico: Marine and Petroleum Geology, v. 34, no. 1, p. 134-149.

Boyer, T. P., Baranova, O. K., Coleman, C., Garcia, H. E., Grodsky, A., Locarnini, R. A., Mishonov, A. V., O'Brien, T. D., Paver, C. R., Reagan, J. R., Seidov, D., Smolyar, I. V., Weathers, K., and Zweng, M. M., 2018, World Ocean Database 2018, NOAA Atlas NESDIS 87: Silver Spring, MD, NOAA.

Collett, T. S., Boswell, R., Frye, M., Shedd, W., Godfriaux, P., Dufrene, R., McConnell, D., Mrozewski, S., Guerin, G., Cook, A., Jones, E., and Roy, R., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Operational Summary.

Collett, T. S., Boswell, R., Frye, M., Shedd, W. W., Godfriaux, P. D., Dufrene, R. S., McConnell, D. R., Mrozewski, S., Guerin, G., Cook, A., Jones, E., and Roy, R., 2010, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II: Logging-While-Drilling Operations and Challenges, Offshore Technology Conference, Offshore Technology Conference.

Cook, A. E., Anderson, B. I., Malinverno, A., Mrozemski, S., and Goldberg, D. S., 2010, Electrical anisotropy due to gas hydrate-filled fractures: Geophysics, v. 75, no. 6, p. 13.

Cook, A. E., Goldberg, D. S., and Malinverno, A., 2014, Natural gas hydrates occupying fractures: A focus on non-vent sites on the Indian continental margin and the northern Gulf of Mexico: Marine and Petroleum Geology, v. in press, p. doi:10.1016/j.marpetgeo.2014.1004.1013.

Eaton, B. A., 1969, Fracture gradient prediction and its application in oil field operations: Journal of Petroleum Technology, v. 21, no. 10, p. 1353-1360.

Flemings, P. B., Phillips, S. C., Collett, T. S., Cook, A. E., Boswell, R., and Scientists, U.-G.-E., 2018, UT-GOM2-1 Hydrate Pressure Coring Expedition Methods, *in* Flemings, P. B., Phillips, S. C., Collett, T. S., Cook, A. E., and Boswell, R., eds., Proceedings of the UT-GOM2-1 Hydrate Pressure Coring Expedition: Austin, TX, University of Texas Institute for Geophysics.

Frye, M., Shedd, W., and Boswell, R., 2012, Gas hydrate resource potential in the Terrebonne Basin, Northern Gulf of Mexico: Marine and Petroleum Geology, v. 34, no. 1, p. 150-168.

Hillman, J. I. T., Cook, A. E., Daigle, H., Nole, M., Malinverno, A., Meazell, K., and Flemings, P. B., 2017, Gas hydrate reservoirs and gas migration mechanisms in the

Terrebonne Basin, Gulf of Mexico: Marine and Petroleum Geology, v. 86, no. Supplement C, p. 1357-1373.

Shedd, W., Frye, M., Godfriaux, P., Dufrene, R., McConnell, D., Boswell, R., Collett, T., Mrozewski, S., Guerin, G., Cook, A., Shelander, D., and Dai, J., 2010, Gulf of Mexico Gas Hydrates Joint Industry Project Leg II: Results from the Walker Ridge 313 Site, Offshore Technology Conference.

Thomas, C., Phillips, S. C., Flemings, P. B., Santra, M., Hammon, H., Collett, T. S., Cook, A. E., Pettigrew, T., Mimitz, M., Holland, M., and Schultheiss, P., 2020, Pressure coring operations during The University of Texas-Gulf of Mexico 2-1 (UT-GOM2-1) Hydrate Pressure Coring Expedition in Green Canyon Block 955, northern Gulf of Mexico: AAPG Bulletin, v. 104, no. 9, p. 1877-1901.