Oil & Natural Gas Technology

DOE Award No.: DE-FE0023919

Quarterly Research Performance Progress Report (Period Ending 12/31/2015)

Deepwater Methane Hydrate Characterization and Scientific Assessment

Project Period 10/01/2014 – 09/30/2020

Submitted by:
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Signature

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Office of Fossil Energy

1. ACCOMPLISHMENTS:

A. What are the major goals of the project?

The goals of this project are to plan and execute a state of the art field program in the Gulf of Mexico to characterize methane hydrates. The project team will acquire conventional core, pressure core, and downhole logs, and perform in situ testing and measure physical properties in methane hydrate reservoirs in the Gulf of Mexico (GOM) to meet this goal.

Previous Milestones

Milestone Description	Status
M1A: Project Management Plan	Complete: 03/18/2015
M1B: Project Kick-off Meeting	Complete: 12/11/2014
M1C: Site Location and Ranking Report	Complete: 9/30/2015
M1D: Preliminary Field Program Operational Plan Report	Complete: 9/30/2015
M1E: Updated CPP Proposal Submitted	Complete: 10/1/2015
M1F: Demonstration of a viable PCS Tool	Complete: 9/30/2015

Table 1: Milestones BP1

Current Milestones

Milestone Description	Status	Verification Method	Comments
M1G: Document results of BP1/Phase 1 Activities	Submitted	Phase 1 Report	
M2A: Complete Updated CPP Proposal Submitted	Complete: 11/2/2015 (BP3, Q1)	Quarterly Report	Update given in Y2Q1 report
M2B: Scheduling of Hydrate Drilling Leg by IODP	Planned: 5/18/2016 (BP2, Q3)	report status immediately to DOE PM	
M2C: Demonstration of a viable PCS tool for hydrate drilling through completion of land-based testing	Complete: 12/21/2015 (BP2, Q5)	PCTB Land Test Report, in Quarterly Report	Update given in Y2Q1 report
M2D: Demonstration of a viable PCS tool for hydrate drilling through completion of a deepwater marine field test	Planned: 1/2/2017 (BP2, Q6)	Marine Field Test Report, in Quarterly Report	
M2E: Complete Refined Field Program Operation Plan	Planned9/26/2017 (BP2, Q8)	Quarterly Report	

Table 2: Milestones BP2

Future Milestones

Milestone Description	Planned Completion	Verification Method
M2F: Document results of BP2/Phase 2 Activities	12/29/2017 (BP3A, Q1)	Phase 2 Report
M3A: Field Program Operational Plan report	12/18/2018 (BP3A, Q5)	Quarterly Report

M3B: Completion of Field Program Permit	12/9/2018 (BP3A, Q5)	Quarterly Report
M3C: Completion of Hazards Analysis	10/9/2018 (BP3A, Q5)	Field Program Hazards Report, in Quarterly Report
M3D: Demonstration of a viable PCS tool for hydrate drilling through completion of field operations	4/4/2019 (BP3A, Q7)	Quarterly Report
M3E: Complete IODP Preliminary Expedition Report	6/27/2019 (BP3A, Q7)	Send directly to DOE PM
M3F: Complete Project Sample and Data Distribution Plan	8/8/2019 (BP3A, Q8)	Send directly to DOE PM
M3G: Initiate Expedition Scientific Results Volume	4/3/2020 (BP3B, Q3)	Send directly to DOE PM
M3H:Complete IODP Proceedings Expedition Volume	8/24/2020 (BP3B, Q4)	Send directly to DOE PM

Table 3: Milestones BP3A, and BP3B

B. What was accomplished under these goals?

PREVIOUS – BUDGET PERIOD 1:

Task	**Status**	**Quarterly Report with Task Information**
Task 2.0 Site Analysis and Selection	Complete	Y1Q1, Y1Q2, Y1Q3, Y1Q4
Task 3.0 Develop Pre-Expedition Drilling/Logging/Coring/Sampling Operational Plan	Complete	Y1Q3, Y1Q4
Task 4.0 Complete and Update IODP CPP Proposal	Completed submissions within BP1 dates	Y1Q2, Y1Q3, Y1Q4
Task 5.0 Pressure Coring and Core Analysis System Modification and Testing	Complete	Y1Q2, Y1Q3, Y1Q4

CURRENT - BUDGET PERIOD 2:

Task 1.0 Project Management and Planning

Status: On Schedule

Objectives and Achievements

Objective 1: Assemble teams according to project needs.

- Recruited and hired Project Manager for Marine Test

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

- Managed the upload of CPP supporting data

- Coordinated logistics of PCTB land test
- Monitored costs

Objective 3: Communicate with project team and sponsors
- Organized regular team meetings
  - Monthly Sponsor Meetings
  - Monthly Mapping Team Meetings
  - Monthly PCTB Development Team Meetings
- Managed SharePoint sites developed for each project team to facilitate online communication and collaboration
- Managed email list serves for key project teams
- Managed archive/website for project deliverables

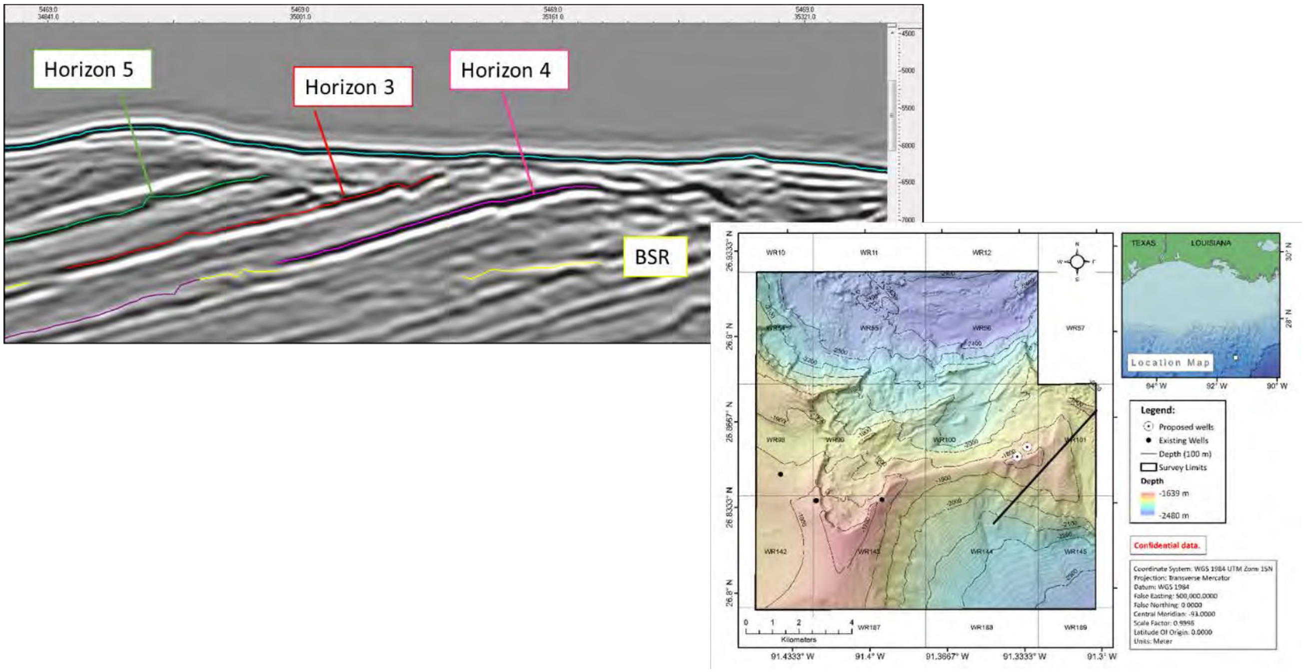
Objective 4: Coordinate and supervise all subcontractors and service agreements to realize deliverables and milestones according to the work plan
- Actively managed subcontractors and service agreements.

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

Task 6.0: Technical and Operational Support of CPP Proposal

Status: On Schedule

1. Upload of data, associated with the CPP proposal, to a designated site-survey databank
   a. Worked to update and submit the required data for the IODP Proposal Databank, and submitted the data for the Nov 1 deadline.
   b. Organized and orchestrated the delivery of the proprietary 3D seismic data to the co-chair of SEP so that the data and the GOM2 project can be evaluated by IODP
2. Refining the planned science within the CPP proposal, and the project in general
   a. Purchased additional data at the Orca Basin site and began work on additional mapping and prospecting in the Orca Basin area
   b. Research conducted during Q1 involved data preparation, reprocessing, and analysis of (existing) USGS seismic lines near GOM2 (GC and WR) site locations.
   c. Reviewed Operational Plan for the IODP---CPP drilling campaign, which includes drill site sequence, core and logging data acquisition, and rig time estimates in preparation for the IODP---CPP proposal technical review.
   d. Discussions with project team members regarding potential additional site locations.



Task 7.0: Continued Pressure Coring and Core Analysis System Modifications and Testing

Status: On Schedule

Subtask 7.1: Review and Complete NEPA Requirements (PCTB Land Test)

Status: Complete

Submitted and received approval for PCTB Land Test NEPA Requirements Y2Q1.

Subtask 7.2: Pressure Coring Tool with Ball (PCTB) Land Test

Status: Complete

1. Completed contracting with vendors for land test
2. Created test plan
3. Created core recovery plan
4. Fabrications for Land Test
    a. 9 7/8 bit, bit sub, and stabilizer
    b. 5 - 10 core liners shortened by 5”
    c. 5 - 10 skirted spring core lifters

Subtask 7.3: PCTB Land Test Report

Status: Complete

See Appendix A: GOM^2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST INITIAL REPORT

Subtask 7.4: PCTB Tool Modification

Status: On Schedule

At various PCTB Team meetings tool modifications were discussed. The discussions and meeting details are summarized below.

Motivation:

During the recent India hydrate expedition two problems were observed (abstracted from a document by Tim Collett):

1. Most importantly, tool performance was reduced in thick, relatively massive, sand units (medium- to fin-grained) with high gas hydrate saturations. This is a reservoir type that was must be able to sample with a relatively high degree of success in the Gulf of Mexico.
2. Within highly interbedded systems (with gas hydrate in sands, water bearing sands, and mud-rich Sections with no gas hydrate) it was difficult to sample. Can additional bit and cutting shoe designs help with this issue?

Objectives:

1. Generate a list of potential modifications and/or upgrades that should be considered for incorporation in the PCTB to improve core quality and quantity.
2. Specify modifications as short term, being able to implement in time for the December land test, or long term, not being able to implement in time for the December land test, and estimated cost.
3. Identify any modifications thought to be critical to the PCTB performance and that must be made before any further testing takes place.
4. Determine if the land test scheduled for December this year should be delayed or not. Note, next open testing window at CTTF is 28 April 2016.

Notes:

The discussion covered a wide spectrum of factors that may potentially affect core recovery. From this discussion seven factors were identified for possible further study.

1. Main bit diameter to core diameter ratio.
2. Cutting shoe extension.
3. Number and placement of stabilizers.
4. Core catcher configurations and combinations.
5. Main bit configuration, tapered, piloted, etc.
6. Composition of drilling fluids to enhance core recovery.
7. Bumper subs.

1. <u>Main Bit Diameter to Core Diameter Ratio</u>

   Past industry experience has shown that the smaller the main bit diameter to core diameter ratio is, the better core recovery is. Currently the PCTB uses a 10-5/8" diameter main bit cutting a 2" diameter core for a ratio of 5.31. Given the size of the drill collars, 8-1/2" diameter, the smallest main bit diameter that can be employed is ~9-7/8". This combination results in a ratio of 4.94 or 93 percent of that of the 10-5/8" main bit.

2. Cutting Shoe Extension

   Currently the PCTB cutting shoe extends approximately 0.6" beyond the main bit face in the cutting shoe configuration and is fixed, i.e., non-retractable. Suggestions have been made that extending the cutting shoe further ahead of the main bit may result in better core recovery. The theory is that it may move the area where the core is being cut/trimmed further away from where the main bit is drilling the borehole and thus further removed from the stresses and disturbance produced by the main bit.

3. Number and Placement of Stabilizers

   Past industry experience has shown that the use of at least two stabilizers in the BHA can improve core recovery. The stabilizers help to eliminate bit whirl and harmonic vibration. Currently the PCTB BHA incorporates a stabilizer in the bit sub located approximately 4 ft above the face of the main bit. It is suggest that at least one additional stabilizer be incorporated in the BHA at the top of the outer core barrel assembly, approximately 44 ft above the face of the main bit.

4. Core Catcher Configurations and Combinations

   To date the PCTB has been deployed almost exclusively with a single basket core catcher. On occasion the PCTB has been recovered with the basket core catcher damaged and with little or no core trapped. The discussion centered around deploying multiple core catcher types including, basket, spring or wedge, clam shell, and full closure. Given the restricted geometry of where the core catchers reside inside the PCTB it may not be possible to incorporate a clam shell or full closure core catcher, however, this needs to be looked into.

5. Main Bit Configuration, Tapered, Piloted, Etc.

   Main bit configuration was discussed regarding changing the cutting structure profile to further separate the borehole cutting action from the core cutting/trimming action. A tapered bit face profile was suggested as was a piloted or stair step profile. Further investigation into what bit face configurations are utilized in the industry is warranted.

6. Composition of Drilling Fluids to Enhance Core Recovery

   Industry experience has shown that the type of drilling fluid used can improve core recovery. However, typically industry uses a riser system so as to enable circulation of the drilling fluid. Given the current program utilizes "pump and dump", i.e., riserless drilling, further study of the types of drilling fluids used in industry and their applicability to a pump and dump operation is warranted.

7. Bumper Sub

   During the discussion, it was stated that industry often utilizes a bumper sub in the BHA to remove residual heave from the bit, thus improving core recovery. A better understanding of the use of a bumper sub in conjunction with a heave compensator is needed to determine if a bumper sub can be incorporated into the PCTB BHA.

Actions This Quarter:

Modification determined not viable:

- Cutting shoe extension – would require complete tool redesign

Modifications determined impactful and necessary for the Land Test:

- Main Bit Diameter to Core Diameter Ratio: 9-7/8" bit, bit sub, and stabilizer. These were manufactured and used at the December Land Test.

Modifications that need further review:

In the next quarter we will review additional options with Subject Mater Experts (SME) and come to consensus on modifications/studies. Pending more investigation these are the main areas for possible modification.

- Bit fabrication for Marine Test
- Additional stabilizers in the BHA
- Clam shell full closure catcher study
- Alternate bit design (tapered, piloted, etc)
- Composition of drilling fluids
- Bumper subs

Task 8.0: Pressure Coring Tool with Ball (PCTB) Marine Field Test

Status: On Schedule

1. Target dates: March 2017 – May 2017
2. Hired Project Manager
3. Bids received for platform negotiations

See Appendix B: GOM^2 MARINE BASED TEST GEOTECHNICAL SOW

Subtask 8.1: Review and Complete NEPA Requirements

Status: On Schedule

Began process of collecting information for NEPA paperwork.

Subtask 8.2: Marine Field Test Detailed Drilling / Logging / Coring / Sampling Operational Plan

Status: Future Task

Subtask 8.3: Marine Field Test Documentation and Permitting

Status: Future Task

Decision Point 2: Marine Field Test Stage Gate

Subtask 8.4: Marine Field Test of Pressure Coring System

Status: Future Task

Subtask 8.5: Marine Field Test Report

Status: Future Task

Task 9: Pressure Core Transport, Storage, and Manipulation

Status: On Schedule

Subtask 9.1: Review and Complete NEPA Requirements (Core Storage and Manipulation)

Status: On Schedule

Submitted NEPA paperwork for approval.

Subtask 9.2: Hydrate Core Transport

Status: Future Task

On hold pending completion of NEPA requirements

Subtask 9.3: Storage of Hydrate Pressure Cores

Status: Future Task

On hold pending completion of NEPA requirements

Subtask 9.4: Refrigerated Container for Storage of Hydrate Pressure Cores

Status: Future Task

On hold pending completion of NEPA requirements

Subtask 9.5 – 9.7: Hydrate Core Manipulator and Cutter Tool, Hydrate Core Effective Stress Chamber, Hydrate Core Depressurization Chamber

Status: Future Task

On hold pending completion of NEPA requirements

Task 10.0 Pressure Core Analysis

Status: On Schedule

Began planning for acquisition of pressure cores and petrophysical and seismic data integration efforts for the PCTB Marine Field Test.

Subtask 10.1: Routine Core Analysis

Status: Future Task

Subtask 10.2: Pressure Core Analysis

Status: Future Task

Subtask 10.3: Hydrate Core-Log-Seismic Synthesis

Status: Future Task

Task 11.0: Update Pre-Expedition Drilling / Logging / Coring / Sampling Operational Plan (Field Program / Research Expedition)

Status: On Schedule

Revisions in response to CPP review by IODP SEP committee and changes in project plans, as required. These included reprocessed high---resolution seismic profiles, additional/revised site locations and target depths, updates to the Preliminary Rig Time Estimate and the GOM2 Operational Plan.

Task 12.0: Field Program / Research Expedition Vessel Access

Status: Future Task

Decision Point 3: Budget Period Continuation

FUTURE – BUDGET PERIOD 3, & 3A: Not Started

C. What opportunities for training and professional development has the project provided?

Continued training 4 graduate students (2 at UT, 2 at Ohio State) and two post-doctoral scientists (one at UT, one at Ohio State) in geological mapping with seismic data.

D. How have the results been disseminated to communities of interest?

This project has only begun. However, we have several abstracts submitted to AGU and will be participating in upcoming Gordon Conference:

Cook, A., Hillman, J., Sawyer, D., 2015, Gas migration in the Terrebonne Basin gas hydrate system, Abstract OS23D-05 presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

Cook, A., Hillman, and D., 2015, Methane migration in the Terrebonne Basin gas hydrate system, Gulf of Mexico, presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

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

Meazell, K., 2015, Methane hydrate-bearing sediments in the Terrebonne basin, northern Gulf of Mexico , Abstract OS23B-2012 to be presented at 2015 Fall Meeting, AGU, San Francisco, CA., 14-18 Dec.

Phillips, S.C., Flemings, P.B., Meyer, D.W., You, K., Kneafsey, T.J., Germaine, J.T., Solomon, E.A., and Kastner, M., 2016, Extraction of pore fluids at in situ pressures from methane hydrate experimental vessels, Poster to be presented at 2016 Gordon Research Conference from Feb28 to Mar04 in Galveston, TX, United States.

E. What do you plan to do during the next reporting period to accomplish the goals?

Task 1.0: Project Management and Planning (continued from prior phase)

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

A key goal of the next quarter is to finish analysis of three potential offshore drilling companies for drilling for the Marine Test. At the conclusion of our analysis, the leadership team will review the potential contractors to select the most appropriate one.

Task 8.0: Pressure Coring Tool with Ball (PCTB) Marine Field Test

Work to set date of Marine Field Test, complete requirements for Decision Point 2.

Task 9: Pressure Core Transport, Storage, and Manipulation

Begin process of design and purchase equipment and storage at UT Austin.

2. PRODUCTS:

A. Publications, conference papers, and presentations

Cook, A., Hillman, J., Sawyer, D., 2015, Gas migration in the Terrebonne Basin gas hydrate system, Abstract OS23D-05 presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

Cook, A., Sawyer, D., 2015, Methane migration in the Terrebonne Basin gas hydrate system, Gulf of Mexico , presented at 2015, Fall Meeting, AGU, San Francisco, CA, 14-18 Dec.

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B. Website(s) or other Internet site(s)

Project Website: http://www.ig.utexas.edu/gom2/

Project SharePoint: https://sps.austin.utexas.edu/sites/GEOMech/doehd/teams/

C. Technologies or techniques

Nothing to Report.

D. Inventions, patent applications, and/or licenses

Nothing to Report.

E. Other products

Nothing to Report.

3. CHANGES/PROBLEMS:

A. Changes in approach and reasons for change

Nothing to report.

B. Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report.

C. Changes that have a significant impact on expenditures

Nothing to report

D. Change of primary performance site location from that originally proposed

Nothing to Report.

4. SPECIAL REPORTING REQUIREMENTS:

CURRENT - BP2 / Phase 2

Task 1 – Revised Project Management Plan

Subtask 7.03 – PCTB Land Test Report

Subtask 8.05 – Pressure Core Marine Field Test Report

Task 11 – Refined Field Program Operational Plan Report

FUTURE - BP 3 / Phase 3

Phase 3A

A Phase 3A Report encompassing the refined Operational Plan, pressure coring team report, and permitting report

Task 14 - Field Program Operational Plan report

Task 15 – Field Program Hazards Report

Phase 3B

Task 16 – IODP Preliminary Expedition Report

Task 18 – Project Sample and Data Distribution Plan

Task 18 – IODP Proceedings Expedition Volume

Task 18 – Expedition Scientific Results Volume

5. BUDGETARY INFORMATION:

Budget Period 2 cost summary is outlined in Table 4 below.

Baseline Reporting Quarter	Budget Period 2							
	Q1		Q2		Q3		Q4	
	10/01/15-12/31/15		01/01/16-03/31/16		04/01/16-06/30/16		07/01/16-09/30/16	
	Q1	Cumulative Total	Q2	Cumulative Total	Q3	Cumulative Total	Q4	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 1,805,358	$ 1,805,358	$ 1,327,931	$ 3,133,289	$ 492,932	$ 3,626,221	$ 492,932	$ 4,119,153
Non-Federal Share	$ 471,771	$ 471,771	$ 471,771	$ 943,542	$ 471,771	$ 1,415,313	$ 471,771	$ 1,887,085
Total Planned	$ 2,277,129	$ 2,277,129	$ 1,799,702	$ 4,076,831	$ 964,703	$ 5,041,534	$ 964,703	$ 6,006,238
Actual Incurred Cost								
Federal Share	$ 790,502	$ 790,502						
Non-Federal Share	$ 267,114	$ 267,114						
Total Incurred Cost	$ 1,057,616	$ 1,057,616						
Variance								
Federal Share	$ (1,014,856)	$ (1,014,856)						
Non-Federal Share	$ (204,657)	$ (204,657)						
Total Variance	$ (1,219,514)	$ (1,219,514)						
	Q5		Q6		Q7		Q8	
	10/01/15-12/31/15		01/01/16-03/31/16		04/01/16-06/30/16		07/01/16-09/30/16	
	Q5	Cumulative Total	Q6	Cumulative Total	Q7	Cumulative Total	Q8	Cumulative Total
Baseline Cost Plan								
Federal Share	$ 1,096,922	$ 5,216,075	$ 10,209,921	$ 15,425,996	$ 1,001,922	$ 16,427,918	$ 1,001,922	$ 17,429,840
Non-Federal Share	$ 848,569	$ 2,735,654	$ 848,569	$ 3,584,223	$ 848,569	$ 4,432,792	$ 848,569	$ 5,281,361
Total Planned	$ 1,945,491	$ 7,951,729	$ 11,058,490	$ 19,010,219	$ 1,850,491	$ 20,860,710	$ 1,850,491	$ 22,711,201
Actual Incurred Cost								
Federal Share								
Non-Federal Share								
Total Incurred Cost								
Variance								
Federal Share								
Non-Federal Share								
Total Variance								

Table 4

Appendix A

GOM^2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST INITIAL REPORT

Submitted by:
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GOM^2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST INITIAL REPORT

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Executive Summary:

The UT DOE Hydrates program performed a field test of the PCTB tool at the Schlumberger Cameron Test and Training Facility. This field test involved 3 Flow Tests, 4 Closure Tests, and 8 Coring Tests.

The first two Flow Tests (one in the 10⅝” face-bit configuration, one in the 9⅞” cutting-shoe configuration) indicated that the standpipe pressure (pressure at the rig floor) would reach the expected 330 psi liner-collapse pressure at a flow rate of ~200 Gpm. The liner did not collapse at these flow rates and pressures. A third Flow Test, a liner-collapse test, demonstrated that the liner would collapse at a standpipe (rig floor) pressure of 775 psi with a flow rate of 400 Gpm.

Closure Tests in the 9⅞” cutting-shoe configuration were partially successful, but two runs had problems with a late or slow charge in the N_2 boost. The slow charge was discovered to be due to human error in setting up the tool.

In four Coring Tests in the 9⅞” cutting-shoe configuration, the ball valve did not close due to material (cuttings or core) that was trapped in the ball valve. One Coring Test in the 9⅞” cutting-shoe configuration recovered core under pressure, but the N_2-boost occurred near the rig floor after pressures inside the liner had dropped to nearly atmospheric conditions. Three final Coring Tests with the 10⅝” face-bit configuration were more successful with the final two tests recovering core under pressure. For both tools, coring penetration rates were very low and in the more mudstone rich penetrations, the jets on the cutting-shoe became clogged with rock paste.

The tests demonstrated the successful operation of the PCTB despite slow coring in the rock formations present at the Cameron Facility. Late firing of the N_2 boost after the core barrel was raised from the bottom occurred in 1 of 4 Closure Tests and 1 of 8 Coring Tests. The face-bit configuration was more successful than the cutting-shoe configuration in coring the mudstone and limestone formations at the Cameron location. This configuration appeared to have less problems with balling at the bit and was more successful at recovering core.

1. Introduction:

The UT DOE Hydrates program performed a field test of the PCTB ('Pressure Core Tool with Ball') from Tuesday 12/8/2015 to Friday 12/18/2015. Representatives from Geotek Coring, Pettigrew Engineering, U.S. Department of Energy, U.S. Geological Survey, and The University of Texas at Austin participated in the testing. The test was performed at Schlumberger's Cameron Testing Facility (near Cameron, TX).

2. Test Description:

Three types of tests were performed: 1) Flow Tests, 2) Closure Tests, and 3) Coring Tests.

2.1. Flow Tests:

The purpose of the Flow Test was to establish the pressure drop through the BHA (Bottom Hole Assembly) at various flow rates so as to establish an upper bound flow rate above which the potential for collapsing the core liner exists. In a flow test, the PCTB is lowered into the BHA within the borehole but above the base of the hole. Drilling fluid is then pumped down the drill string and pressure on the rig floor (the standpipe pressure) is measured. Flow rates are increased by increments, while the standpipe pressure is measured. Previous laboratory testing of the PCTB suggests that when the pressure differential across the liner is increased above 300 PSI, the core liner collapses.

2.2. Closure Tests:

In the Closure Test, the PCTB was deployed by wireline in the drill pipe, actuated downhole, and then recovered by wireline while the BHA was suspended off bottom in the hole. The purpose of the Closure Tests was to verify overall mechanical function of the PCTB without actually coring. This included 1) complete mechanical exercising of the tool under hydrostatic pressure, 2) successful actuation of the autoclave boost nitrogen charge, 3) retention of near downhole hydrostatic pressure, without the introduction of core, and 4) verification that the PCTB wireline deployment and retrieval tools worked successfully in an actual wellbore environment.

2.3. Coring Tests:

The purpose of a Coring Test was to verify the complete overall function of the PCTB. This included 1) wireline deployment, 2) cutting of core, 3) capture of core, 4) closing of the autoclave, 5) actuation of the autoclave boost nitrogen charge, 6) wireline retrieval of the PCTB, and 7) retention of the core under near in situ or boosted pressure conditions in an actual well bore environment.

3. Test Results:

During the 9 day test, 3 Flow Tests, 4 Closure Tests, and 8 Coring Tests were performed (Table 1 and Table 2).

Test Type	***Cutting-shoe***	***Face-bit***
Flow	2	1
Closure	4	0
Coring	5	3

Table 1: Summary of different tests performed during the Land Test of the PCTB tool.

Date	***Activity***
Tuesday, December 08, 2015	***Rig up***
Wednesday, December 09, 2015	***Flow Tests 1 (face-bit) and 2 (cutting-shoe)***
Thursday, December 10, 2015	***Closure Tests 1 and 2; Coring Test 1***
Friday, December 11, 2015	***Drilling through Buda Limestone; Coring Test 2***
Monday, December 14, 2015	***Coring Test 3; Liner Collapse Test; Coring Test 4***
Tuesday, December 15, 2015	***Closure Tests 3 and 4; Coring Test 5***
Wednesday, December 16, 2015	***PCTB-Face-bit: Coring Tests 6, 7, and 8***
Thursday, December 17, 2015	***Rig down, dress and pack tools, ship drill pipe***
Friday, December 18, 2015	***Ship containers***

Table 2: Summary of daily activities.

3.1. Flow Test Results:

The Flow Test 1 results are illustrated in Figure 1. Flow Test 1 tested the 10⅝" face-bit configured PCTB tool as one continuous flow test, starting with a pump rate of 25 GPM, and continuously ramping up the flow rate at 25 GPM increments. The first Flow Test ramped up the flow rate by 25 GPM increments to 200 GPM, increasing standpipe pressures to 246 psi. Examination of the core liner after the test showed no indications of collapse. Pressure data from inside the core liner measured by "fish pill" data storage tags (DST) show an increase to 30 psi during the first two flow rate steps, and then a leveling off at 25 psi for the remainder of the test.

Flow Test 2 tested the cutting-shoe configured PCTB. The flow test was conducted with the cutting-shoe tool with a 9⅞" cutting-shoe bit. It was performed as one continuous flow test, starting with a pump rate of 25 GPM, and continuously ramping up the flow rate at 25 GPM to 200 GPM, reaching a standpipe pressure of 236 psi (Fig. 2). The flow was further increased to 213 GPM reaching a pressure of 283 psi. Examination of the core liner after the test showed no indications of collapse. The DST pressure transducer failed during this test.

Flow Test 3 was performed to liner collapse with the PCTB cutting-shoe configuration PCTB and the 9⅞" cutting-shoe bit. In this test, the flow rate was incrementally increased. However, between each flow rate, the PCTB was extracted by wireline and the core liner was examined for evidence of collapse. In this case, at a flow rate of 450 Gpm, the standpipe pressure was 972 psi and when the core liner was examined it was slightly deformed. At the next flow rate of 500 Gpm, the standpipe pressure was 1184 psi and the liner was found to have been collapsed when examined. No DST data were available from within the core liner. Results of Flow Test 3 are shown in Figures 2 and 3.

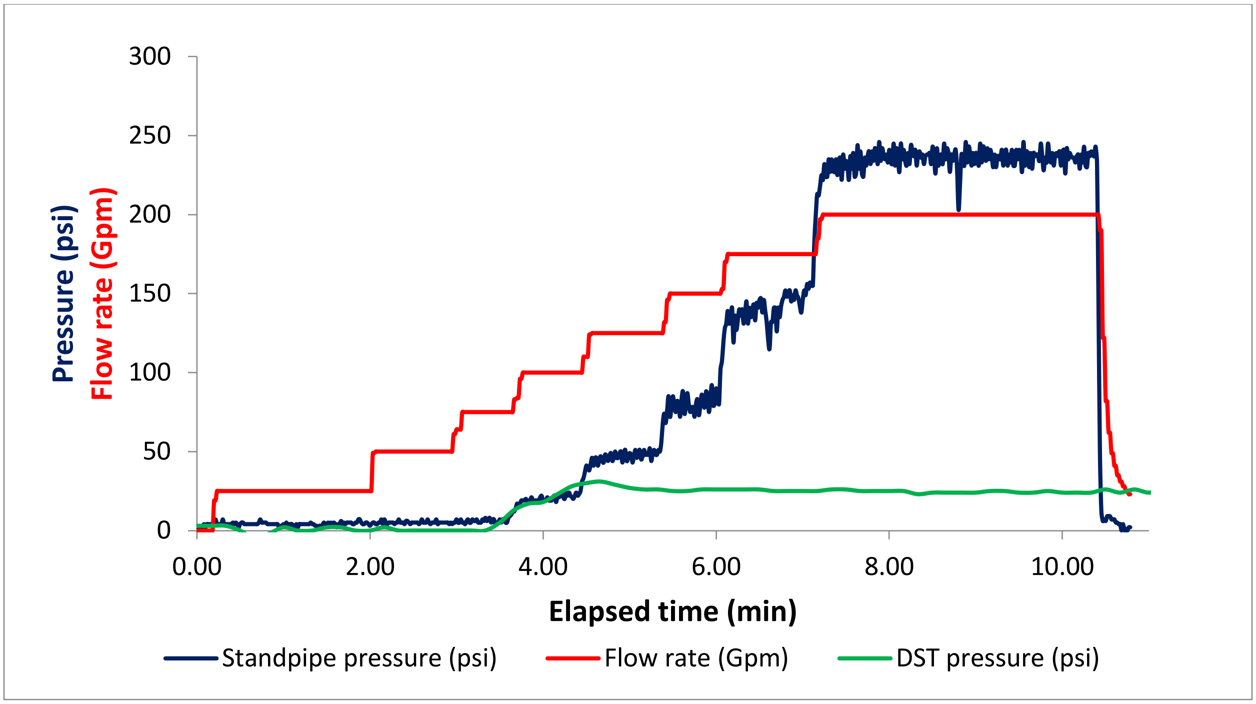

Figure 1: Flow Test 1 results. Pressure was measured at the rig floor (standpipe pressure, blue line) and inside the core liner ('DST' is acronym for 'data storage tag', which is a 'fish pill'). At a pump rate of 200 Gpm, the flow standpipe pressure is ~250 psi.

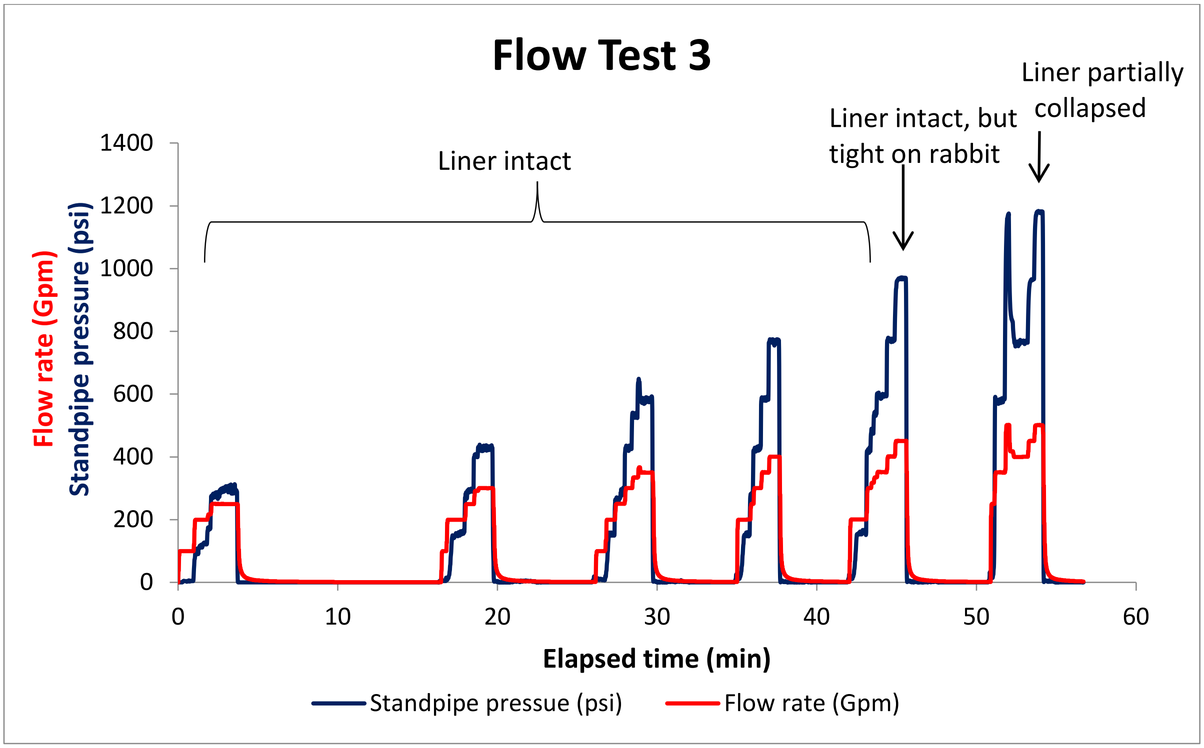

Figure 2: Flow Test 3 (liner collapse test). Flow rate in red and standpipe pressure in blue.

Between each flow rate increase, the PCTB was extracted by wireline and the core liner was examined for evidence of collapse. At 450 Gpm, the standpipe pressure was 972 psi and when the core liner was examined it was slightly deformed. At the next flow rate of 500 Gpm, the standpipe pressure was 1184 psi and the liner was found to have been collapsed when examined. No DST data were available from within the core liner.

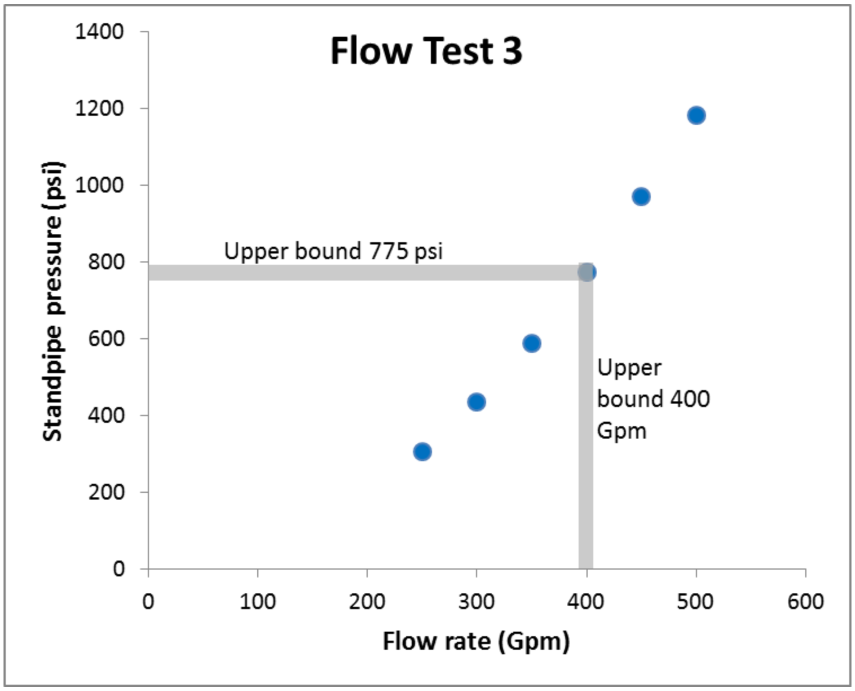

Figure 3: The results of Flow Test 3 suggest 400 Gpm is an upper bound for the PCTB cutting-shoe configuration.

A. Flow Test Discussion:

Previous Static Laboratory Collapse Tests demonstrated that above a differential pressure (between the inside and outside of the core liner) of 330 psi, the liner collapsed (Geotek Coring, Inc., 2015). A PCTB autoclave was used as the pressure vessel. In these tests, the core liner and liner tube were installed in the normal coring configuration except that the bottom of the core liner was sealed with a plug. A static hydrostatic pressure was then applied internally to the autoclave, producing a differential pressure across the core liner and liner tube. Fish pill (DST) data recorders were used to monitor the autoclave internal pressures during the tests.

The Field Dynamic Flow Test contrasts that of the Static laboratory Collapse Test because the collapsing pressure is dynamically applied by pumping down the drill string and the bottom of the core liner was not plugged. In addition, the field test was performed with the PCTB in a vertical position, while the laboratory test was performed in a horizontal position. Also, the differential pressure between the inside and outside of the liner cannot be measured directly in real time. Thus, the only real time feedback the operator has is the standpipe pressure. The standpipe pressure represents the total pressure differential between the upstream pressure at the rig floor and the annulus pressure at the rig floor. It thus includes a pressure loss due to the frictional forces of driving fluid through the entire system. If it is assumed that all of the pressure loss is due to driving fluid through the tool around the liner, the standpipe pressure may be a measure of the maximum possible differential pressure felt by the liner.

The results of Flow Tests 1 and 2 suggest that the flow rate must be kept below 200 Gpm in order for the standpipe pressure to be less than 300 psi to avoid collapsing the core liner. The cutting-shoe configuration and the face-bit configuration version of the PCTB tool behaved similarly, suggesting that bit configuration is not a major factor in the internal pressure of the PCTB. The most conservative approach would be to keep the flow rate less than 200 GPM under the assumption that all of the pressure loss is felt by the liner. During Flow Test 1, DST pressure data from within the core liner show a leveling off at 25 psi, even as the standpipe pressure approaches 300 psi, suggesting that the standpipe pressure minus 25 psi is the maximum differential pressure across the liner.

Flow Test 3 (liner collapse test) suggests that a significantly larger standpipe pressure can be applied without collapsing the liner. In this example, during the Field Dynamic Flow Test, no liner deformation was observed up to a flow rate of 400 GPM or a standpipe pressure of 770 PSI. This is perhaps an upper bound for the standpipe pressure that the tool can withstand without collapsing the core liner. At a flow rate of 500 GPM with a corresponding standpipe pressure of 1184 PSI, the liner was found to have collapsed. Upon recovery we noted that only part of the core liner had collapsed (Fig. 4), the area from the ball-valve up about 3 feet. In this section of the tool, the liner is not supported by the inner-tube when in the coring position, which allows for the pressure differential to establish between the liner and the inner-tube. This test indicates that a flow rate of 400 GPM with a corresponding stand pipe pressure of 770 psi is perhaps a true upper bound for operating the PCTB without collapsing the liner (Fig. 3).

The dramatic differences between the Static and Dynamic Flow Tests results is due to the complex fluid dynamics within the BHA and within the PCTB tool itself as fluid is pumped past and through the PCTB and out of the bit jets. Thus, the need for the empirical data generated by the Dynamic Flow Test.

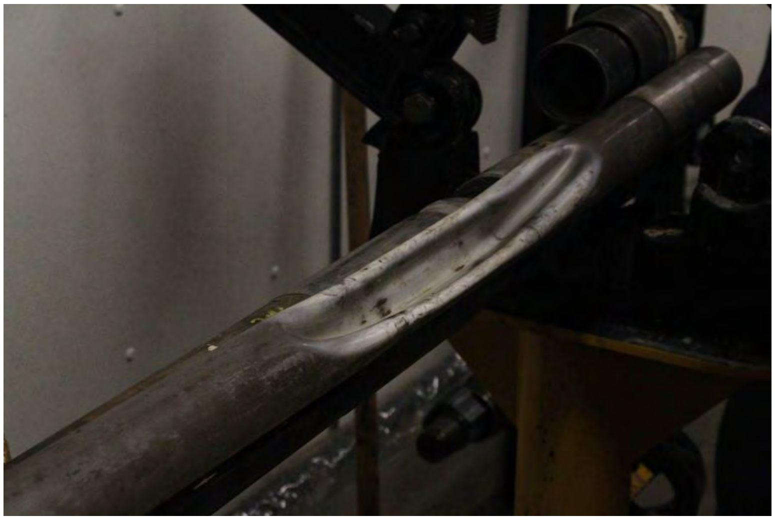

Figure 4: Collapsed liner after Flow Test 3.

3.2. Closure Tests Result:

Field Closure Tests 1 and 2 were conducted at a depth of 1871 ft. with a calculated hydrostatic pressure of 925 psi. Plots of DST data from all closure tests are available in Appendix A.

<u>Closure Test 1:</u> The autoclave boost was set at ~1500 psi. Upon recovery, the autoclave was found to contain 1408 psi pressure. Subsequent review of the fish pill data indicated that the autoclave boost occurred slowly over a brief period of time. This was attributed to a nearly fully closed bullet valve which restricted the hydraulic boost flow driven by the nitrogen gas charge in the accumulator. However, at no time did the autoclave pressure drop below ~800 psi.

<u>Closure Test 2:</u> The autoclave boost was set at ~1500 psi. Upon recovery, the autoclave was found to be at 1580 psi.

Subsequently, after four less-than-successful coring tests, two additional closure tests were conducted at a depth of 2050 ft. and a calculated hydrostatic pressure of 1010 psi.

<u>Closure Test 3:</u> The PCTB was deployed on wireline and actuated. The PCTB was then recovered and the autoclave maintained a pressure of 1484 psi. DST (fish pill) data indicate that the autoclave boost fired correctly but the boost was late.

<u>Closure Test 4:</u> The PCTB was deployed on wireline and actuated. The PCTB was then recovered and the autoclave maintained a pressure of 1486 psi (Fig. 5). DST data indicate the autoclave boost fired correctly.

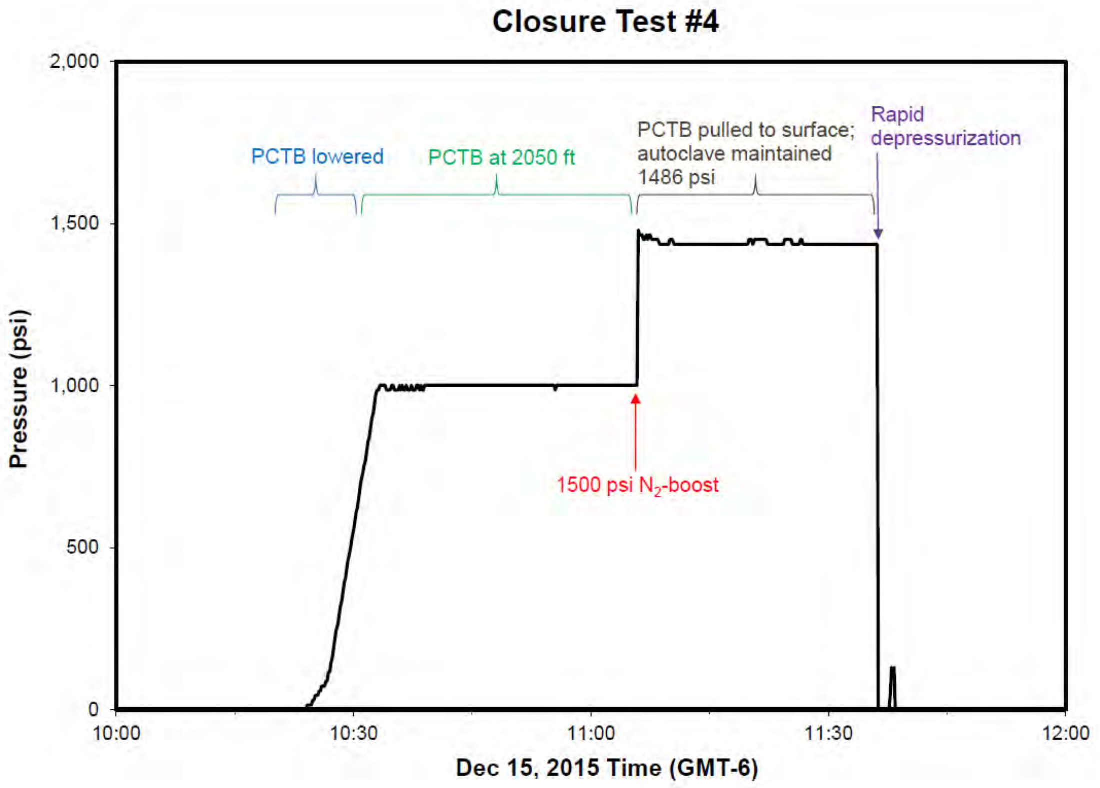

Fig 5: DST pressure from Closure Test 4.

A. Field Closure Test Discussion:

The Field Closure Test contrasts that of the Laboratory Closure Test in that the field closure test was conducted vertically, in a wellbore environment and using wireline tools to actuate the PCTB. In contrast, the laboratory closure test was conducted horizontally with simulated hydrostatic pressure and simulated wireline actuation.

Although the autoclave boost was slightly delayed during Closure Test 1, both Closure Test 1 and Closure Test 2 were able to maintain pressure at the rig floor. The success of Closure Tests 3 and 4 further demonstrate that the PCTB is functioning correctly and maintaining pressure during recovery. All closure tests were performed using the cutting-shoe configuration, so it is unclear if the late-firing issues were due to this type of configuration. Successful coring attempts using the face-bit configuration indicate that the tool functions properly in this configuration. However, it is unlikely that late-firing is influenced by cutting-shoe or face-bit configuration.

3.3. Coring Test Results:

8 coring tests in total were run; 5 in the cutting-shoe configuration and 3 in the face-bit configuration (Table 3). Plots of DST data from all coring tests except Coring Test 5 (DST failure) are available in Appendix B.

Coring Test 1: Coring began at a depth of 1938 ft. using the 9-7/8” cutting-shoe configuration, then proceeded slowly with a penetration of 5 ft. over 3 hr. The PCTB was recovered with a pressure of 1490 psi. The DST (fish pill) data show that the boost fired late while the tool was being raised up the hole, at ~100 ft. A 1.5 ft. core of silty shale to siltstone was recovered. The flow ports on the cutting-shoe were clogged and the outer edge of the core showed evidence of grinding.

Core Test 2: The hole was drilled using a center bit from 1943 ft. to 1992 ft. before attempting Coring Test 2. Core Test 2 (9-7/8” cutting-shoe configuration) cored ~3 ft. to 1995 ft. over 2 hr and when the PCTB was recovered, although the ball valve had closed, it was not sealed and the autoclave pressure was found to be 0 PSI. The seal on the ball valve was coated with mud containing angular fragments preventing a seal. 29” of core and ~ 9” of core catcher material were recovered. The DST (fish pill) data was inconclusive in that the DST worked only intermittently and there was no useful data during recovery of the core.

Core Test 3: The hole was drilled using a center-bit to the top of the Grayson Formation at 2060 ft. before attempting Coring Test 3 (9-7/8” cutting-shoe configuration). Coring began at a depth of 2060 ft., just below the expected transition from the Buda Formation limestone to the Grayson Formation mudstone and ended at a depth of 2063.8 ft after 2 hr of coring. Upon recovery, the ball valve on the PCTB was not fully closed. The PCTB did not maintain pressure due to jamming of the ball valve by rock fragments. 27” of core were recovered (60% recovery) plus additional pulverized material in the core catcher.

Core Test 4: Core Test 4 (9-7/8” cutting-shoe configuration) began at a depth of 2063.8 ft. and ended at a depth of 2069.02 ft after 1.5 hr of coring. Upon recovery, the core liner was found to be broken just above the core catcher and the ball valve was not closed. No material was present in the core liner, but the cutting-shoe and core catcher were packed by ground-up material with a polished rind.

Coring Test 5: Coring Test 5 (9-7/8” cutting-shoe configuration) began at a depth of 2069 ft. in the Grayson Formation. This test was drilled for 1 hr. with approximately half the bit weight (10,000 lb. – 14000 lb.) that was applied during the previous coring tests in an attempt to recover a short core without building up a fine paste and jamming the PCTB. Coring stopped at a depth of 2069.57 and the PCTB was recovered. The PCTB autoclave maintained a pressure of 1494 psi and no core was recovered.

Coring Test 6: Coring Test 6 began at a depth of 2069.57 ft. using the PCTB face-bit configuration and 10-5/8” face-bit and ended at a depth of 2075 ft after 45 min of coring. Upon recovery of the PCTB the ball valve was found not to have closed due to a piece of core sticking out of the core catcher. A total of 36” of rock was recovered.

Coring Test 7: Coring Test 7 began at a depth of 2075 ft. using the PCTB face-bit configuration and 10-5/8” face-bit. Coring ended at a depth of 2076.25 ft after 1 hr of coring. The ball valve closed properly following a successful twist-off of the formation, and the autoclave maintained a pressure of 1710 psi. 20” of mudstone were recovered under near the nitrogen boost set pressure.

Coring Test 8: The eighth and final coring test of the land test began at a depth of 2076.25 ft. using the same face-bit configuration as tests 6 and 7. Coring ended at a depth of 2078.38 ft. after 1 hr of coring and the PCTB recovered. The ball valve closed properly following a successful twist-off of the formation, and the autoclave maintained a pressure of 1501 psi. 29" of shale with limestone were recovered at the nitrogen boost set pressure (Fig. 6).

Coring Test	Configuration	Correct ball valve closure?	Correct N_2 boost timing?	Pressure at surface (psi)	Coring begin depth (ft)	Coring stop depth (ft)	Penetration (ft)	Core recovered (ft)	Formation
1	Cutting shoe	Y	N	1490	1938	1943	5	1.5	Eagle Ford shale
2	Cutting shoe	N	Unknown	0	1992	1995	3	2.5	Eagle Ford shale
3	Cutting shoe	N	Unknown	0	2060	2063.8	3.8	2.3	Buda Limestone
4	Cutting shoe	N	Unknown	0	2063.8	2069	5.2	0.5	Grayson shale
5	Cutting shoe	Y	Unknown	1494	2069	2069.6	0.6	0	Grayson shale
6	Face bit	N	Unknown	0	2069.6	2075	5.4	3	Grayson shale
7	Face bit	Y	Y	1710	2075	2076.3	1.3	1.6	Grayson shale
8	Face bit	Y	Y	1501	2076.3	2078.4	2.1	2.4	Grayson shale

Table 3: Coring summary noting the configuration, success of pressure boost/ball valve operation, pressure on recovery, coring intervals (in feet below rig floor), and penetration depths.

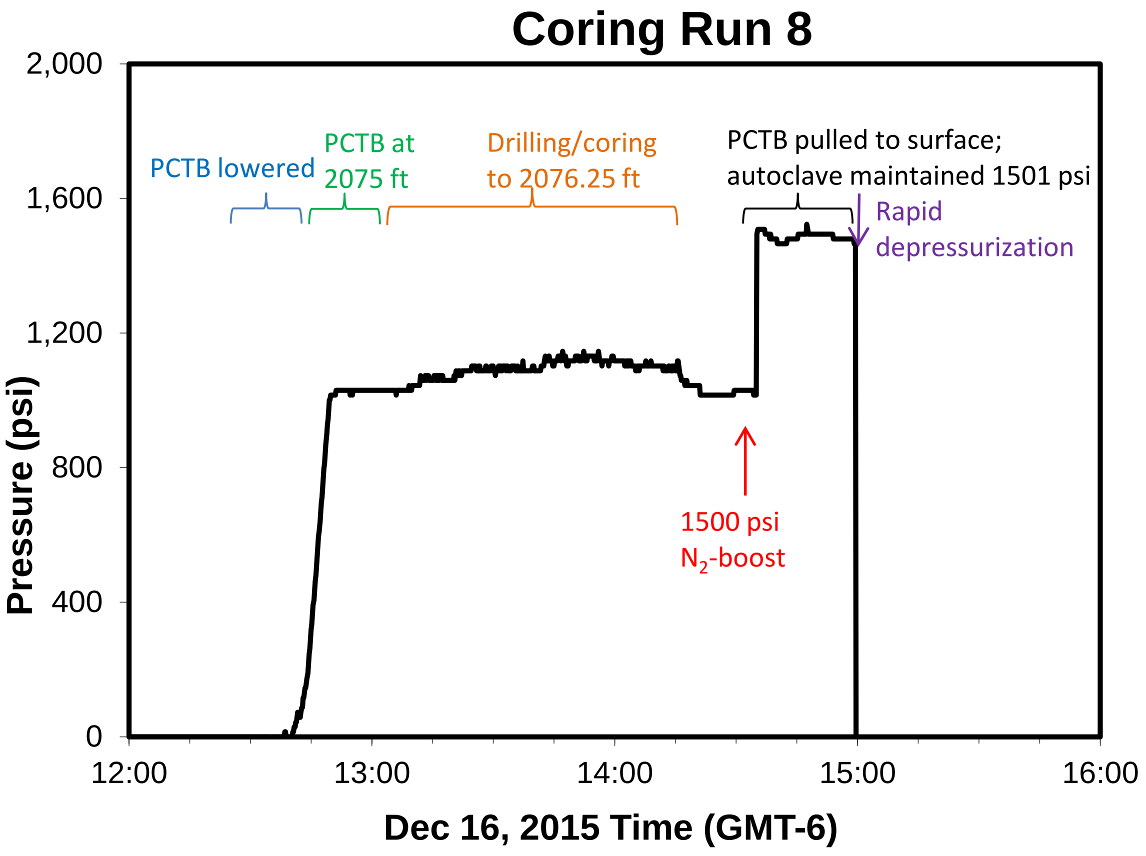

Fig 6: Successful operation of Coring Test 8.

A. Coring Test Discussion

The first two Coring Tests were made in the relatively soft mudrock of the Eagle Ford Formation. Coring Test 3 was performed at the base of the limestone Buda Formation, and Coring Tests 4 through 8 were made in the marlstone and interbedded mudstone and limestone of the Grayson formation (Fig. 7).

Overall, coring rates were very low during each the Coring Tests (Fig. 8). Penetration rates did not differ by PCTB configuration. Coring Tests 1 through 5 were made with the cutting-shoe configuration, in the clay-rich Eagle Ford Formation and the more carbonate-rich Buda and Grayson Formations. (Fig. 7). A core was recovered at boosted pressure during Coring Test 1; however, the N_2 boost occurred near the rig floor after the core had nearly dropped to atmospheric pressure. Several attempts were made to drill down to more favorable formations without an increase in successful coring using the cutting-shoe configuration. Bit-balling and jet-plugging were problematic in the cutting-shoe configuration, but the problem appeared to be lessened in the carbonate formations. In Core 3, after coring the most carbonate-rich interval of the test, the PCTB recovered an intact core, but without proper ball valve closure. As the amount of clay increased again in Cores 4 and 5, recovery dropped drastically. Slow penetration rates persisted in the hard carbonate-rich rock, and jamming of the ball valve continued to be an issue. After the liner collapse tests, the flow rates during Coring Tests 4 and 5 were increased up to 300 Gpm from 225 Gpm in previous tests. Even with increased flow rates in Coring Test 5, these issues persisted.

Based on these results, and the previous and successful face-bit coring results using the JOGMEC HPCT III in this same hole, the decision was made to change over to the PCTB face-bit configuration. Flow rates up to 250 Gpm were used during the face-bit Coring Tests. Successful Coring Tests 7 and 8, indicate that the face-bit configuration is a better choice for these formations. Bit-balling was not observed when coring in the face-bit configuration, even with lower flow rates compared to Coring Tests 4 and 5. This occurred despite the fact that some of the rock was a relatively soft mudstone. Although penetration rates remained slow in the face-bit configuration, core recovery was high.

If a successful run is defined as recovering intact core and maintaining in situ or boosted pressure back to the surface, then only Coring Tests 7 and 8 were completely successful. Other runs recovered core without maintaining pressure, maintained pressure but recovered no core, or maintained core under pressure but fired after the core barrel was pulled off the bottom. In the end, 2 of the 3 face-bit configuration Coring Tests were completely successful, but 0 of 5 in the cutting-shoe configuration were completely successful. It is clear that in these consolidated, lithified formations the face-bit is the most appropriate configuration.

These successful coring tests also indicate that the improvements to the PCTB have increased the tools overall reliability considerably. Although the formations being cored were not ideal, much was learned regarding the overall operation of the PCTB and an increased confidence in the tool was gained. Late firing was an issue in 1 of the 8 Coring Tests; however, in 5 tests there were problems with ball valve closure or DST measurements that leave uncertainty in the timing of the N_2 boost, and it is not known if the N_2 boost occurred at the correct time.

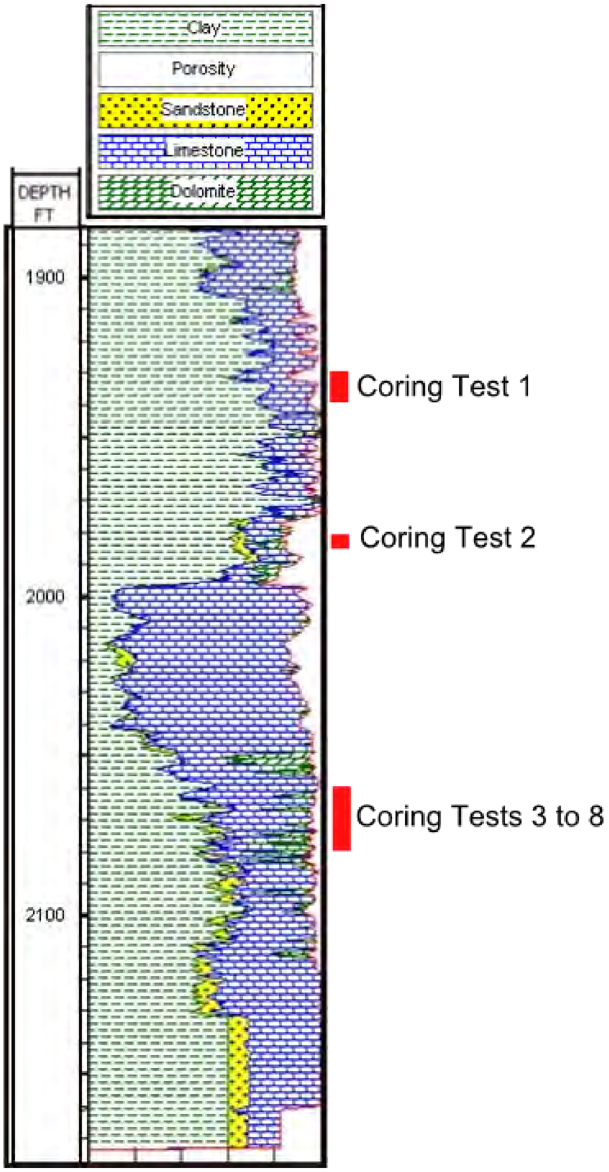

Figure 7: Depths of coring tests plotted with lithology. Lithologic logs from the Cameron Test and Training Facility were provided by Schlumberger.

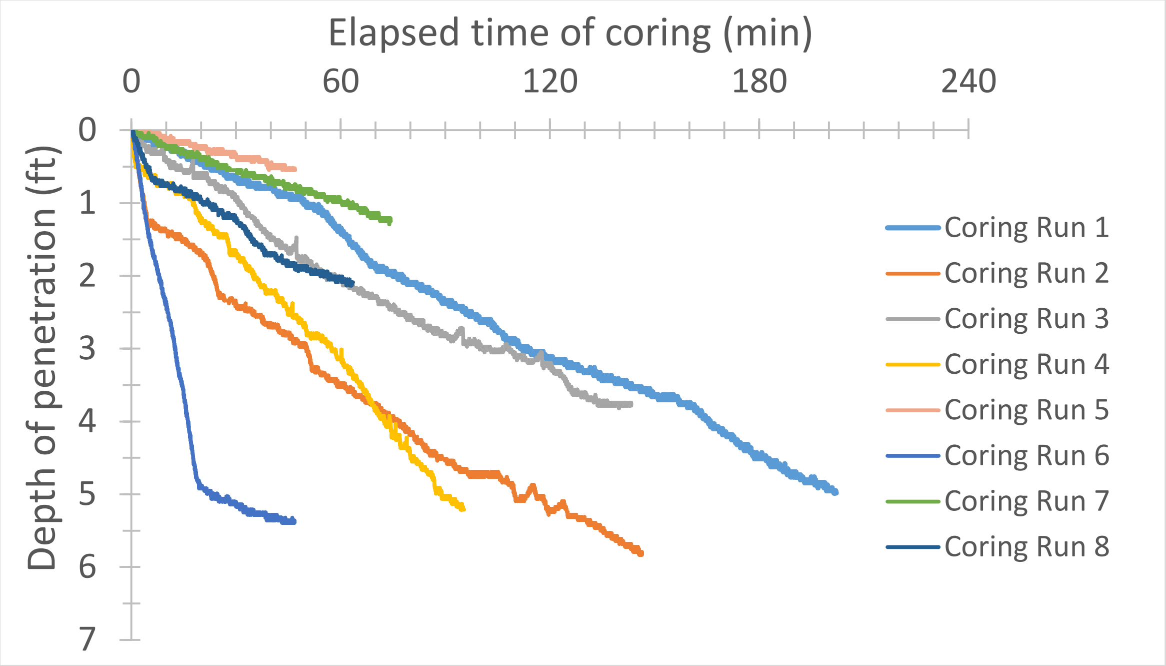

Figure 8: Depth versus penetration for all coring tests.

4. Summation

The PCTB Land Test provided additional operational experience with the PCTB tool in an actual wellbore environment. The results indicate that the PCTB is a reliable tool. Penetration rates were low at this location due to bit-balling during coring of mudstone and due to the hardness of carbonate rocks. The test results also suggest that the liner can withstand a higher operational pressure than was previously thought, which will allow for the use of a higher flow rate.

The following issues will be examined further. First, the tool design will be studied to determine if there are possible modifications that will improve the reliability of the nitrogen boost. Second, the cutting-shoe configuration will be examined to determine if there is any way to reduce bit-bit balling and poor recovery.

Finally, the cutting-shoe tool has the distinct operational advantage that it can be used with other downhole tools during drilling. In contrast, the face-bit tool cannot accommodate other tools. This operational efficiency is contrasted with the improved recovery demonstrated by the face-bit configuration. Finally, it should be remembered that the intervals of marine gas hydrate that will be drilled may have very different properties than the rocks drilled at Cameron and may pose a different set of challenges than was encountered in the formations in Cameron.

5. GOM^2 PCTB Land Test at the Cameron Test and Training Facility Daily Reports

5.1. Daily Report for December 8, 2015

Preparations for the PCTB land test began on 12/8/2015, one day early due to the faster-than-expected completion of JOGMEC HPCT testing.

The 6⅝" drill pipes were laid out and 22 stands of 5" drill pipes were made up and stood up in the derrick. The face-bit bottom-hole assembly was assembled. It was discovered that the DOE vans do not have any sinker bars. The Japanese sinker bars were used for this test because they are compatible with DOE wireline tools, and will be used for testing. Geotek does not have a bit seal for the bits. One will be shipped overnight, scheduled to arrive mid-day on December 9. Electricity, air, and water were connected to the PCTB service van. Work stopped at approximately 19:30.

5.2. Daily Report for December 9, 2015

Work with the PCTB tool began at approximately 10:00. Initial configuration of the tool within the bottom-hole assembly at 11:00 revealed a spacing issue in which the PCTB was ¾" too long, which prevented proper latching of the tool with the wireline. By 15:00, the bit seal had arrived and was installed. By 16:00 the tool was adjusted in length and the spacing was too short, and only ¼" of adjustment was necessary. After lengthening the tool by ½", it was sufficient to move forward with configuration with the 10 ⅝" face-bit.

The first flow test began at 17:00, ramping up the flow rate by 50 GPM increments to 200 GPM, increasing standpipe pressures to 246 psi. Examination of the core liner after the test showed no collapse. The second flow test was configured with a 9⅞" cutting-shoe bit, and the test began after dinner, at approximately 19:00. The flow was increased again with 50 GPM increments to 200 GPM, reaching a standpipe pressure of 236 psi. The flow was further increased to 213 GPM reaching a pressure of 283 psi. The results of these tests suggest a 200 GPM flow rate as an upper bound for both configurations. Work ended at approximately 20:00.

We also obtained a sample rig data from Schlumberger to ensure we could import and read the data properly. We were able to successfully open the data.

5.3. Daily Report for December 10, 2015

The bottom hole assembly was lowered to 1871 ft. for the first Closure Test at approximately 08:40. The Closure Test will test the overall function of the tool without actually coring. This includes the following:

- fully exercising the wireline tools: running the core barrel on wireline, actuating the tool (the mechanical pull actuates the tool), and recovering the core barrel.

- testing the autoclave pressure boost feature, testing the pressure-retaining capability, and confirming the overall mechanical function of the tool.

Closure Test 1: Operational time from 07:00hr to 11:00hr. The PCTB cutting-shoe version run into hole on wireline at 10:10. It was latched into the BHA. The running tool was recovered and then the PCTB recovery tool was run into the hole. The tool latched onto the PCTB and the tool was brought to the surface. The core barrel was recovered at 11:20.The DST (fish pill) data record an initial modest pressure drop (~100 psi) followed by a slow pressure build over ~40 minutes. The final pressure reached was 1408 psi before the tool was opened. The slow pressure build up was attributed to a bullet valve that was not fully open that slowed the boost. The expected downhole pressure was 924 psi (hydrostatic pressure calculated with a 9.5 PPG mud). The nitrogen pressure boost to a total of 1500 psi and therefore the ideal pressure that would be recovered in the pressure core would be approximately 1500 psi not accounting for any changes due to temperature.

Closure Test 2-First Lowering: Operational time: 13:00hr to 15:00hr (similar setup to Closure Test 1). The PCTB-cutting-shoe version was run in on wireline. However, the PCTB could not pass the bore-seal of the BHA. Tool was recovered to surface and one of the valve ports in the pressure section had backed off and was scraping along the inside of the drill pipe. The tool was returned to the service van to tighten the valve port.

Closure Test 2- Second Lowering: Operational time from 15:00hr to 16:00hr (similar setup to Closure Test 1). BHA set at 1871 ft. The PCTB-cutting-shoe version was run in on wireline at 15:35. The PCTB latched into the BHA and released – normal operation, no running in or latching problems. The PCTB was recovered with PCTB recovery tool. No tripping problems. The core barrel was recovered at 16:10. Upon recovery the ball valve was closed with internal pressure of 1580 psi (boost set pressure at 1500 psi), and boost section still had pressure. The DST (fish pill) data indicated that the pressure boost (and therefore the closing of the ball valve) reached approximately 1500 psi which dropped to 1408 psi just before the tool was opened.

Coring Test 1: Operational time 16:30hr to 21:00 hr. BHA set at 1871 ft. at start of test. At 17:50, the BHA reached the bottom of the hole to begin drilling at 1938 ft. for the first coring test. The PCTB was then lowered by wireline into the hole. Coring began at 17:30. Drilling then proceeded slowly, with a penetration of 5 ft. over 3 hr. The PCTB was recovered at 22:00 with a pressure of 1490 psi. The PCTB was recovered at 22:00 with a pressure of 1490 psi. The DST (fish pill) data show that the boost fired late while the tool was being raised up the hole, at around 100’ MD. A 1.5 ft. core of silty shale to siltstone was recovered. The flow ports on the cutting-shoe were clogged and the outer edge of the core showed evidence of grinding.

5.4. Daily Report for December 11&12, 2015

Work began at 08:00 with cleaning the drill bit at the rig floor. Core 1P, recovered during the previous night, was cut in the liner, labeled, capped, and boxed. UT helped cut, box, and label JOGMEC cores.

Drilling with cutting-shoe-version and center bit from 1953’MD began at 11:30. The goal was to drill out of the Eagle Ford Shale to the underlying Buda Limestone and Grayson Formation, which was felt to be a more appropriate lithology for coring.

Drilling ceased at 17:10 at a depth of 1992 ft. It was felt that this location, although still within the Eagle Ford Shale, offered the potential of a better pressure core. The center bit was recovered at 17:50 and the PCTB was rigged on the wireline at 18:20. Coring for Core 2P began at 19:00. Coring ceased at 21:30. The PCTB was recovered with some pressure at the rig floor (inferred from the mechanical status of the tool) but although the ball valve had fired it was not sealed and fluid was observed leaking from around the ball valve seal. On connection to the pressure read out device in the service van the pressure was found to be 0 PSI. The seal on the ball valve was coated with mud containing angular fragments. 29” of core and ~ 9” of core catcher material were recovered. The outer surface of the core appeared to be grinded and coated with a rind of mud. The DST (fish pill) data indicated that the pressure boost (and therefore the closing of the ball valve) occurred near to the rig floor, perhaps during handling. The DST data is incomplete during the recovery phase of the tool (pressure drop outs) but the boost generated at least 170 PSI in the autoclave despite the leaking ball valve.

At 12/11/2015 24:00 hr., drilled out with cutting-shoe-version and center bit. Operational time from 12/12/15 00:25 hr. to 12/12/15 05:20. RIH center-bit on wireline, no deployment problem. Spud into formation at 12/12/2015 00:25hr at a depth of 1997.85 ft. MD. Drilling parameters at spud included weight on bit to 18,000 lbs., pump rate 400 GPM, pump pressure up to about 210 psi; torque variable ranging from 300-500 ft-lb.

The top of the Buda Limestone was encountered on 12/12/15 00:48 hr. at 1998.9 ft. MD. This was marked by a significant and sustained increase in the measured DS torque. The drilling torques became highly variable ranging from 800 to greater than 6000 ft-lb. Weight on bit at a constant of about 17,000 lbs., pump rate 400 GPM, pump pressure up to about 210 psi. Penetration rates increased significantly to as high as 23 ft. /hr.

Reached the target of the top of the Grayson Formation 2060’ MD at around12/12/15 05:20 with an ROP varying around a little but up at around 20 ft. /hr., particularly in the lower section. Bit was then returned to surface and is very clean.
Operations ceased at 12/12/15 07:00.

5.5. Daily Report for December 14, 2015

Start 07:00 hr., end of operations 01:00 hr. (next day, 12/15/2015).

From the morning of 12-Dec-2015, the entire drill string and BHA was recovered and stacked in the rig. Inspected the bit from Saturday (12/12/15) morning's drilling and found to be in good shape. Retrieved center bit and then lowered the bit to 2050 ft. for the next coring run.

Coring Test 3: BHA set at 2047 ft. MD at start of test. PCTB cutting-shoe version was run into the BHA. The BHA was then lowered and coring began at 2060.00 ft. Coring began at 10:45 at a depth of 2060 ft., just below the expected transition from the Buda Formation limestone to the Grayson Formation mudstone. Coring stopped at 13:03 at a depth of 2063.8 ft. after a total of 3.8 ft. was drilled. Upon recovery, the ball valve on the PCTB was not fully closed. The PCTB did not maintain pressure, due to the jamming of the ball valve by rock fragments. 27" of core were recovered (60% recovery) plus additional pulverized material in the core catcher. Core 3P recorded a transition from limestone to marlstone containing limestone rip-up clasts.

Pump Test: Decision was made to move ahead with plan to test the upper limits of internal working pressures of the PCTB. The drill string was tripped in preparation for a liner collapse test to determine the maximum flow rate that will not collapse the liner. The goal of increasing flow rates was to enhance the clearing of material around the bit, increasing the speed of drilling and improving core recovery.

Flow rate (GPM)	Standpipe Pressure (psi)	Comments
250	308	
300	437	
350	590	
400	775	
450	972	Liner a little snug on rabbit
500	1184	Liner collapsed

A series of flow tests were performed starting at 16:20 by increasing the maximum flow rate in 50 GPM increments and then checking the condition of the liner after each flow increase. The liner showed no sign of collapse up through a flow rate of 400 GPM with a corresponding pressure of 775 psi. At 450 GPM (972 psi), the liner showed signs of slight collapse and at 500 GPM (1184 psi) the liner fully collapsed near the ball valve. It was determined that the liner could safely withstand pressures associated with flow rates of 350 GPM, with some uncertainty of how core in the liner will affect the pressure differential across the liner.

Coring Test 4: The second coring run of the day (Core 4P) began at 21:00 from a depth of 2063.8 ft. with a flow in rate of 275 GPM. At 21:15 at a depth of 2064.5, the flow rate was increased to 300 GPM. At 22:35, coring was stopped at a depth of 2069.02 ft. Recovered tool without any problem. Upon recovery, the core liner was found to be broken just above the core catcher and the ball valve was not closed. It is speculated that the core catcher ripped off the liner during pull off of the tool, preventing the ball valve from closing. No material was present in the core liner, but the cutting-shoe and core catcher were packed by ground-up material with a polished rind. Recovered about 1.0 ft. of core, consisting of well lithified carbonate and carbonate-cemented mudstone. The cutting-shoe was filled with welded sediment and some mud caking, but the ports were open.

Operations ceased at 12/14/2015 01:00.

5.6. Daily Report for December 15, 2015

Start: 07:00 hr., end of operations: 21:30

Closure Test 3: The PCTB was deployed starting at 08:30 for Closure Test 3. The PCTB was recovered at 09:35 and the autoclave maintained a pressure of 1484 psi. DST (fish pill) data indicate that N-boost fired correctly at the 2050 ft. testing depth.

Closure Test 4: The PCTB was deployed for Closure Test #4 at 10:25. The PCTB was recovered at 11:35 with an autoclave pressure of 1486 psi. Again, the DST data indicate the N-boost fired at the target depth. These tests demonstrate the functionality of the PCTB tool in actuating at the correct depth and maintaining pressure during recovery. The small variation in autoclave pressures from 1500 psi is likely driven by temperature changes between the borehole and the surface.

Coring Test 5: Coring Test 5 began at 13:30 from a depth of 2069 ft. in the Grayson Formation with a flow in rate of 250 GPM. This run was drilled for 1 hr. with approximately half the bit weight compared to previous runs, in an attempt to recover a short core without building up a fine paste and jamming the PCTB. Drilling stopped at 14:30 at a depth of 2069.57. The PCTB autoclave maintained a pressure of 1494 psi, but with zero core recovery.

After Coring Test 5, the bit was switched to a 10⅝” bit. At 17:50, a spacing test of the PCTB in the face-bit configuration indicated no problems with spacing or latching. The hole was reamed down to the bottom of the hole using the 10⅝” bit by approximately 21:30.

5.7. Daily Report for December 16, 2015

Start time: 05:30. End of operations: 15:30.

Coring Test 6: Coring Test 6 began at 06:22 at a depth of 2069.57 ft using the face-bit configuration, with an 8 klb bit weight and 250 Gpm flow rate. 5 ft of Grayson Formation were penetrated by 06:35. Rate of penetration went to zero at 06:42. From 06:42 to 07:00 there was little to no penetration. At 07:03 coring ended at a depth of 2075 ft. At 07:45 the PCTB was recovered. The ball valve did not close due to a piece of core sticking out of the core catcher. 36" of rock was recovered in core 6P, primarily fissile shale with a transition to a hard carbonate-cemented mudstone at the base of the core.

Coring Test 7: Coring Test 7 began at 09:00 from a depth of 2075 ft using the face-bit configuration, with an 8-10 klb bit weight and 250 Gpm flow rate. Coring ended at 10:10 at a depth of 2076.25 ft. The PCTB was recovered at 10:45. The PCTB ball valve closed properly following a successful twist-off of the formation, and the autoclave maintained a pressure of 1710 psi. 20" of mudstone were recovered in core 7P with a spiral fracture visible at the bottom of the core. The mudstone appeared to be carbonate-cemented, but was not nearly as hard as the rock in the bottom of core 6P.

Coring Test 8: The eighth and final coring run of the land test began at 13:17 from a depth of 2076.25 ft, using the same configuration as Runs 6 and 7. Coring ended at 14:21 at a depth of 2078.38 ft. The PCTB was recovered at 14:45. The PCTB ball valve closed properly following a successful twist-off of the formation, and the autoclave maintained a pressure of 1501 psi. 29" of shale with limestone were recovered in core 8P with the twisted-off surface visible at the bottom of the core. The top of core 8P appeared to match the fractured surface at the bottom of core 7P.

Coring Runs 7 and 8 successfully demonstrated the functionality of the PCTB to maintain a core under pressure.

6. References:

Geotek Coring, Inc. (2015), Hybrid Pressure Coring System (PCTB) 2015 Laboratory Test Program Final Report, September 30, 2015.

Appendix A: Closure Test DST plots

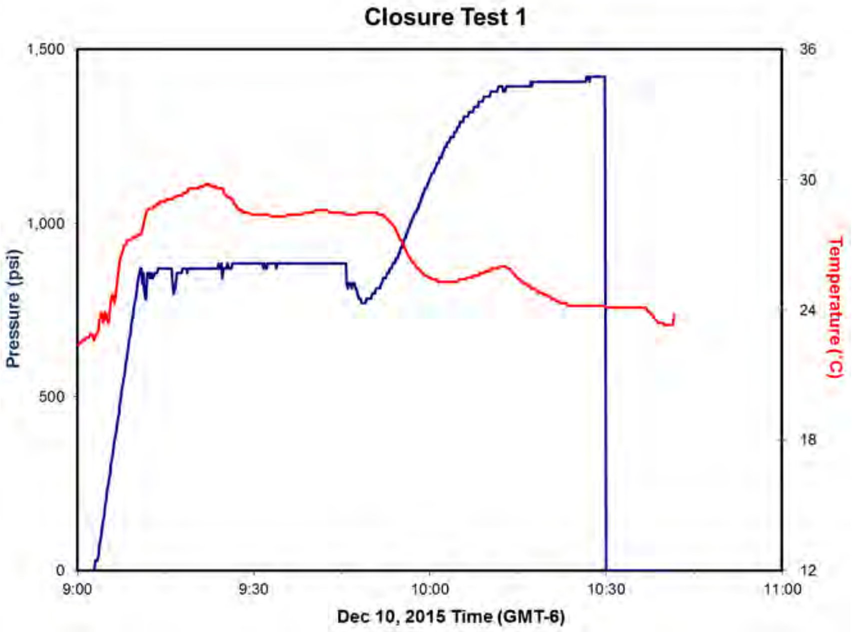

Figure A1: DST data from Closure Test 1.

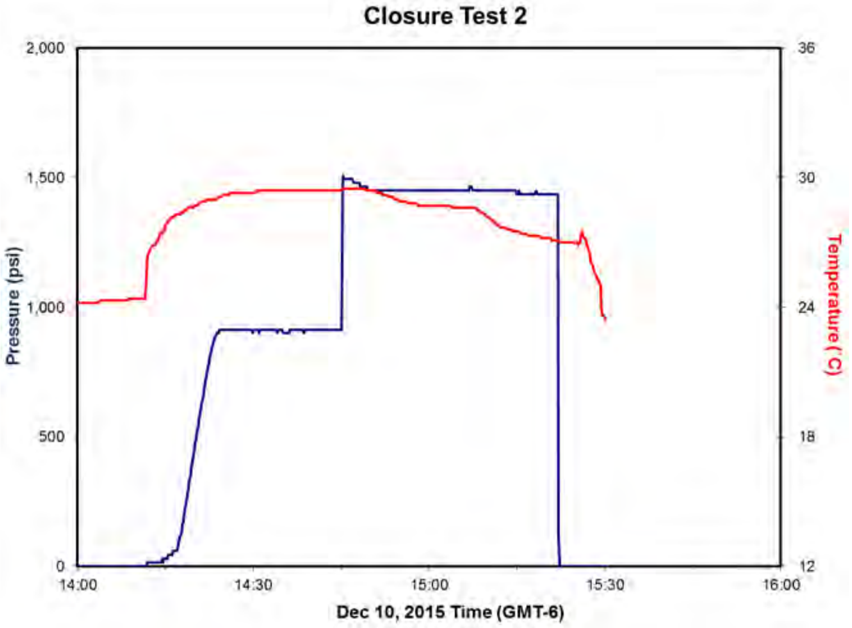

Figure A2: DST data from Closure Test 2.

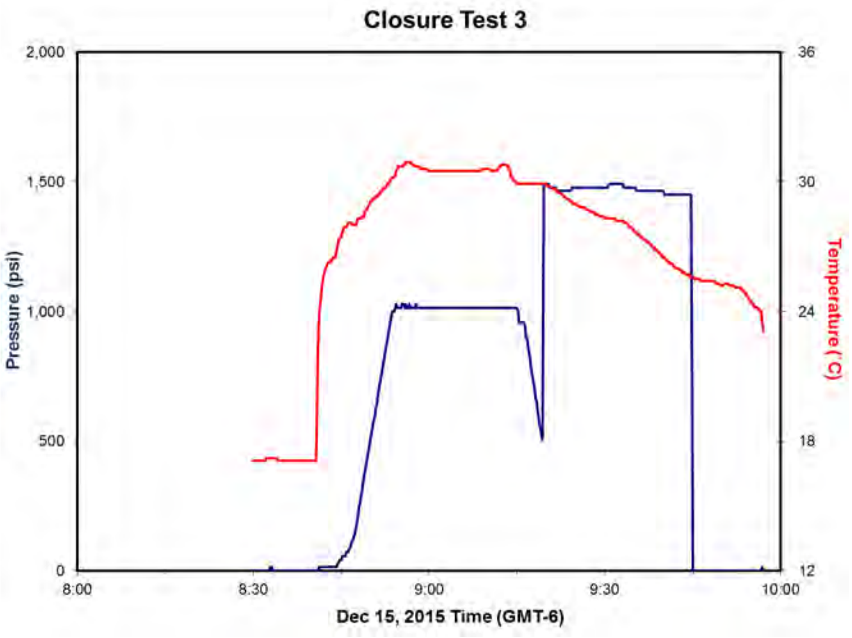

Figure A3: DST data from Closure Test 3.

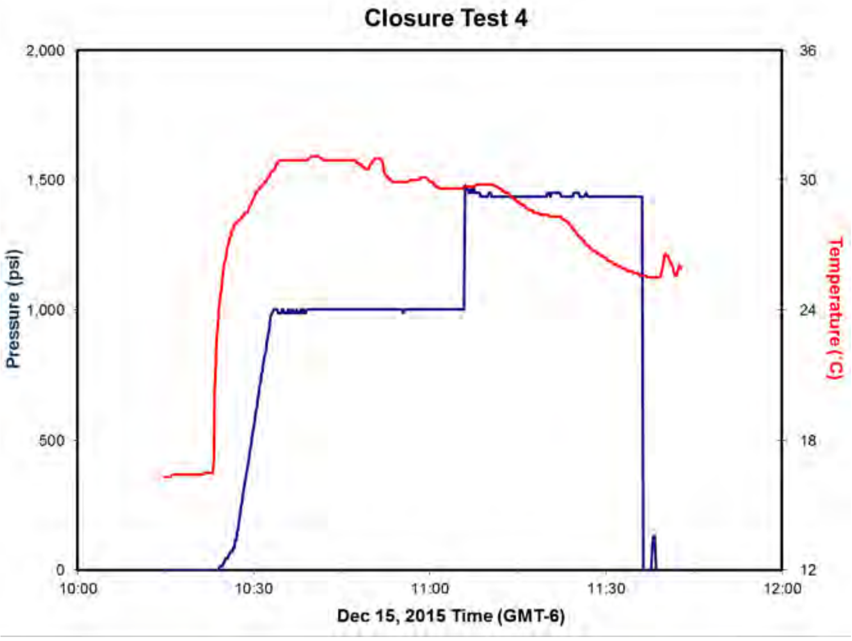

Figure A4: DST data from Closure Test 4.

Appendix B: Coring Test DST plots

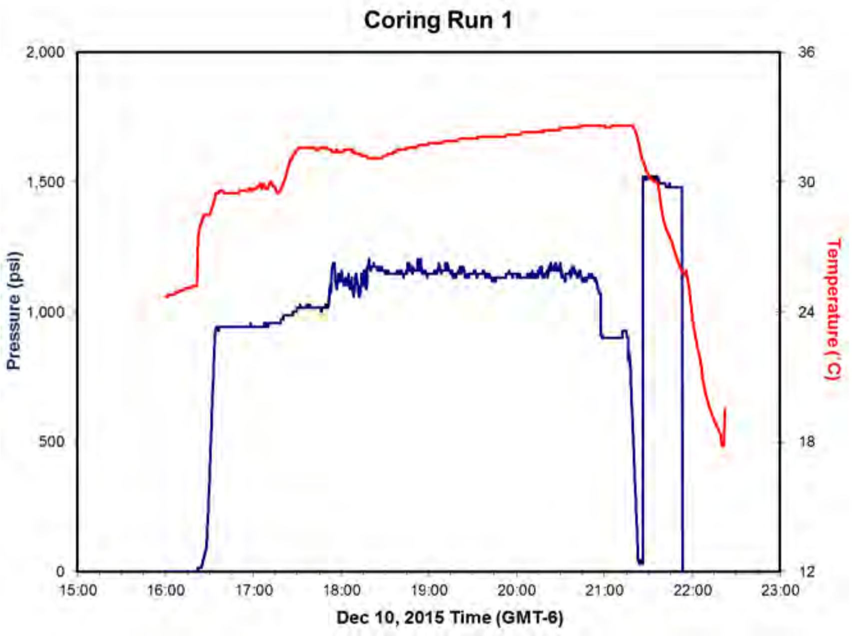

Figure B1: DST data from Coring Run 1.

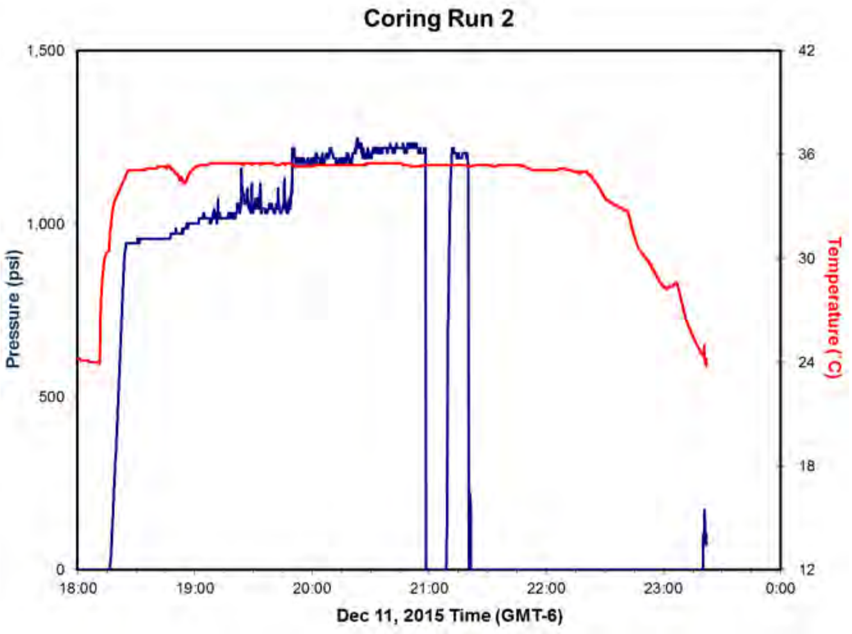

Figure B2: DST data from Coring Run 2. Note the dropouts in data starting at 21:00.

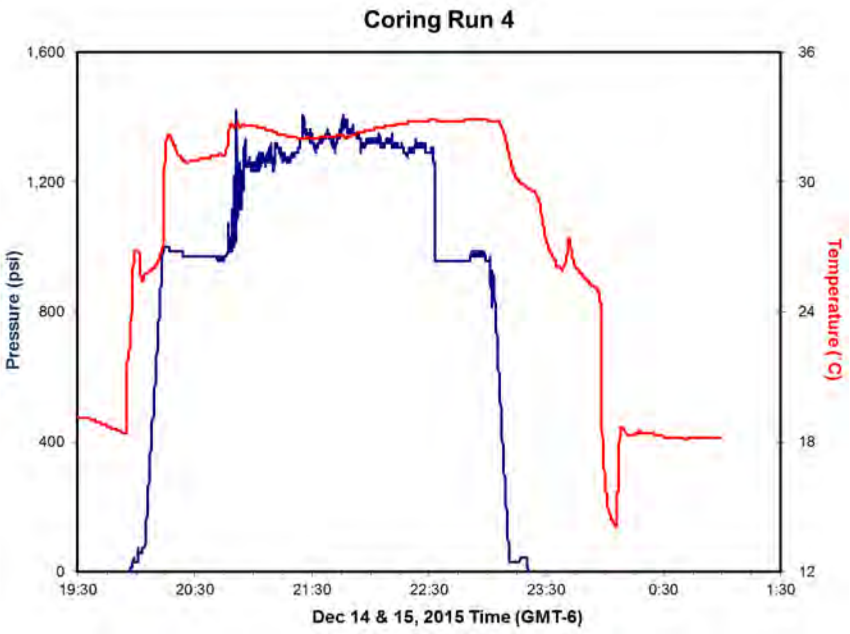

Figure B3: DST data from Coring Run 4.

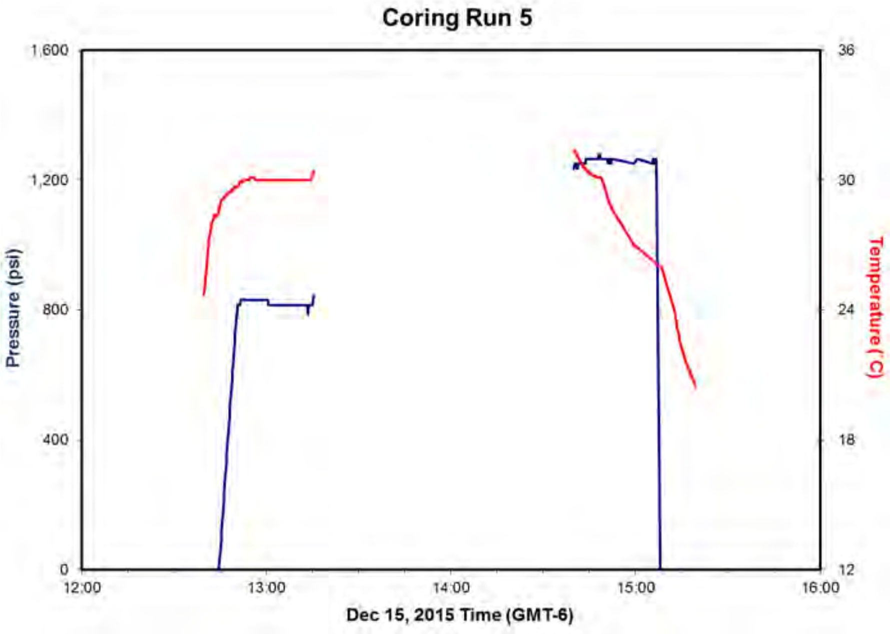

Figure B4: DST data from Coring Run 5. There is a drop out of data in the middle of the run.

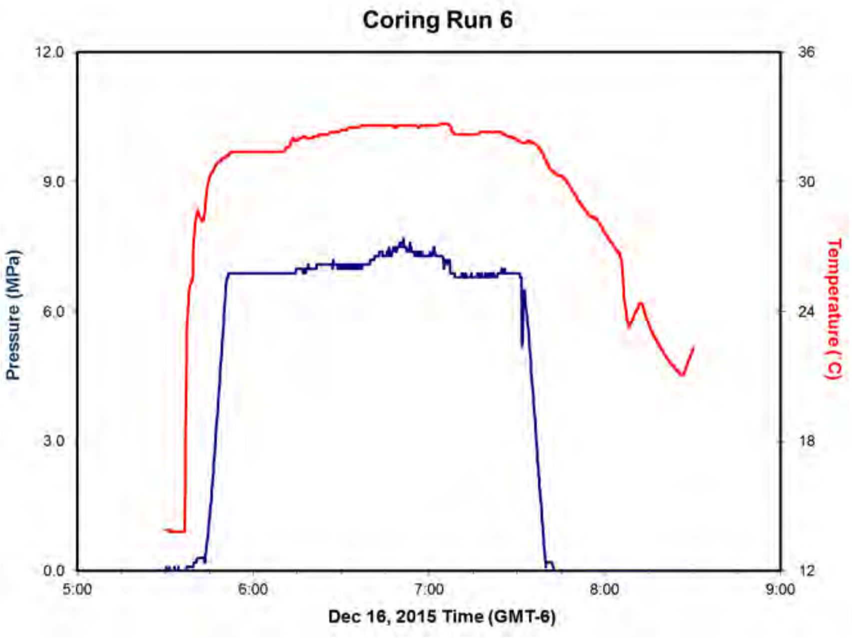

Figure B5: DST data from Coring Run 6.

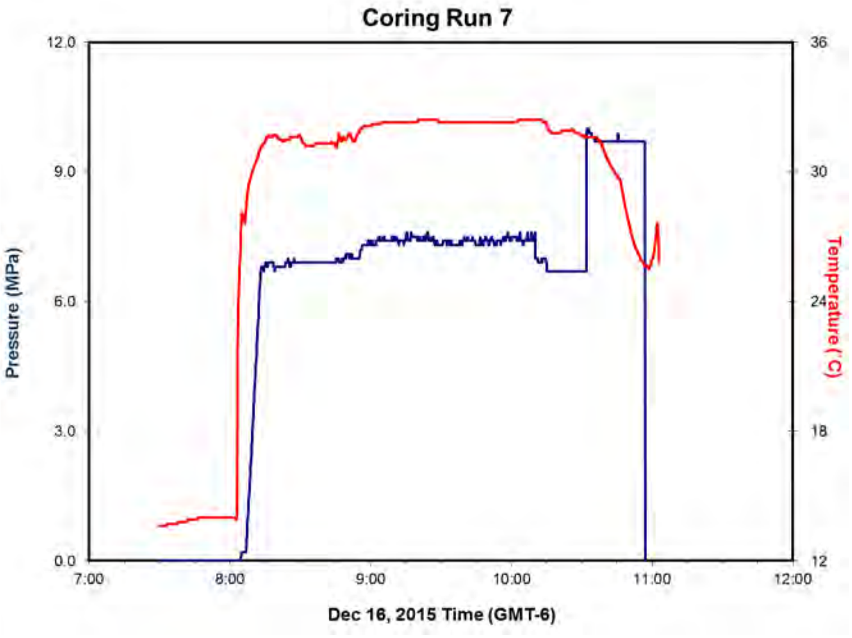

Figure B6: DST data from Coring Run 7.

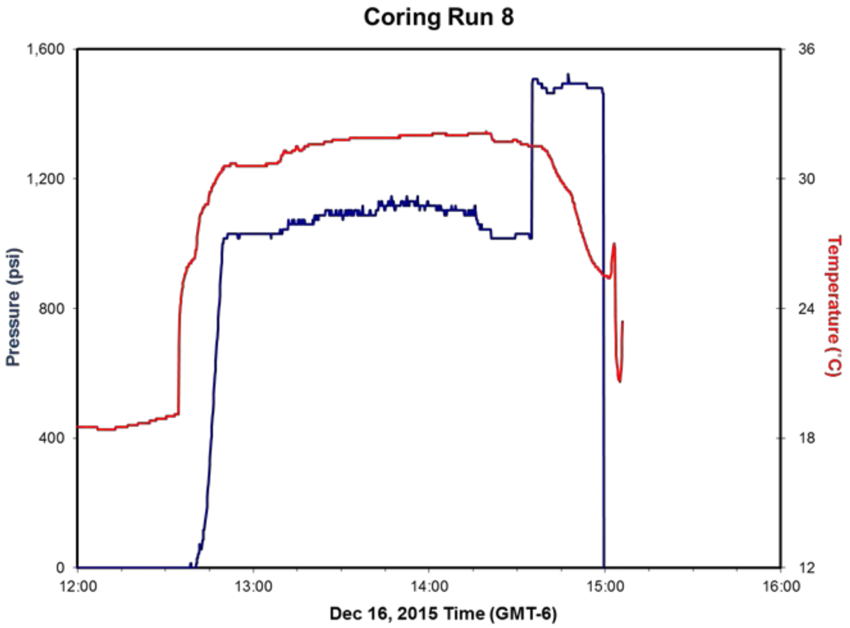

Figure B7" DST data from Coring Run 8

Appendix C: Core Photos

Figure C1: Core 1

Figure C2: Core 2

Figure C3: Core 6

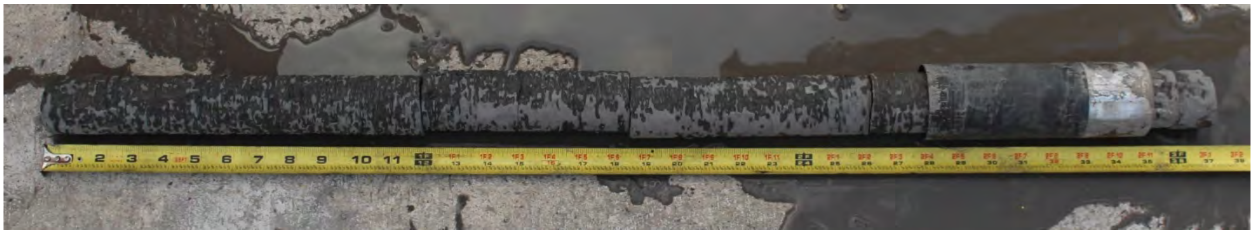

Figure C4: Core 7

Figure C5: Core 8

GOM^2 MARINE BASED TEST GEOTECHNICAL SOW

Contents

I. Executive Summary

The GOM^2 project will perform geotechnical drilling in approximately 6670’ (2034 m) of water depth to a total depth of either 8148’ (Green Canyon 955) or 9136’ (Walker Ridge 313) (Table 1). The project will test the DOE pressure-coring tool (the PCTB). The PCTB has its own BHA. We will perform the experiment in either Walker Ridge Block 313 (WR-313) or Green Canyon Block 955 (GC 955). The water depths at both locations are similar. However, the target for pressure coring is significantly shallower at GC955 (1358’ below seafloor at GC 955 vs. 2132’ and 2643’ below seafloor at WR-313) (Table 1). At the chosen location, we will drill two wells and take 10 pressure cores in each hole. We will use the PCATS (Pressure Core Analysis and Transfer System) from GeoTek Engineering to analyze the cores on the ship. We wish to perform our drilling program December 2015 and June 2016. If vessel availability is outside this window, we will consider other dates.

We request separate bids for drilling in the WR313 and the GC955 locations. The base bid should include the time of vessel availability, and should account for the cost of deploying the PCTB as described.

Green Canyon 955	***TVD subsea ft***	***TVD Subsea meters***	***Meters below sea floor (mbsf)***	***ft below sea floor (ft)***
sea floor	6670	2034	0	0
Hydate sand top	8028	2448	414	1358
Hydrate sand bot	8148	2484	451	1478
Base of well	8654	2638	605	1984
Walker Ridge	***TVD subsea ft***	***TVD Subsea meters***	***meters below sea floor (mbsf)***	***ft below sea floor (ft)***
sea floor	6450	1966	0	0
Blue Sand Top	8582	2616	650	2132
Blue Sand Bot	8753	2668	702	2303
Orange Sand Top	9094	2772	806	2644
Orange Sand Bot	9136	2785	819	2686

Table 1: Overview of Drilling locations and key target surfaces. We will drill at either Green Canyon 955 or Walker Ridge 313. At GC955, the target is a single sand between 1358 and 1478 feet below seafloor. At WR313, there are two target sands: The Blue Sand at 2132’ below seafloor and the Orange Sand at 2644’ below seafloor.

II. Vessel Capability

The vessel will need to have the capacity to drill to the target horizons (650 mbsf and 806 mbsf at Walker Ridge; or 414 mbsf at Walker Ridge). We estimate the specific requirements below.

A. Derrick Capacity Hook Load

1. **Walker Ridge:** Derrick capacity hook load
    a. WD = 1965 m (6445 ft), HD = 880 mbsf (2886 ft), Total string length ~ 2,900 m (9,332 ft)
    b. HL (5” DP) = 9,000 ft X 19.2 lb/ft + ~60,000 lb (BHA) = 232,800 lb
    c. HL (5-1/2” DP) = 9,000 ft X 26.4 lb/ft + ~60,000 lb (BHA) = 297,600 lb
2. **GC 955**: Derrick capacity hook load
    a. WD = 2033 m (6670 ft), HD = 450 mbsf (1478 ft), Total string length ~ 2484 m (8148 ft)

    b. HL (5” DP) = 8,000 ft X 19.2 lb/ft + ~60,000 lb (BHA) = 213,600 lb
    c. HL (5-1/2” DP) = 8,000 ft X 26.4 lb/ft + ~60,000 lb (BHA) = 271,200 lb

B. Derrick Clearance

1. Running/Pulling capability – need to be able to clear at least singles (30 ft jts). Doubles or triples would reduce the time required to put out the drill string. However, given that we are only drilling in a single location and will not need to pull the string during the drilling, doubles or triples are not particularly advantageous.
2. PCTB length = 46 ft 9 in (14.25 m) plus wireline sinker bar assembly
3. Pipe handling/racking
   Need to be able to handle and rack sufficient drill pipe to meet objective.

C. Other Requirements

1. Drill pipe/BHA (Bottom Hole Assembly)
   4-1/8” minimum ID through all joints and BHA components
2. UT/DOE will supply BHA components
   Minimum make up torque capacity = 60,000 lb-ft
3. The PCTB has a 3&3/4” OD and must fit inside a 4” minimum ID pipe. All of the components that it lands and latches in exist. They have 6&5/8” FHM connections.
4. Weighted mud will be used to drill the well. In previous drilling (LWD) at these locations, borehole instability and the inability to clear cuttings necessitated the continuous use of a 10.5 ppg mud below depths of about 1600 fbsf. See (Collett, 2009) for a summary of previous operations.
5. There must be capability to visualize the well head for any flow. We envision that a simple ROV will be used. However, it is possible cameras mounted on a seabed from could be used for this. .
6. There must be capability to cement the well.
7. The vessel must have the capability to accommodate these containers on the deck (Table 2).
    a. Containers #1 & #2 (PCATS & PCATS1) – These containers house the PCATS. They need to be positioned end to end (60 ft total length) and close enough to the rig floor for easy transport of the PCTB autoclave from the rig floor to these containers.
    b. Container #3 (PCATS2) – This container is a refrigerated container for core storage. It can be positioned anywhere on deck that provides reasonably easy access from the PCATS.
    c. Container #4 (PCTB) – This container is used to service the PCTB between deployments. It needs to be positioned in close proximity to either the pipe rack or the rig floor. The PCTB subassemblies will be moved between the ring floor and this container, via tugger, for servicing.

#	Container	Length	Weight
1	PCATS	40 ft	19,360 kg = 42,681 lbs
2	PCATS1	20 ft	8,710 kg = 19,202 lbs
3	PCATS2	20 ft	8,810 kg = 19,423 lbs
4	PCTB	40 ft	12,246 kg = 27,000 lbs
	TOTAL		49,126 kg = 108,306 lbs = ~ 49 metric Tonnes or 54 tons (US)

Table 2: Containers

III. Schedule:

Our preferred window is 1 December 2016 to 15 June 2017.

IV. The Pressure Coring Tool with Ball (PCTB) Experiment Plan

A. The PCTB:

The PCTB (Pressure Coring Tool with Ball) is a pressure coring system developed with support from the Department of Energy. The tool is designed to recover core samples that will be brought to the surface while maintaining in-situ pressure. The PCTB in part, consists of a ball valve, autoclave, and nitrogen pressure booster. As the tool is driven into the formation—using cutting shoe, face bit, or direct push—the sample is driven into the autoclave. A shipboard operator then uses the wireline to pull up on the PCTB, which closes the ball valve and opens the nitrogen pressure booster. The nitrogen gas floods the autoclave until the pressure inside is elevated to ~200 psi above hydrostatic. The wireline operator then brings the PCTB to the surface, the now pressurized autoclave is replaced and the ball and nitrogen pressure booster are reset, and the tool is lowered back into the formation.

B. PCATS:

Once shipboard, the autoclave is loaded into the PCATS (Pressure Core Analysis and Transfer System) where it is removed from the autoclave, transferred into a pressure vessel and stored for future shipboard or dock-side analysis. Alternatively, PCATS can be used to slice/sub sample the core, perform core log analysis, or prepared for future analyses.

C. Experimental Plan:

We will drill two holes in one location (either WR313 or GC955) and will acquire approximately 20 pressure cores. GeoTek Engineering (a subcontractor of UT) will be responsible for loading and managing the deployment of the PCTB and PCATS on the ship.

Figure 1: PCTB (Pressure Coring Tool with Ball)

V. Location:

We will perform the experiment at either WR-313 or GC 955. At both locations we will twin a previously occupied hole as described below.

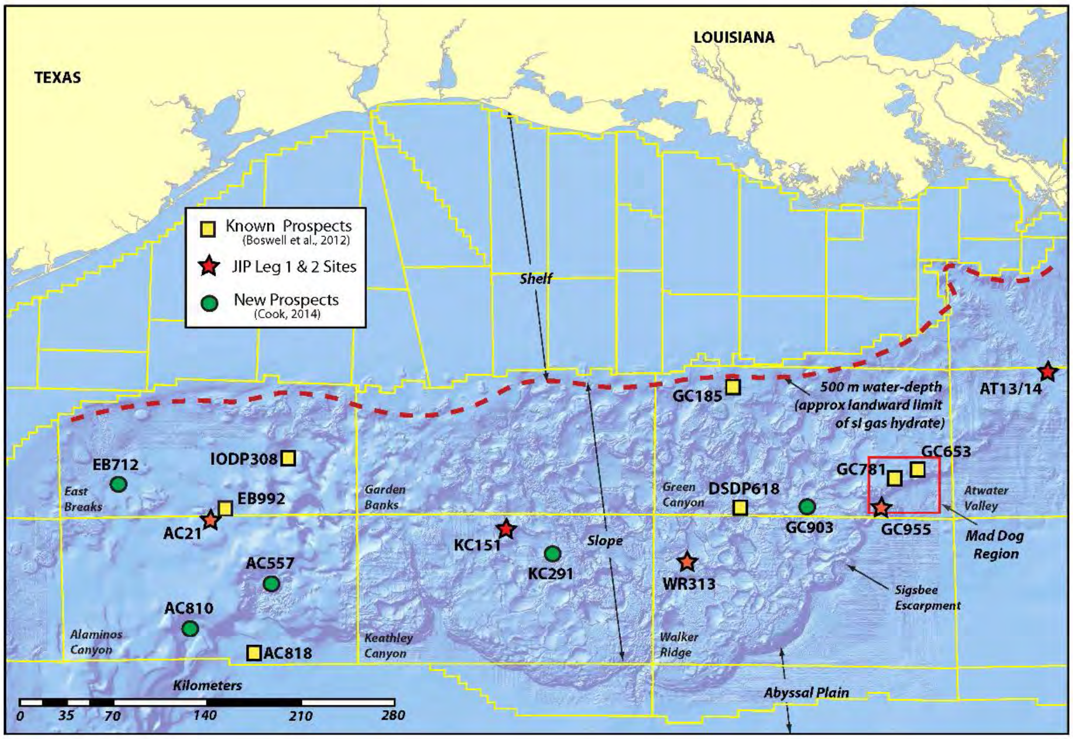

Figure 2: We will drill at either GC 955 or WR 313. Modified from (Boswell et al., 2012).

A. Walker Ridge Block 313 Location:

The WR-313 site is in 1965 m (6450 ft) of water, and has an extremely deep base of hydrate stability at ~880 m (2900 ft) below seafloor. The WR313 site was selected for drilling due to a series of high amplitude phase-reversals (or dim-outs) in several tilted stratigraphic layers that aligned with the inferred base of the methane hydrate stability zone (Figure 3). In previous drilling, high saturation methane hydrate (up to 80% of pore space) was found in Hole WR313-G and WR313-H (Figure 4).

Methane hydrate was encountered in multiple intervals in Hole WR313-H, in 1) a thick section (164-316 mbsf) where methane hydrate occurs in near-vertical fractures, 2) the 'Blue' sand (650-702 mbsf) where methane hydrate appears in varying saturations in thin sands, 3) and the 'Orange' sand (806-819 mbsf) where methane hydrate appears at high saturations in thicker sands (Frye et al., 2012) (Fig. 4). Also, within the fractured layer at 292 mbsf, a thin ~3m sand appears with high hydrate saturations.

Walker Ridge	***TVD subsea ft***	***TVD Subsea meters***	***meters below sea floor (mbsf)***	***ft below sea floor (ft)***
sea floor	6450	1966.5	0	0
Fractured Interval top	6987.9	2130.5	164	537.9
Fractured Interval bot	7486.5	2282.5	316	1036.5
Blue Sand Top	8582.0	2616.5	650	2132.0
Blue Sand Bot	8752.6	2668.5	702	2302.6
Orange Sand Top	9093.7	2772.5	806	2643.7
Orange Sand Bot	9136.3	2785.5	819	2686.3
Bottom Sim Reflector	9336.4	2846.5	880	2886.4

Table 3: Walker Ridge 313 Location (Terrebone).

We will drill at the previously drilled WR313H well location.

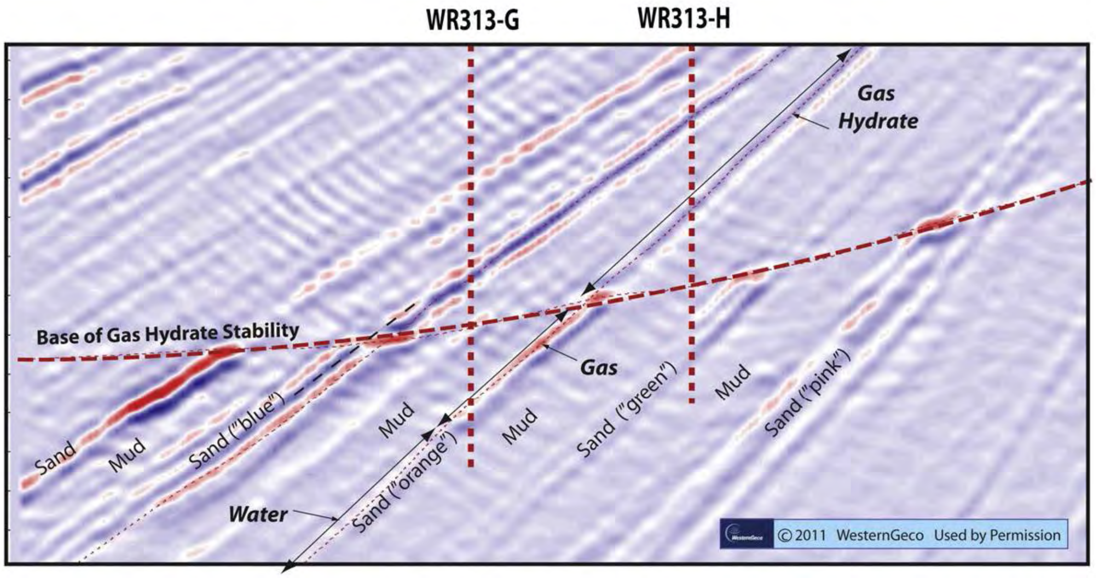

Figure 3: Seismic cross section through the Walker Ridge 313 JIP hydrate drilling locations. Modified from (Boswell et al., 2012). We will twin the H well.

Coring and Logging Plan at WR313: We will drill two holes at the H well location focusing only on taking pressure cores near and in the hydrate horizons. We will take approximately 10 pressure cores in the Orange sand.

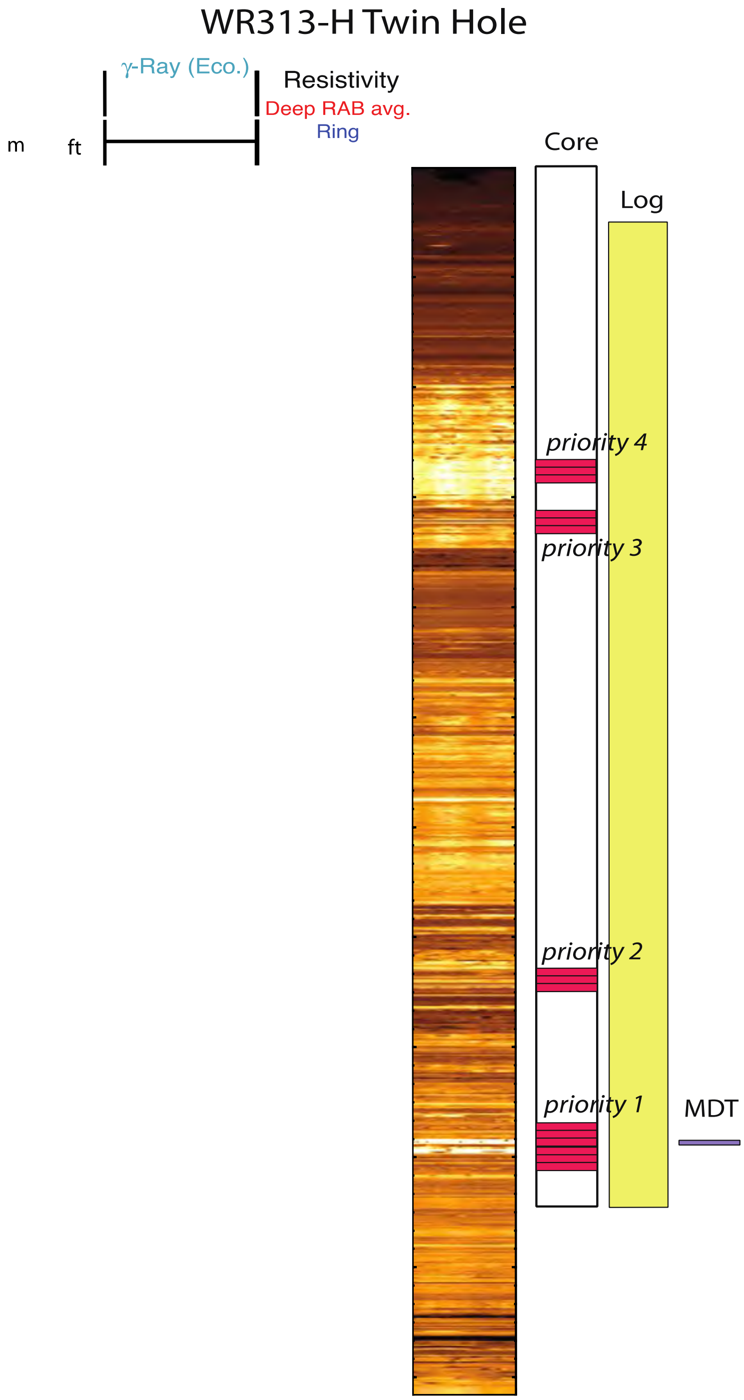

Figure 4: The WR 313-H hole was previously drilled. Our target locations are labeled Priority 1 and Priority 2 for this drilling project. See Table 1 and Table 3.

B. Green Canyon 955 location

Previous Drilling: Multiple LWD wells were previously drilled through the JIP program (Figure 5, 6).

Planned Drilling: We will drill two holes at the GC955-H well (Fig. 6). We will take 20 pressure cores in or near the hydrate bearing sand at 1400 fbsf.

Green Canyon 955	***TVD subsea ft***	***TVD Subsea meters***	***meters below sea floor (mbsf)***	***ft below sea floor (ft)***
sea floor	6670.0	2033.5	0.0	0.0
Hydate sand top	8028.0	2447.6	414.0	1358.0
Hydrate sand bot	8148.0	2484.1	450.6	1478.0
Base of well	8654.0	2638.4	604.9	1984

Table 4: Green Canyon Blk 955 depths of key surfaces

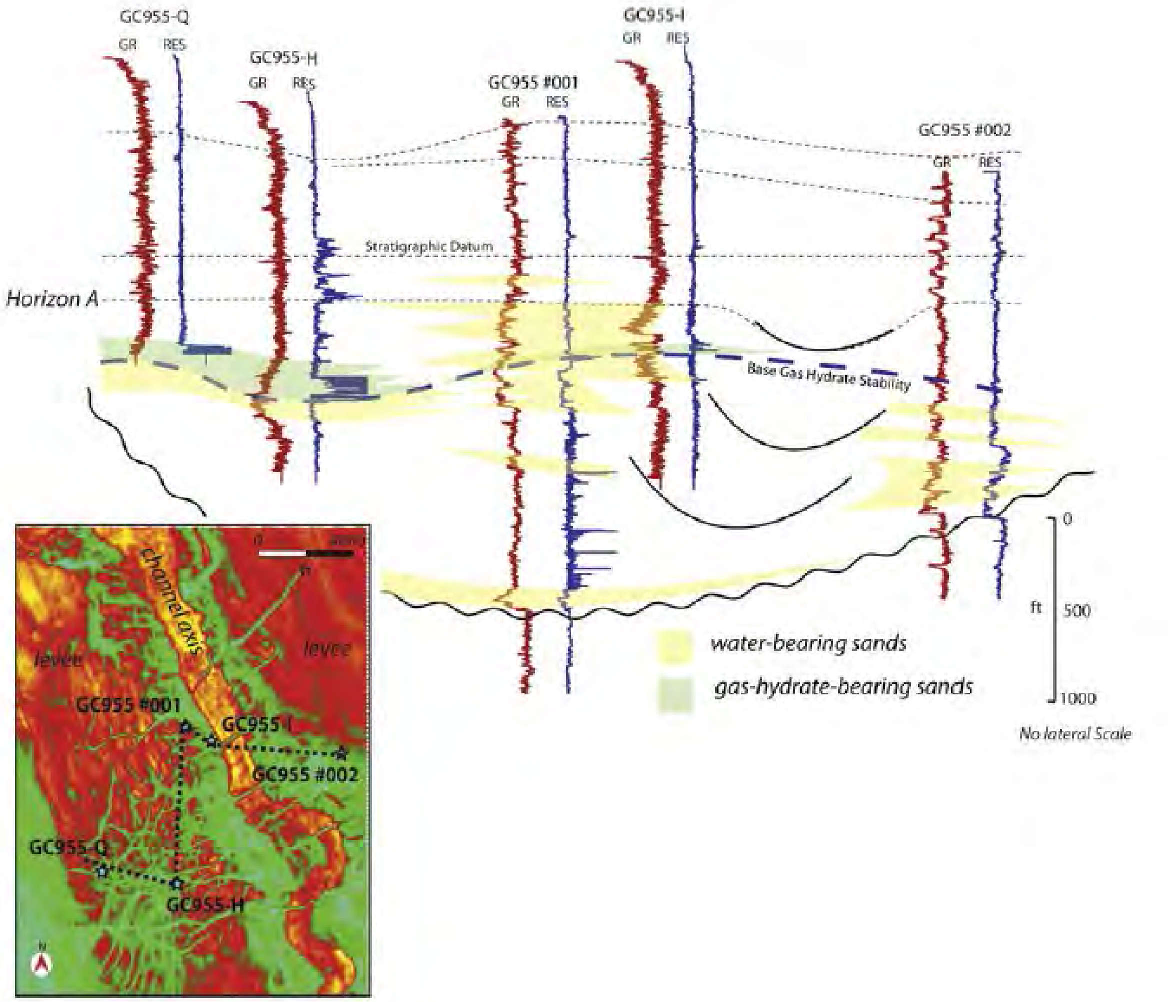

Figure 5: LWD gamma-ray (red) and resistivity (blue) data from five wells in GC955, showing the thick massive sands on the eastern portion of the block in contrast with the more thinly-bedded units located to the west. Inset map shows seismic amplitude at the horizon A, showing the position (at that time) of the main channel axis and the bounding levees. (Boswell et al., 2012)

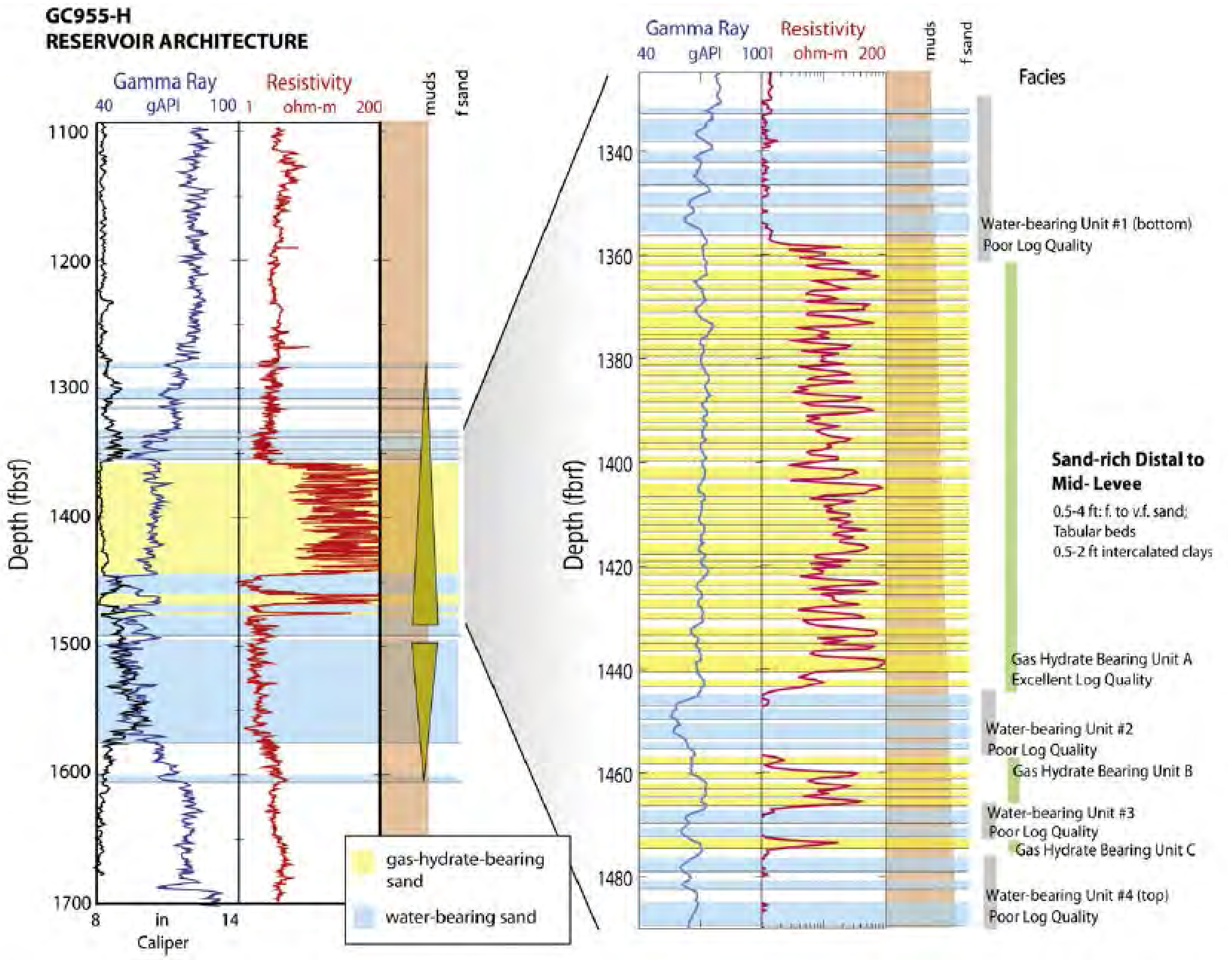

Figure 6: LWD data from the reservoir sands in the GC955-H well showing the thinly-interbedded nature of the gas-hydrate-bearing sands, as well as the areas of poor LWD data quality in the bounding water-saturated sand-rich units. Lithology as inferred primarily from the GR log to right (yellow ¼ fine sand; beige ¼ silts and silty muds). Intervals of graded bedding (fining-upwards and coarsening upwards) indicated by brown triangles. For more information on the LWD data used in Leg II, please see Collett et al., (2012).

VI. Scientists and Technicians shipboard

Depending on the ship that is chosen, the number of staff it can accommodate will change. We estimate that we will need to house 15-20 scientists, engineers, and technicians from UT, GeoTek and other institutions.

VII. References

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

Collett, T. B., R.; Mrozewski, S.; Guerin, G.; Cook, A.; Frye, M.; Shedd, W.; McConnell, D., 2009, Gulf of Mexico Gas Hydrate Joint Industry Project Leg II — Operational Summary.

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