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Deepwater Methane Hydrate Characterization and Scientific Assessment

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DISCLAIMER

ABSTRACT

This is the Phase 3 Report for the 'Deepwater Methane Hydrate Characterization and Scientific Assessment or Genesis of Methane Hydrates in the Gulf of Mexico (GOM2)' research project (DOE Award No. DE-FE0023919). The report summarizes activities from January 16, 2018 to September 30, 2019. The project is led by the University of Texas at Austin (UT). The objective 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 the geologic occurrence, regional context, and characteristics of marine methane hydrate deposits in the Gulf of Mexico outer continental shelf (OCS).

We determined that it would not be possible to pursue the project with the International Ocean Discovery Program (IODP) and then developed a revised science and operations plan to maximize the science using a commercial vessel within the budget that is available. We improved the scientific capability of the UT pressure core center by adding the ability to X-ray pressure cores, and the ability to cut and store multiple core samples for experimental analysis. We transferred pressure cores to peer institutions, including the National Energy Technology Lab (NETL) the United States Geological Survey (USGS Woods Hole). We made advances in understanding the composition and source of gasses locked in the methane hydrate from Green Canyon 955 (GC-955). We developed approaches to determine the in-situ salinity of hydrate-bearing samples, revealing that the in situ salinity of the GC 955 reservoir is just above that of seawater. We determined that the GC-955 hydrate reservoir is composed of sandy silt with a high concentration of hydrate interbedded with clayey silt with no hydrate present. We determined that some or all of the intervals bounding the hydrate reservoir are composed of material similar to the reservoir (sandy silt with hydrate and clayey silt with no hydrate), but with a lower net to gross. We determined that the reservoir effective permeability at a hydrate saturation of ~80-90 % is ~0.1 mD (or 1.0×10-16 m2) to ~0.5 mD (or 5.0×10-16 m2) and the intrinsic permeability is ~12 mD (or 1.2×10-14 m2). The GC-955 reservoir in-situ porosity of sandy silt is 0.38 to 0.40 and is largely independent of effective stress, and that the porosity of clayey silt is 0.33 at an in situ effective stress of 3.8 MPa to ~0.37 at zero effective stress. We developed a systematic, repeatable approach to studying hydrate reservoir properties by reconstituting individual lithofacies from dissociated pressure cores. We determined index properties of GC-955 reservoir, including liquid limit and plasticity, porosity, capillary behavior, and particle size distribution. We developed a more robust pressure coring technology. We finalized and published the UT-GOM2-1 Expedition Volume and we finalized a dedicated volume on the UT-GOM2-1 expedition that will be published in the American Association of Petroleum Geologists Bulletin (AAPG) in spring 2020.

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1 EXECUTIVE SUMMARY

This is the Phase 3 Report for the 'Deepwater Methane Hydrate Characterization and Scientific Assessment or Genesis of Methane Hydrates in the Gulf of Mexico (GOM2)' research project (DOE Award No. DE-FE0023919). The report summarizes activities from January 16, 2018 to September 30, 2019.

The project is led by the University of Texas at Austin (UT). The objective 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 the geologic occurrence, regional context, and characteristics of marine methane hydrate deposits in the Gulf of Mexico outer continental shelf (OCS).

We summarize significant achievements during Phase 3 below.

1. Determined the International Ocean Discovery Program (IODP) could not perform UT-GOM2-2 drilling expedition: UT provided operational and technical support of the International Ocean Discovery Program's (IODP) Expedition 386, and assisted the IODP and the *JOIDES Resolution* Facilities Board (JRFB) with preliminary assessments of regulatory and vessel certification requirements for conducting deepwater stratigraphic tests in the Gulf of Mexico OCS. We learned that the *JOIDES Resolution* did not meet regulatory requirements and the IODP withdrew from performing Expedition 386. UT then proposed that the IODP's European component, ECORD, pursue this expedition. ECORD considered this, but ultimately declined citing existing priorities. UT, with DOE and the GOM2 Project Team then determined that UT will execute UT-GOM2-2 by contracting a commercially available drilling vessel.
2. Developed a viable path forward to complete the UT-GOM2-2 expedition with commercial vessel: The GOM2 Project Team evaluated the scope, budget, and schedule that would result from using a commercial vessel. We prioritized UT-GOM2-2 science objectives, and we proposed multiple operational scenarios to maximize the achievement of these objectives. We then chose a final plan that accomplishes as much of the original science objectives as possible in a prioritized order within the existing budget.
3. Developed more robust Pressure Coring Technology: We analyzed the performance of the pressure coring tool (the PCTB) during the 2017 GOM2-1 Marine Field Test and designed 5 incremental improvements to improve tool performance. The modifications will be fully incorporated into the PTCB design in the next project period.
4. Improved the scientific capability of the Pressure Core Center: We added the ability to X-ray our pressure cores in the laboratory at UT. This allows us to more accurately sample and to study the effects of storage. We also added the ability to cut and store multiple samples for experimental analysis. This increases our throughput and decreases sample degradation.
5. Successfully transferred pressure cores to peer institutions to further petrophysical research: We supported the successful transfer of pressure cores to the National Energy Technology Lab (NETL) the United States Geological Survey (USGS Woods Hole).
6. Determined source of methane at GC-955: Molecular and isotopic analysis indicate that the gas in hydrates at the GC-955 reservoir is primarily microbially sourced. We developed a new sampling technique to collect gas samples during pressure core degassing with minimal atmospheric

contamination, allowing for improved interpretation of noble gas measurements from hydrate-bearing sediments.

7. Determined in situ salinity of the GC 955 reservoir: We used slow depressurization to estimate the in-situ salinity of hydrate-bearing samples, revealing a salinity just above seawater. Hydrate dissociation occurs along the freshwater phase boundary due to local freshening.
8. Refined lithofacies interpretation at GC-955: We determined that the hydrate reservoir is composed of sandy silt with a high concentration of hydrate interbedded with clayey silt with no hydrate present.
9. Advanced Understanding of GC-955 Reservoir Bounding Units: The bounding units to the GC-955 reservoir are most likely composed of interbedded hydrate-bearing sandy silt and clayey silt beds. This is similar to the lithologies present in the reservoir. However, the bounding intervals have a lower fraction of sandy silt to clayey silt beds, and the sandy silt beds are thinner, than within the reservoir interval.
10. Determined Reservoir Permeability: We determined the effective permeability (the permeability of the reservoir in the presence of hydrate) and the intrinsic permeability at in-situ effective vertical stress. The effective permeability at a hydrate saturation of ~80-90 % is ~0.1 mD (or 1.0×10^{-16} m^2) to ~0.5 mD (or 5.0×10^{-16} m^2) and the intrinsic permeability is ~12 mD (or 1.2×10^{-14} m^2).
11. Determined Reservoir Porosity: The in-situ porosity of sandy silt is 0.38 and 0.40 an is largely independent of effective stress. The porosity of clayey silt is 0.33 at an in situ effective stress of 3.8 MPa to ~0.37 at zero effective stress.
12. Studied Hydrate Reservoir Properties by reconstituting lithofacies: We developed approaches to reconstitute individual lithofacies from dissociated pressure cores. This is a systematic, repeatable, approach to study material properties including: (1) porosity vs. permeability (2) permeability vs. grain size (3) compressibility, and 4) capillary behavior.
13. Determined Index Properties of GC-955 Reservoir: We studied the liquid limit and plasticity, the porosity, the capillary behavior, the particle size distribution of the GC-955 reservoir.
14. Released UT-GOM2-1 Scientific Report: We finalized and published the UT-GOM2-1 Expedition Volume (similar to IODP-style). https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/
15. Finalized dedicated volume on the UT-GOM2-1 (GC 955) Gulf of Mexico drilling expedition: This will be published in the American Association of Petroleum Geologists Bulletin (AAPG) in spring 2020.

2 INTRODUCTION

The objective of GOM2 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 the geologic occurrence, regional context, and characteristics of marine methane hydrate deposits in the Gulf of Mexico Continental Shelf.

Phase 1 occurred from Oct. 1, 2014 to Sep. 30, 2015. In Phase 1, potential UT-GOM2-2 field sites were identified, appraised using available geophysical and geologic data, and ranked relative to one another using criteria developed in conjunction with DOE (TASK 2). Following site selection, a pre-expedition drilling, coring, logging and sampling operational plan was developed (TASK 3). A Complementary Project Proposal (CPP), based on the Operational Plan, was submitted to the International Ocean Discovery Program (IODP) as a primary method of accessing a suitable scientific drilling vessel (TASK 4). Concurrently, lab testing and modification of the pressure coring tool with ball-valve (PCTB) was conducted (TASK 5).

Phase 2 occurred from Oct. 1, 2015 to Jan. 15, 2018. In Phase 2, UT continued support of the CPP, and modified the proposal as needed (TASK 6). A land-based field test (Land Test) of the PCTB was conducted (TASK 7). A Marine Field Test (UT-GOM2-1) of the PCTB was conducted, during which hydrate-bearing pressure cores were acquired from two drill-sites in Green Canyon Block 955 in the Gulf of Mexico, outer continental shelf (TASK 8). UT developed the capability to transport, store, and manipulate pressure cores, acquired during the UT-GOM2-1 Marine Field Test (TASK 9). Pressure cores acquired during the UT-GOM2-1 Marine Field Test were transported to land-based facilities, stored, subsampled, and characterized (TASK 10). The Operational Plan for the UT-GOM2-2 Scientific Drilling Program was refined (TASK 11). UT continued to support efforts to acquire access to a scientific drilling vessel, provided updates of CPP outcomes and, evaluated alternate means of gaining access to a vessel for the UT-GOM2-2 Scientific Drilling Program (TASK 12).

3 SUMMARY OF PHASE 3 TASKS

Phase 3 tasks are summarized in Table 3-1.

Table 3-1: Summary of Phase 3 tasks

PHASE 3/BUDGET PERIOD 3	
Tasks continued from previous phases	
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 Operational Plan for UT-GOM2-2 Scientific Drilling Program**
Task 12.0	**UT-GOM2-2 Scientific Drilling Program Vessel Access**
Tasks initiated this project phase	
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 DOE Pressure Coring System**
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*

3.1 Task 1.0: Project Management and Planning

Objectives

The Recipient will execute the project in accordance with the approved PMP covering the entire project period. The Recipient will manage and control project activities in accordance with their established processes and procedures to ensure tasks and subtasks are completed within schedule and budget constraints defined by the PMP. This includes tracking and reporting progress and project risks to DOE and other stakeholders.

Accomplishments

During GOM2 Phase 3, UT accomplished the following project management and planning tasks:

Assembled team to meet project needs

1. Hired Research Scientist Associate, Aaron Price, in Jan. 2019.

Coordinated the overall scientific progress, administration, and finances of the project

1. Monitored and controlled project cost, scope, and schedule. Reported status updates, risks, and change requests to DOE Project Manager.
2. Completed post-expedition UT-GOM2-1 Marine Field Test permit submissions.
3. Supported UT-GOM2-1 AAPG editors and GOM2 scientists and staff with communications, organizing meetings, and identifying potential topics and authors.
4. Coordinated efforts with the *JOIDES Resolution* (*JR*) Science Operator (JRSO) to assess requirements for the *JR* to meet 1989 International Maritime Organization (IMO) Mobile Offshore Drilling Unit (MODU) Code, and/or 46 Code of Federal Regulation (CFR) part 108 requirements.
5. Performed extensive evaluation of scope, budget, and schedule implications of implementing UT-GOM2-2 without the scientific and operational capabilities of the *JR*.
6. Engaged with IODP and the European Consortium for Ocean Research Drilling (ECORD) to pursue execution of UT-GOM2-2 as a an ECORD Mission Specific Platform (MSP).
    a. Developed alternative UT-GOM2-2 operational scenarios as options for potential implementation as an ECORD MSP.
    b. Presented the CPP-887 science and operations plan to the European Science Operator (ESO) in a teleconference on 8 June, 2018.
    c. Provided technical summary document of UT-GOM2-2 and possible alternate operation plans to ECORD Facility Board (EFB) on September 7, 2018 for consideration in EFB planning meeting on September 10, 2018.
7. Developed cost frameworks, operational plans, timelines, and scientific objectives that could be achieved with alternative UT-GOM2-2 operational plans. Presented alternatives analysis to DOE, the GOM2 Advisory Board, and Co-PIs, to acquire consensus on a final UT-GOM2-2 drilling program.
8. Responded to DOE request to explore feasibility of executing a logging-while drilling (LWD) program in early 2020 aboard the Pacific Drilling-Pacific Khamsin drillship, while on long-term lease to Equinor ASA (Equinor).

   a. Prepared draft operational planning documents and developed cost framework, timeline, and budget for possible LWD expedition.
   b. Met with Equinor, in-person, on May 16, June 5, and June 20, 2019.
9. Developed BP3 to BP4 budget period transition proposal and submitted to DOE on July 29, 2019.

Communicated with project team and sponsors

1. Worked with Expedition Science Party and UTIG staff to finalize the UT-GOM2-1 expedition scientific report (containing 4 major chapters), a digital data base of the initial technical findings, and all supporting materials and website. Published Expedition Volume similar to IODP style including preliminary pages, expedition summary, methods, and well reports. Created and published data directory of all initial results. https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/
2. Organized regular team meetings, including weekly UT Management Meetings, Monthly Sponsor Meetings, Mapping Team Meetings, PCTB Development Team Meetings, and UT-GOM2-2 Operational Planning Meetings
3. Coordinated DOE visit to University of Texas at Austin to review this project and DE-FE0028967 (HP3), on January 30, 2018.
4. With Ohio State, hosted a two-day technical GOM2 scientific workshop at Ohio State from September 24-25, 2018 including:
   a. 10+ Technical presentations
   b. 25+ Posters
   c. UT-GOM2-2 Brainstorming sessions
   d. Identified action items and launched UT-GOM2-2 working groups
      i. Operational Team
      ii. Nuts and Bolts
      iii. In situ Test Team
      iv. Core Analysis Team
      v. Rock Physics Team (Pressure Core Petrophysics Team)
      vi. Methane Source Team (Microbiology)
5. Held meetings with the GOM2 Advisory Board on January 24, 2019, February 7, 2019, and March 18, 2019 to develop final consensus on the revised UT-GOM2-2 Operations Plan.
6. Managed SharePoint sites developed to facilitate project team collaboration.
7. Managed archive websites for project deliverables.

Coordinated and supervised subcontractors and service agreements

1. Actively managed subcontractors and service agreements.
2. Negotiated and finalized service agreement with Reaction Engineering International (REI) for Computational Fluid Dynamics (CFD) analysis of the PCTB.
3. Negotiated and finalized service agreement with Geotek Coring Inc. (Geotek) for continued PCTB modifications and testing and UT-GOM2-2 coring deployment.

4. Negotiated service agreement with Schlumberger Technology Corporation (STC) for use of the Cameron Testing and Training Facility (CTTF) during the PCTB Land Test.
5. Amended service agreement with Pettigrew Engineering, PLLC (Pettigrew Engineering) for continued engineering and consulting services throughout Phase 3.
6. Negotiated revised scope of work and budget for Ohio State sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Ohio State act as the Site Characterization Technical and Science Lead for UT-GOM2-2 and will perform conventional core and gas geochemical analysis.
7. Negotiated revised scope of work and budget for the University of New Hampshire (UNH) sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. UNH will lead the lithostratigraphy effort for UT-GOM2-2.
8. Negotiated revised scope of work and budget for Columbia University LDEO sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Lamont-Doherty will contribute to ensuring that the sampling and analytical plan is appropriate to fully address the expedition objectives, particularly in regard to the physical properties and geochemical observations needed to assess the relative contribution of in situ and migrating methane, long-range aqueous methane migration, and the temporal evolution of hydrate accumulations.
9. Negotiated revised scope of work and budget for Oregon State sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Oregon State University will lead the microbiology effort for UT-GOM2-2.
10. Negotiated revised scope of work and budget for the University of Washington (UW) sub-awards based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. UW will lead the geochemistry effort for UT-GOM2-2.
11. Negotiated and finalized materials transfer agreements with NETL and USGS for the safe transfer of pressure core back to NETL labs. NETL will focus on micro-coring and X-ray imaging of cores under pressure. USGS will analyze UT-GOM2-1 pressure core using the PCCT.
12. Started negotiations with AIST (Japan) on a research agreement so that they could work in the pressure core center and safely remove and transfer UT-GOM2-1 pressure core back to AIST for research in their labs using PNATS and other tools.

Identify, monitor, and manage risks, and communicate risks and possible outcomes to stakeholders.

1. Actively monitored project risks and reported as needed to project team and stakeholders.
    a. Identified risk that *JR* may not meet regulatory requirements to drill in U.S. outer continental shelf.
    b. Identified risk that JRSO and JR ship owner (ODL-SIEMS) may choose to not pursue vessel upgrades enabling continued planning and execution of UT-GOM2-2.
    c. Proactively communicated developments of evaluation of *JR's* ability to comply with regulatory requirements with DOE and project sponsors on a monthly, bi-monthly, or more frequent basis, as warranted.
    d. Developed risk mitigation strategies for UT-GOM2-2 and took risk mitigation steps:

i. Expressed UT’s willingness to pursue a review of potentially inappropriate vessel regulations imposed upon JR, and/or seek alternative regulations.
ii. Reevaluated minimum-viable UT-GOM2-2 scientific objectives.
iii. Defined and developed cost estimates for alternative UT-GOM2-2 expedition scenarios.
iv. Interfaced with ECORD to pursue executing UT-GOM2-2 as an MSP.
v. Initiated planning of UT-GOM2-2 independently of IODP/ECORD once it was recognized that collaborating IODP/ECORD may prove infeasible.

3.2 Task 6.0: Technical and Operational Support of CPP Proposal

Objectives

The Recipient will continually refine the planned science within the CPP proposal, and the project in general, as the project develops. The Recipient will evaluate and respond to all reviews conducted of the CPP proposal, in conjunction with the Project Advisory Team, within the timeframes identified by IODP.

The Recipient will coordinate with the IODP U.S. Implementing Organization (USIO) to determine eligibility of the JOIDES Resolution (JR) scientific drillship to be permitted to drill in the Gulf of Mexico. The Recipient will also investigate alternative means of accessing a drill ship through the IODP's European counterpart, the European Consortium for Ocean Drilling (ECORD) if it is determined that the JR cannot perform the planned UT-GOM2-2 drilling activities.

Accomplishments

In spring, 2018, it became apparent that the *JOIDES Resolution (JR)* did not meet the regulatory requirements for a mobile offshore drilling unit (MODU) and the 1989 International Maritime Organization (IMO) MODU Code or 46 Code of Federal Regulation (CFR) part 108, required by the US Coast Guard (USCG) and the Bureau of Safety and Environmental Enforcement (BSEE) for drilling and conducting deep stratigraphic testing (boreholes deeper than 500 feet below seafloor) on the Outer Continental Shelf (OCS). A review of the 1989 IMO MODU Code, performed by UT, the JRSO and the *JR* ship owner (ODL-SIEMS), resulted in the conclusion by the JRSO and ODL-SIEMS that there was neither sufficient time, nor sufficient funds, to modify the *JR* to meet the requirements.

The UT GOM2 team and the DOE emphasized that they were willing to seek review of any potentially inappropriate regulations. However, UT was not provided with an accounting of specific issues from the JRSO or OD-SIEMS for which a discussion with Federal regulators would be worthwhile. In April 2018, the JRSO and ODL-SIEMS withdrew from performing IODP Expedition 386 in 2020 in the Gulf of Mexico.

On May 21, 2018, UT received formal notification that that JRFB had canceled IODP Expedition 386 and removed it from the *JR*'s 2020 schedule, citing high costs and insufficient available time for ship upgrades required for the *JR* to meet MODU 1989 Standards mandated by the United States Coast Guard (USCG) for drilling in the Gulf of Mexico outer continental shelf (**Appendix A**).

The JRFB proposed that UT-GOM2-2 could be considered for implementation by the IODP's European component, the European Consortium for Ocean Research Drilling (ECORD), a Mission Specific Platform (MSP). The JRFB suggested that UT should start working with ECORD to assess this possibility (**Appendix A**).

UT held a web-conference with the ECORD Science Operator (ESO) on June 14, 2018 to provide a technical and operational overview of the UT-GOM2-2 expedition and provide information required for ESO to scope to assess potential for mounting expedition as an MSP. Attendees included Peter Flemings, Carla Thomas, and Jesse Houghton of UT, Timothy Collett of United States Geological Survey (USGS), Richard Baker and Ray Boswell of DOE, Dave McInroy, Dave Smith, and Graham Tulloch of British Geological Survey (BGS), Ursula Rohl of MARUM Center for Marine Environmental Sciences, Sally Morgan of University of Leicester, Gilbert Camoin of the European Centre for Research and Teaching in Geosciences (CEREGE), and others. UT provided ESO with the UT-GOM2-2 operations plan and vessel requirements.

On September 7, 2018, UT provided the ECORD Facility Board (EFB) with the original UT-GOM2-2 field program and multiple scenarios for how this program could be achieved by an ECORD MSP, without the technical capabilities of the *JR*. The ECORD Facility Board (EFB) met on September 10, 2018 to review CPP-887 and evaluate implementing UT-GOM2-2 as an MSP. Subsequently, the EFB recommended that the ESO support an abridged CPP-887 program as an MSP for implementation in 2021.

The ECORD Council (funding entity that coordinates a common approach to IODP policy) and ECORD Science Support and Advisory Committee (ESSAC) met on November 7-8, 2018 to plan operations and allocate budgets. The ECORD Council determined that previously-postponed Arctic and Antarctic expeditions would be prioritized for implementation in 2021-2022. Therefore, the ECORD Council determined it was not possible to implement CPP-887 as an MSP. The complete ECORD Council Consensus Statements from the November meeting are available at https://www.ecord.org/?ddownload=11188.

The relevant ECORD Council Consensus Statements are:

- *ECORD Council Consensus 18-11-06*
  Considering the EFB recommendation to implement Expedition 377 'Arctic Ocean Paleoceanography (ArcOP)' as a first-priority expedition before the end of IODP (EFB Consensus 18-03-05) and ECORD Council Consensus 18-11-04, the ECORD Council decides to schedule this expedition in FY21.

- *ECORD Council Consensus 18-11-07*
  Considering ECORD Council Consensus 18-11-06, the ECORD Council does not consider it possible to schedule an MSP expedition based on proposal #887-CPP2 'Gulf of Mexico Methane Hydrate', as proposed by the EFB following its e-meeting held on September 10, 2018. This decision is based on the new information received from ESO and on the EFB priorities supported by the ECORD Council.

As a result of the ECORD Councils decision, there is no longer a path forward to accessing an IODP or ECORD drilling program through CPP-887. Therefore, UT, in consensus with the US DOE and GOM2 Advisory Team, made the decision to pursue an alternate means of acquiring vessel access for UT-GOM2-2.

A record of all completed CPP-887 tasks and outcomes are provided in Table 3-2.

Table 3-2: Completed Complimentary Project Proposal Tasks and Outcomes

DATE	ACTIVITY
April 1, 2015	First Submittal of CPP
May 1, 2015	Upload data to IODP SSDB
October 1, 2015	Revised Submittal of CPP
January 8, 2016	Upload data to IODP SSDB
Jan 12-14, 2016	SEP Review Meeting
April 1, 2016	CPP Addendum Submittal
May 2, 2016	Upload data to IODP SSDB
May 15, 2016	Proponent Response Letter Submitted
Jun 21-23, 2016	SEP Review Meeting
June 1, 2016	Safety Review Report Submitted
July 1, 2016	Safety Presentation PowerPoint
July 11-13, 2016	Environmental Protection and Safety Panel Meeting
March 2, 2017	Submit CPP Addendum2
March 10, 2017	Upload Revised Site Survey Data
April 1, 2017	Submit EPSP Safety Review Report V2
May 3, 2017	EPSP Safety Review Presentation V2
May 24, 2017	Scheduling of CPP-887 Hydrate Drilling Leg by JR Facility Board: Exp. 386, Jan-March 2020
May 15-16, 2018	Expedition 386 removed from *JR* schedule
September 10, 2018	EFB recommends that ESO support an MSP expedition based on Plan B-3 for implementation in 2021
November 7-8, 2018	ECORD Council and ESSAC determine that it is not possible to implement CPP-887 as an MSP

For additional information on UT-GOM2-2 Scientific Drilling Program vessel access, refer to *Task 12.0: UT-GOM2-2 Scientific Drilling Program Vessel Access*.

3.3 Task 9.0: Pressure Core Transport, Storage, and Manipulation

3.3.1 Subtask 9.8: X-ray Computed Tomography

Objectives

The Recipient will develop an X-ray Computed Tomography (CT) scanning capability, compatible with the Pressure Core Transport, Storage, and Manipulation system. The X-ray CT capability will enable cores transferred from storage chambers to be fully inspected and characterized using either 2D X-ray transmission radiography or 3D X-ray CT and will allow selection of suitable subsamples for further spectroscopic or X-ray micro CT analysis

Accomplishments

The UT Pressure Core Center with its Mini-PCATS facility had no way to image the cores within the pressure vessels. This meant that we could not visualize the core to properly cut specific samples in Mini-PCATS. Instead, we relied on the images taken of the pressure cores when they were originally analyzed at sea or dockside. Unfortunately, the cores have shifted somewhat and thus, we could not locate exactly where we are in the section. To rectify this problem, UT coordinated the purchase of custom X-ray computed tomography (X-ray CT) with P-wave attachment from Geotek, enabling UT to image the cores inside Mini-PCATS.

UT received the X-ray CT system with P-wave attachment for Mini-PCATS from Geotek on November 12, 2018. UT and Geotek, installed the X-ray CT (XCT) system with P-wave attachment for Mini-PCATS in January 2019 (Figure 3-1).

We now X-ray scan every core section we process in mini-PCATS. These scans revealed that the pressure core had undergone changes in core diameter while in storage. We attribute these changes to dissolution of methane hydrate into the confining water. All cores show a reduction in core diameter, with more extreme changes in cores that were compromised during recovery (see Figure 3-2 and Figure 3-3). In the next project Phase, we will explore possible approaches to reduce this degradation.

Figure 3-1: Top: Images of the new CT scanning attachment installed on the UT Mini-PCATS system. Bottom: Images of the P-Wave attachment and initial data.

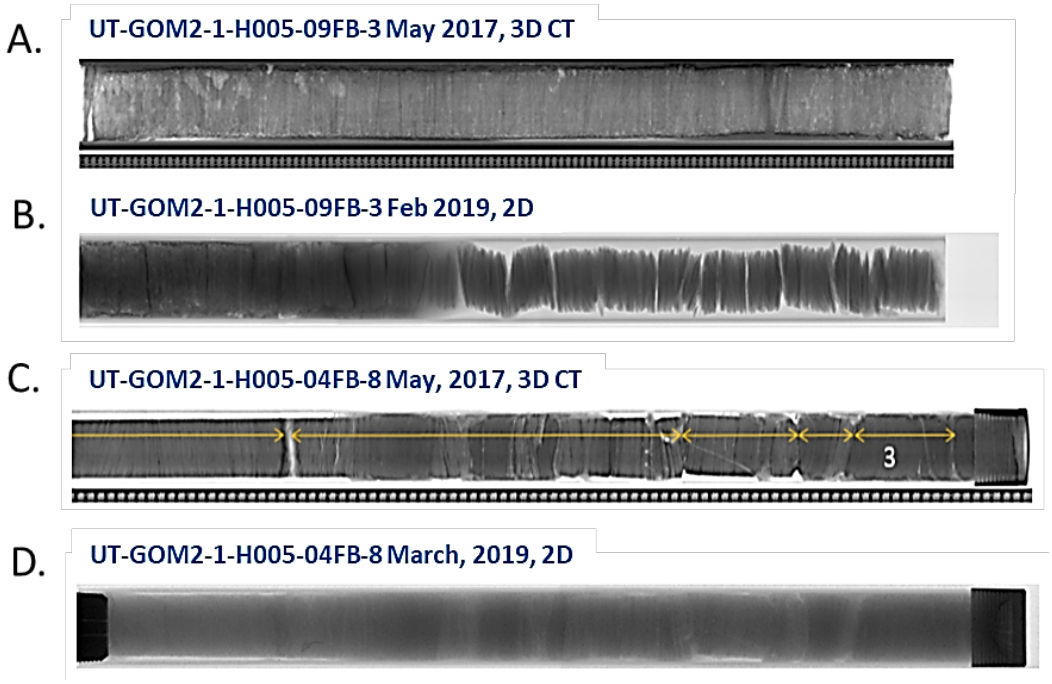

Figure 3-2: A comparison of H005-09B-3 pressure core images before and after storage. A. Full 3D CT scan of compromised Core UT-GOM2-1-H005-09FB-3 during the expedition, B. Quick 2D scan of compromised Core UT-GOM2-1-H005-09FB-3 after almost 2 years of storage showing a large degree of degradation of the core, C. Full 3D CT scan of uncompromised Core UT-GOM2-1-H005-04FB-8 during the expedition, D. Quick 2D scan of uncompromised Core UT-GOM2-1-H005-04FB-8 after almost 2 years of storage showing significant reduction of the core diameter.

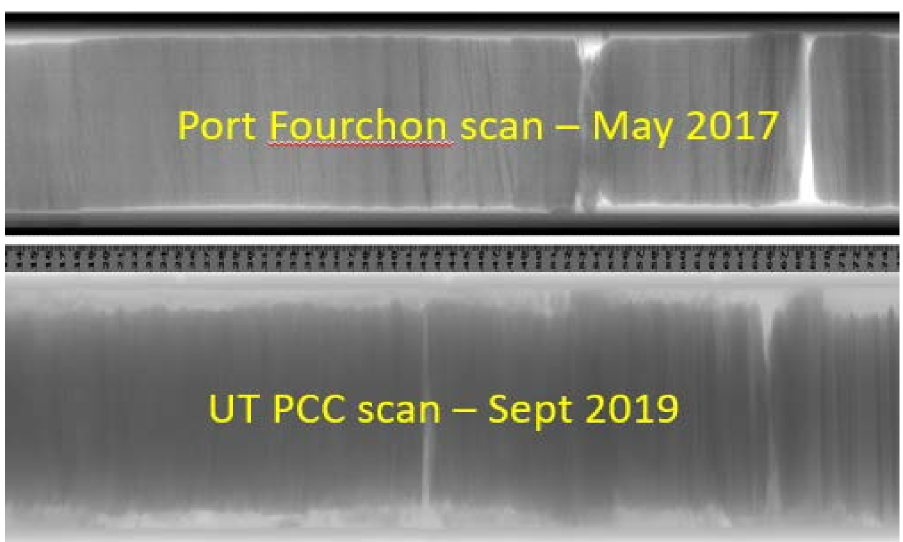

Figure 3-3: A comparison of H005-07B-3 pressure core images before and after storage. Top PCATS scan of H005-07FB-3 using PCATS at Port Fourchon in May of 2017. Bottom scan of H005-07FB-3 using Mini-PCATS in the PCC at UT in September of 2019.After 2 years of storage there is a clear decrease in the core diameter as well as more irregularity in the core diameter.

3.3.2 Subtask 9.9: Pre-Consolidation System

Objectives

The Recipient will develop the capability to cut consecutive pressure core samples and store them at an applied effective stress within a pre-consolidation system. The Pre-consolidation System will then be directly loaded into the Hydrate Core Effective Stress Chamber to measure permeability and compressibility (Subtask 9.6). With this equipment, the recipient will reduce sample wastage and increase the rate of sample analysis.

Accomplishments

UT purchased a Pre-Consolidation system from Geotek to enable more efficient use of the K0 permeameter and faster production of data. The Pre-Consolidation system performs reconsolidation of pressure core samples by subjecting them to their in-situ effective stress conditions prior to making hydraulic permeability measurements in the K0 Permeameter. This allows for multiple K0 permeameter samples to be cut, stored, and prepared for analysis, which saves time and the amount of core required.

The Pre-Consolidation system was delivered to UT on June 19, 2019. After installation, the system was tested in late June with an 8cm Delrin sample. The Delrin sample was successfully extruded from the core liner into the Viton sample membrane inside the test section. After sealing the sample in the membrane and establishing a 400 kPa effective stress, the test section was then transferred to the Pre-Consolidation Manifold. The system properly maintained the desired effective stress as designed.

In late July 2019, a pressure core sample was cut and transferred into a test section for placement onto the Pre-Consolidation System. The Pre-Consolidation successfully maintained pressure of the test section.

3.4 Task 10.0: Pressure Core Analysis

3.4.1 Subtask 10.4: Continued Pressure Core Analysis (UT-GOM2-1)

Objectives

The Recipient will continue to perform, or facilitate performance by others, analysis on the hydrate pressure core acquired from the UT-GOM2-1 Marine Field Test in Phase 2, Task 8.

- *For selected samples, permeability will be measured during depressurization*
- *For selected samples, geotechnical properties (such as compression index and Young's modulus) will be measured during depressurization.*

Accomplishments

3.4.1.1 Pressure Core: Sample Distribution

UT actively supported the transfer of pressure cores to other institutions, including providing technical feedback on pressure chamber designs, to ensure safe transfer and compatibility with mini-PCATs. UT used approved sample requests to cut the requested sections and transfer core into vessels for shipment.

Four 30 cm core segments were successfully transferred at ~24 MPa from the UT Pressure Core Center to the DOE National Energy Technology Laboratory in Morgantown, WV (Figure 3-4) and two full length pressure cores were transferred to the United States Geological Survey Marine and Coastal Science Center in Woods Hole, MA (USGS, Figure 3-5).

UT also began executing research and material transfer agreements between UT and the National Institute of Advanced Industrial Science and Technology (AIST) (Sapporo, Japan). Sections from UT-GOM2-1-3FB-5 and 5FB-3 (Figure 3-6) were transferred to two AIST chambers manufactured by Geotek Figure 3-7. At the end of Phase 3, the chambers were attached to the UT pressure maintenance and relief system (PMRS) until AIST could transport them to Japan.

The ability to cut and transfer core to collaborating institutions allows for a greater range in geomechanical and physical property analyses to be performed on UT-GOM2-1 cores, as well as reproducibility in measurements such as permeability and gas chemistry.

Figure 3-4: Images from the Pressure Core transfer from UT to NETL. Top, NETL storage and transfer chamber attached to UT Mini-PCATS. Lower left, chamber tagged w/ core info, certified by PCC lab manager and staff scientist. Lower center and lower right, NETL storage chambers ready for transfer to reefer van.

Figure 3-5: Images from the Pressure Core transfer from UT to NETL. Top right – USGS storage and transfer chamber attached to UT Mini-PCATS. Bottom right – chamber tagged w/ core info, certified by PCC lab manager and staff scientist. Center left – USGS storage chambers ready for transfer to refrigerated transport vehicle.

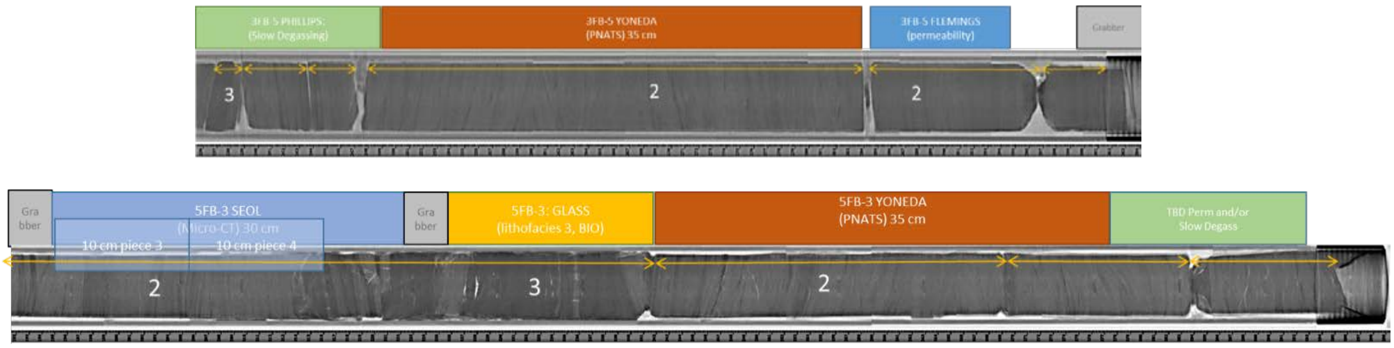

Figure 3-6: Sections of UT-GOM2-1 pressure core (identified in orange) cut and transferred to AIST chambers.

Figure 3-7: Photo of the AIST pressure chamber in the UT PCC.

3.4.1.2 Pressure Core: Microbial Sampling

Oregon State, Georgia Tech, and the USGS (Figure 3-8) visited UT to perform experiments using the USGS BIO chamber (Santamarina et al., 2012), shown in Figure 3-9. The goal was to conduct high-pressure sampling and anoxic depressurization of UT-GOM2-1 sediment for DNA and 16S RNA analysis at Texas A&M Corpus Christi (TAMU-CC) in the Reese Lab. The respective analyses allow the chance to determine genetic diversity and identity (DNA) and specific activity (RNA) of microbes in the sediments.

During their visit, the BIO chamber was successfully attached to Mini-PCATS and 17 cm core sections were transferred to the BIO chamber, including one sample from each of the three identified UT-GOM2-1 lithofacies: silty clay, sandy silt, and clayey silt (Figure 3-10). Using the BIO chamber, sub-samples were scraped under pressure and transferred to smaller bio-reactors and are currently stored at UT. Remaining sediment was placed in bags under N_2 atmosphere in a glove box, stored in liquid nitrogen and transferred to the TAMU-CC Reese's clean lab. DNA will be extracted at TAMU-CC and then sent for sequencing. Results will be compared to those characterized at ExxonMobil which were rapidly depressurized during core recovery or quantitative degassing on the vessel and in Port Fourchon. One core (H005-01FB) was sampled both using conventional methods in Port Fourchon and the BIO chamber at UT.

It was estimated that at least 20 g of pressure-preserved core material would be required for each extraction due to the exceedingly low biomass. The biomass was measured by ExxonMobil in previous experiments on UT-GOM2-1 depressurized core. This finding of marginally detectable microbial biomass in Gulf of Mexico sediments is consistent with other investigations of deep subsurface microbial communities. We have anticipated this “low biomass challenge” since the beginning of the project and continue to prepare for this by incorporating new approaches to gleaning the minimal amounts of microbial DNA and other microbially-associated macromolecules as required to characterize these cells.

New methods for DNA extraction were obtained from Ian Drake (Exxon). After trying multiple methods, the FastDNA kit for soil was the most effective as it allowed high throughput and better yields and purity than other kits or approaches. Drake includes a number of modifications that optimize the DNA yield below. The final modifications will be set by Colwell, Zara Summers (ExxonMobil), and Reese (TAMU-CC). In summary, approaches were identified to capture DNA from ultra-low biomass samples that may be modified in order to also collect samples for RNA determinations.

- Limit freeze thaw cycles before sampling
- Get samples into a phosphate buffer before any lysis so that the PO_4 sources (PolyA) binds to the sediment before your genomic DNA has a chance to.
- Sample only the middle of the core and scrape away a layer before sampling for extraction, to avoid drill mud. Multiple samples throughout the center of the core is best as this increases your chances in yielding DNA from these low biomass samples
- Microbes appear too patchy in their distribution (scattered pockets of communities). Apparent replicates of the same samples may yield dramatically different concentrations of DNA even though it appeared to be the same sample.
- Extract many of these “biological replicates” from each core sample, as the FastDNA soil kit only handles 0.5g at a time. Each 0.5g “replicate” subsample should be sequenced to avoid losing DNA by trying to combine and concentrate samples.
- Linear poly acrylamide (LPA) may be used as a co-precipitant as necessary with low biomass samples.
- For the samples that never really yielded a large enough amount of DNA, a Sygnis Whole Genome Amplification kit works well, especially on low concentrations of DNA, possibly because it uses primase to generate primers in situ instead of using random hexamers.

Figure 3-8: Photos of USGS and Oregon State researchers in the UT PCC working on the BIO chamber (left) and moving sediment to bags in an anoxic environmental chamber.

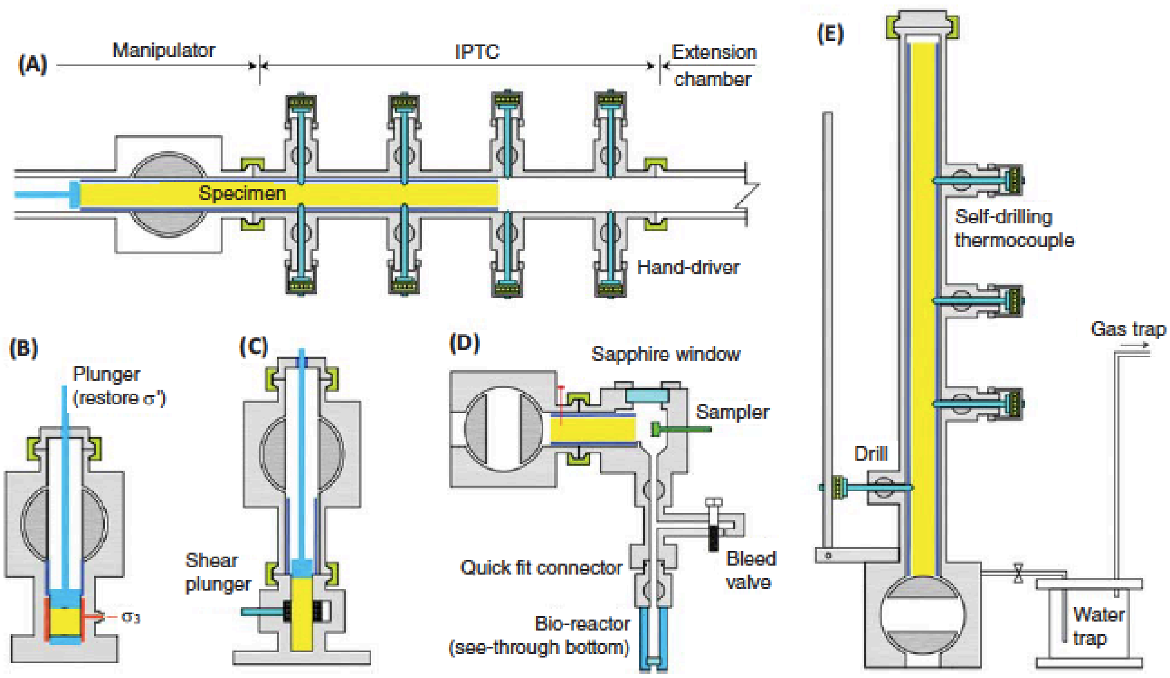

Figure 3-9: Diagram of pressure core characterization tools (PCCTs) showing the biochamber or bio-reactor (D, center bottom of diagram) that can be used for microbiological experiments with subsamples of the primary core material. Image from (Santamarina et al., 2012).

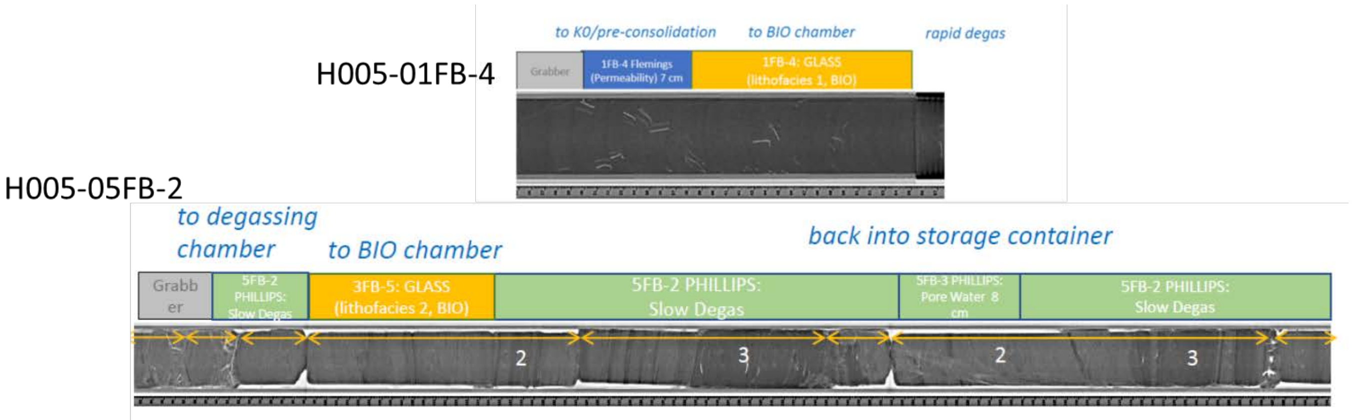

Figure 3-10: Sections of UT-GOM2-1 pressure core (identified in yellow) cut and transferred to the USGS Bio chamber (Santamarina et al., 2012).

3.4.1.3 Pressure Core: Hydrate Saturation, Quantitative Degassing and Gas Analysis

3.4.1.3.1 Hydrate Saturation from X-ray imaging

Ohio State assessed whether gas hydrate saturation could be determined from the expedition X-ray image data of the pressure cores to compare to quantitative degassing results. To date, four core sections that were also quantitatively degassed had been analyzed. The data shows the predicted saturation from the images to match the measured saturation with in the measured saturation margin of error (Table 3-1). The method uses the subset of X-ray image data that matches the section degassed with image artifacts and, where needed of the edge of the core was damaged or uneven, the image outer edge of the core removed. Figure 3-11 shows the X-ray image for Core H005-3FB-3, sandy silt. An image artifact at the center of the core was removed (Figure 3-11B, inner black circle). The method, then compares the X-ray image with the X-ray data from a section of sandy silt we assumed was water-saturated to determine hydrate saturation (i.e. the hydrate saturated core has lower CT values and we use that difference to determine saturation).

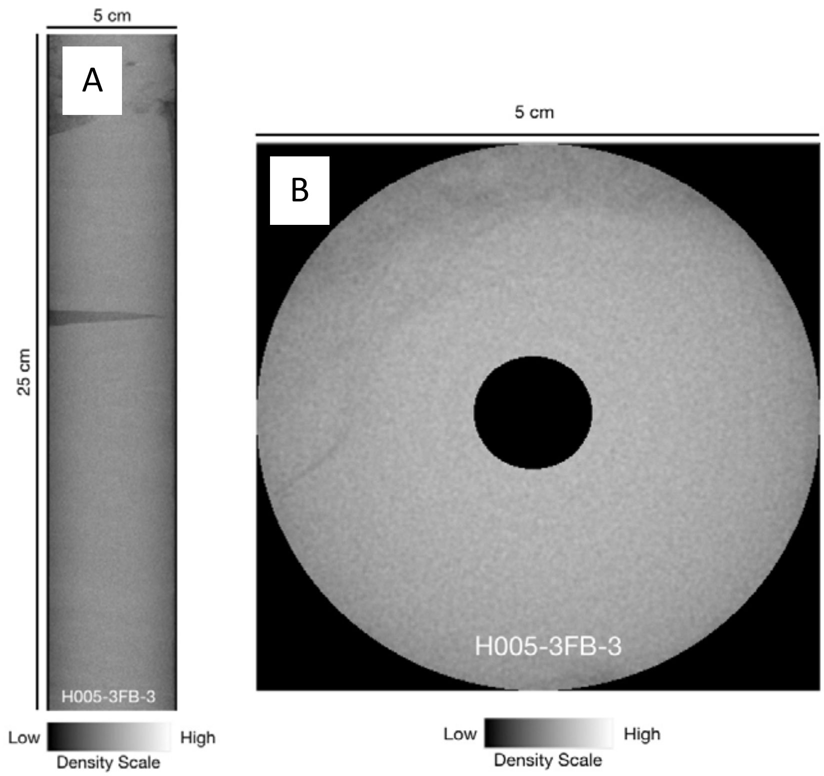

Figure 3-11: XCT scans from core section H005-3FB-3. A. The interval which was selected for X-ray image hydrate saturation analysis and was also quantitatively degassed. B. A slice of the volume showing where the center image artifact was removed (inner black circle)

Table 3-3: Preliminary results presented at AGU Fall meeting. XCT-derived hydrate saturations match closely those calculated from quantitative degassing.

Core Section	Quantitative Degassing Hydrate Saturation	CT Derived Hydrate Saturation
H005-3FB-3	88 $\pm$ 3.5%	core liner calibrated: 89.6 $\pm$ 4.8% water calibrated: 82.0 $\pm$ 4.8%
H005-4FB-4	87 $\pm$ 3.5%	84.7 $\pm$ 4.8%
H005-4FB-7	86 $\pm$ 3.5%	89.6 $\pm$ 4.8%

3.4.1.3.2 Hydrate saturation by lithofacies

UT improved its approach to calculating hydrate saturation from the amount of gas released during depressurization by: 1) using better estimates of core volume from computed tomography (CT) images rather than a single estimate based on core liner inner diameter (Figure 3-12); and 2) directly measuring grain density in the laboratory. These approaches increased our estimate of hydrate saturations by 10% on average.

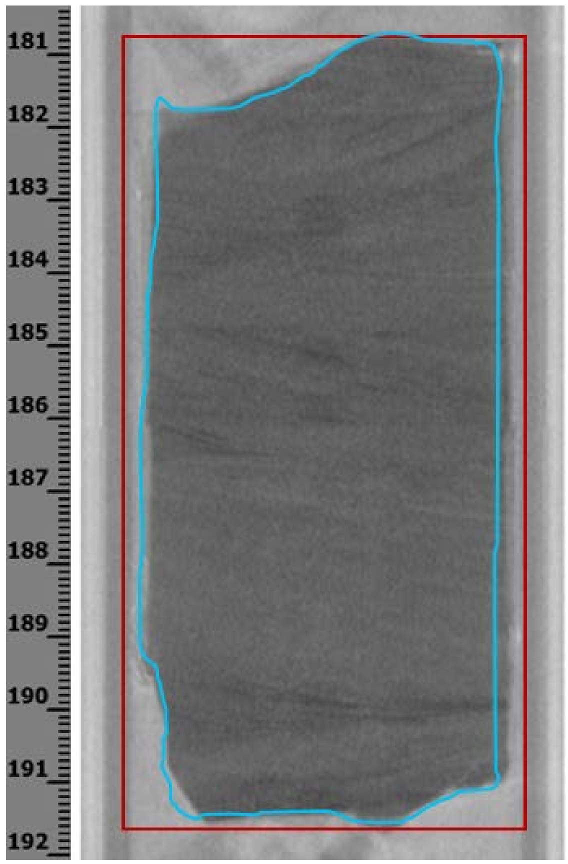

Figure 3-12: Image comparing old (red) and new (blue) estimates of core volume used in the calculation of hydrate saturation in core section 6FB-2. Using the core volume instead of liner volume increases the hydrate saturation by 13%.

UT analyzed additional pressure core sections to determine hydrate saturation (Table 3-4). Samples were selected to fill in the gaps and increase the resolution of estimated variation in hydrate saturation downhole.

We also performed a more advanced interpretation of hydrate saturation from quantitative degassing through detailed comparisons of X-ray CT and P-wave velocity data from each section. This analysis revealed that the sandy silt is relatively homogenous high saturation and the silty clay overlying the hydrate reservoir is consistent near-zero saturation (Figure 3-13 panels A and E). We observed that the clayey silt lithofacies is much more heterogeneous with what appear to be high-saturation layers interbedded with clay at the mm-to-cm scale (Figure 3-13 panels B through C). This suggests that the intermediate hydrate saturations (14-30%) observed in the clayey silt lithofacies is due to thin layers with >80% hydrate saturation within clay with <2% hydrate. We interpret that almost all hydrate in the hydrate reservoir at GC955 is present in coarse-grained, high-saturation layers, and that the interbedded clay does not contain significant hydrate saturation.

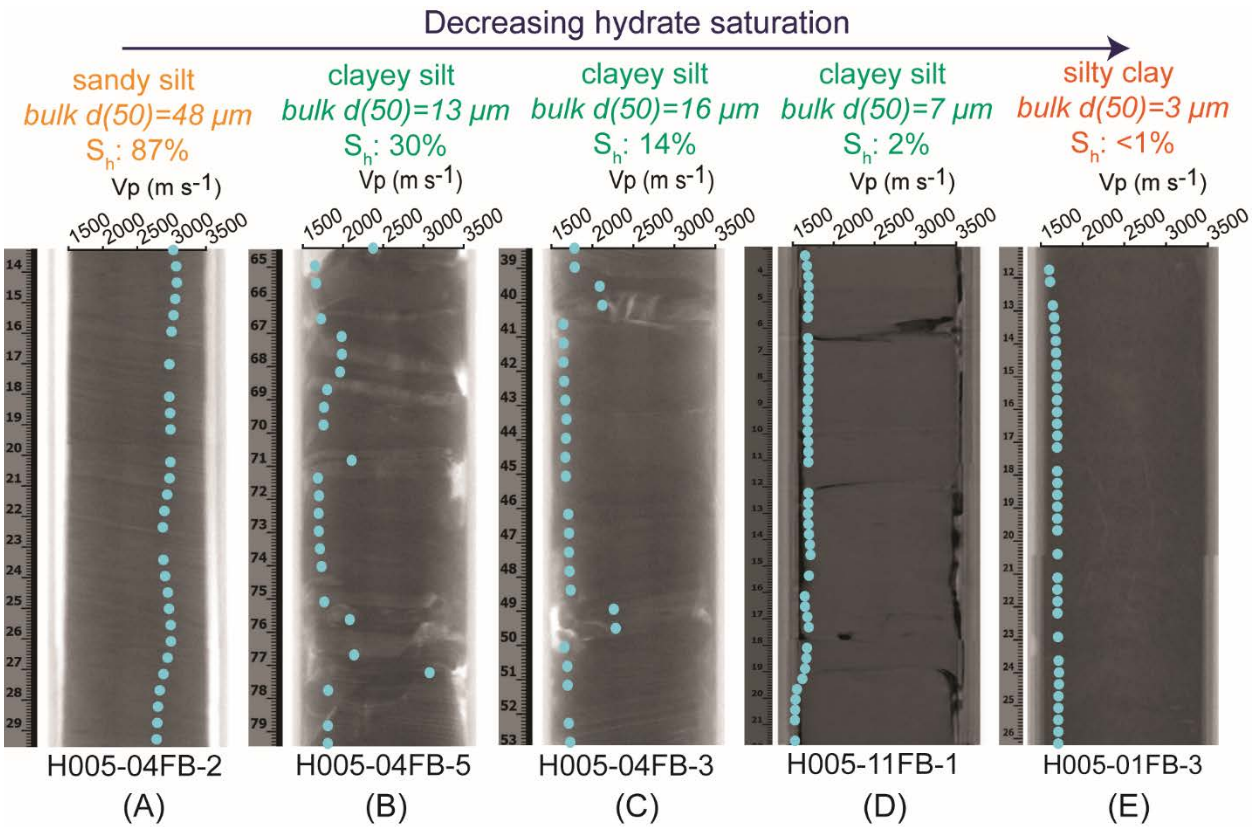

Figure 3-13: X-ray computed tomography and P-wave velocity scans of heterogenous clayey silt samples (panels B through D). These examples show thin layers of elevated Vp (light blue dots) that we interpret as sandy silt with high Sh. Sandy silt and silty clay sediments (A and E, respectively) are more homogenous end members in Vp and Sh. Darker colors in the CT slab images indicate higher X-ray attenuation and correspond to clay-rich material. Bulk hydrate saturation in these degassing samples decreases from A to E with increasing light-colored intervals in the X-ray image and higher Vp. Note that the uncertainty in Sh is ±3.5%. From Phillips et al. (in press).

Table 3-4: Quantitative degassing *results of sections of pressure core that were degassed in the UT Pressure Core Lab. Total methane, methane, saturation, and C1/C2, are reported here.*

Hole	Core-Section	Depth in core (top) (cm)	Length (cm)	Top depth (mbsf)	Bottom depth (mbsf)	Lithofacies	Core volume (L)	Total methane (L)	Maximum dissolved methane (mmol)	Methane hydrate saturation (% of pore volume)	C1/C2
H005	03FB-4	60.8	16.5	421.41	421.57	multiple	0.26	5.64	19	27	-
H005	06FB-2	5	10	428.47	428.57	compromised	0.18	10	12	74	-
H005	06FB-2	20	7	428.62	428.69	compromised	0.14	3.13	10	32	-
H005	06FB-2	40	20	428.82	429.02	compromised	0.41	9.52	28	33	8333
H005	06FB-2	60	8	429.02	429.10	compromised	0.16	4.82	11	44	-
H005	06FB-2	68	32	429.10	429.42	compromised	0.65	32.61	44	76	-
H005	08FB-2	104	14.1	435.68	435.82	clayey silt	0.29	2.99	20	13	-
H005	04FB-8	40	54	423.97	424.11	silty clay	0.22	14.49	0.43	75	-
H005	13FB-1	5	18	447.19	447.32	silty clay	0.21	15.33	0.40	86	2413
H005	05FB-2	4	18	425.45	425.59	silty clay	0.20	14.49	0.37	93	-

3.4.1.3.3 In situ salinity from slow quantitative depressurization of pressure core

UT conducted work on estimating downhole in-situ salinity from depressurization curves based on the initial pressure and temperature of dissociation during degassing. It appears that the salinity of the samples has decreased over 1.5 years of storage due to mixing with the freshwater in the storage vessel. The samples degassed during period ending December 31, 2018 indicate in situ salinities between 27 and 35 ppt in contrast to salinities of 35 to 48 ppt observed in degassing experiments performed soon after core collection. We show that slow degassing of pressure cores is an effective technique for estimating the in situ salinity of hydrate-bearing sediment, but this approach should be used soon after core collection (during on-board or dockside operations). Due to the high-saturation and coarse-grained nature of hydrate reservoirs, this may be the best approach to quantify the pore water salinity within hydrate reservoirs.

We ran a number of slow quantitative degassing experiments lasting several days to several weeks. In these experiments we monitored the pressure and temperature within the sample over the course of depressurization and used these values to compare to the methane hydrate phase boundary at different salinities. Even in degassing experiments performed over several days, the sample approached the freshwater phase boundary during continued dissociation despite having significant bulk salinity in the sample. We attribute this behavior to a local equilibrium in which the dissociating hydrate is bathed during freshwater and salinity is limited by salt diffusion (Figure 3-14). This work suggests that models of hydrate dissociation that assume a bulk salinity at the grid scale should use a freshwater phase boundary. For the GC955 reservoir, this means that while lowering the pressure to 18 Ma would initiate dissociation, the pressure would need to be lowered to 14 MPa to sustain dissociation if the hydrate is surrounded by freshwater at the pore scale.

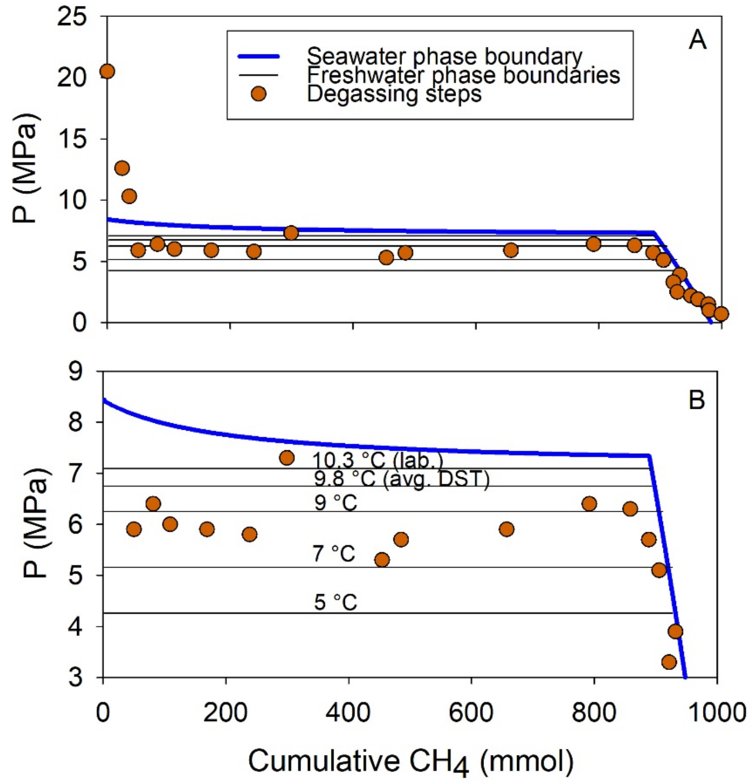

Figure 3-14: Quantitative degassing data from core section H002-04CS-1 (orange dots) compared to modeled phase boundaries assuming a homogenous temperature and salinity. Bulk equilibrium calculations are based on the hydrate saturation and an initial sweater salinity and assuming homogenous temperature and salinity (blue line). Black lines show the bulk equilibrium phase boundary of freshwater at various temperatures. A shows the full range of pressures from the experiment and B shows and expanded scale near the methane hydrate phase boundary. The measured values fall below the expected diluted sweater conditions and are consistent with freshwater conditions at temperatures colder than measured. These results indicate that due to local freshening and cooling, dissociation over several days is best described by the freshwater phase boundary at temperatures cooler than measured by the DST.

3.4.1.3.4 Gas Collection Techniques

UT, with The Ohio State University (Ohio State), tested and improved our methods of collecting gas samples during quantitative degassing to reduce atmospheric contamination. A section of core from H005-013FB was used to collect gas samples in evacuated copper and steel tubes both prior to the bubbling chamber using a vacuum line (pre-bubbling chamber, or PBC, method), and after expanded through the bubbling chamber (after bubbling chamber, or ABC, method). Figure 3-15 shows the experimental set-up. Sixteen gas samples were collected in copper tubes using the PBC method, 11 gas samples were collected in steel canisters using the PBC method, and 12 gas samples were collected in copper tubes using the ABC method. 5 additional PCATS and bubbling chamber water samples were also collected in copper tubes. All samples in copper tubes were shipped to Ohio State.

Ohio State showed that the new experimental set up dramatically reduced the concentration of N_2 and other atmospheric gases (Ar). Three samples acquired using the new sampling technique were run on Ohio State's Stanford Research System RGA 300 Quadrupole mass spectrometer (MS). All three contained less than 0.026 ccSTP/cc of nitrogen. Samples from the old set up contained 0.12 ccSTP/cc to 0.79 ccSTP/cc of nitrogen. The improved PBC sampling method which reduces atmospheric contamination allows for improved interpretation of noble gas and CO_2 isotope measurements from hydrate-bearing samples, and we recommend that sampling gases from the manifold become standard practice during pressure core degassing to avoid the interaction of gases with bubbling chamber water. This improved sampling approach will allow for an expanded use of using noble gases to trace fluid and gas sources in gas hydrate systems.

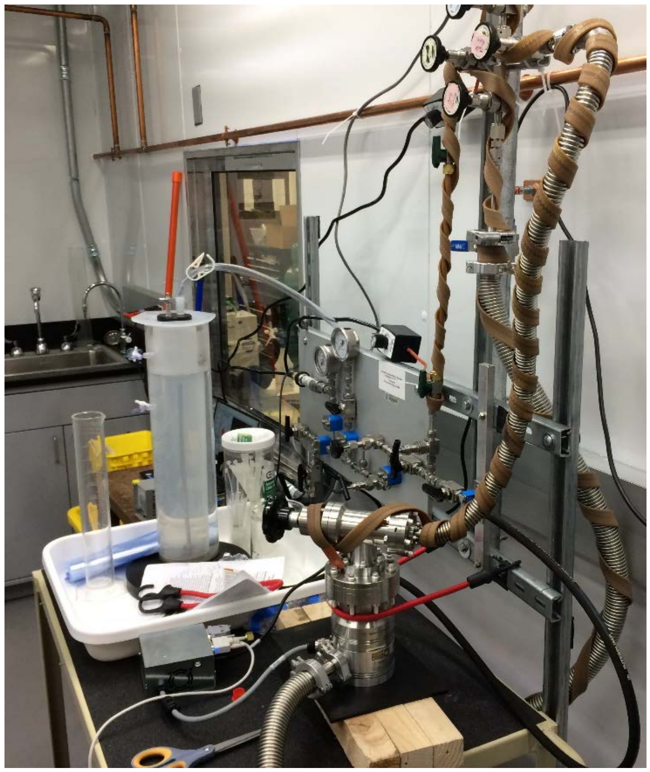

Figure 3-15: The degassing system with the heating tapes throughout the additional vacuum system and copper tube (used to collect the Pre-Bubbling Chamber (PBC) samples). The heating tapes help to pump away vapor prior to sample collection and between sample collection periods during the degassing.

3.4.1.3.5 Gas Composition and Interpretation

Ohio State measured the C1 to C5, N2, and CO_2 molecular composition of these and other collected gas samples using gas chromatography with thermal conductivity (TCD) and flame ionization (FID) detection. These analyses allow us to quantify gas composition and interpret the genetic source of gases whether thermogenic, biogenic, or mixed.

Analyses of 13 samples was completed in period ending June 30, 2018. Data is shown in Table 3-5.

Initial measurements of the methane/ethane (C1/C2) ratio as a function of when the gas was released from the core sample (samples were collected using the ABC method) show a drop in the C1/C2 ratio as more gas trapped in the methane hydrate cage is released indicating a potential fractionation effect during hydrate dissociation (Figure 3-16). A small portion of the decrease in C1/C2 is a result of dissolution of hydrate gases in the bubbling chamber water.

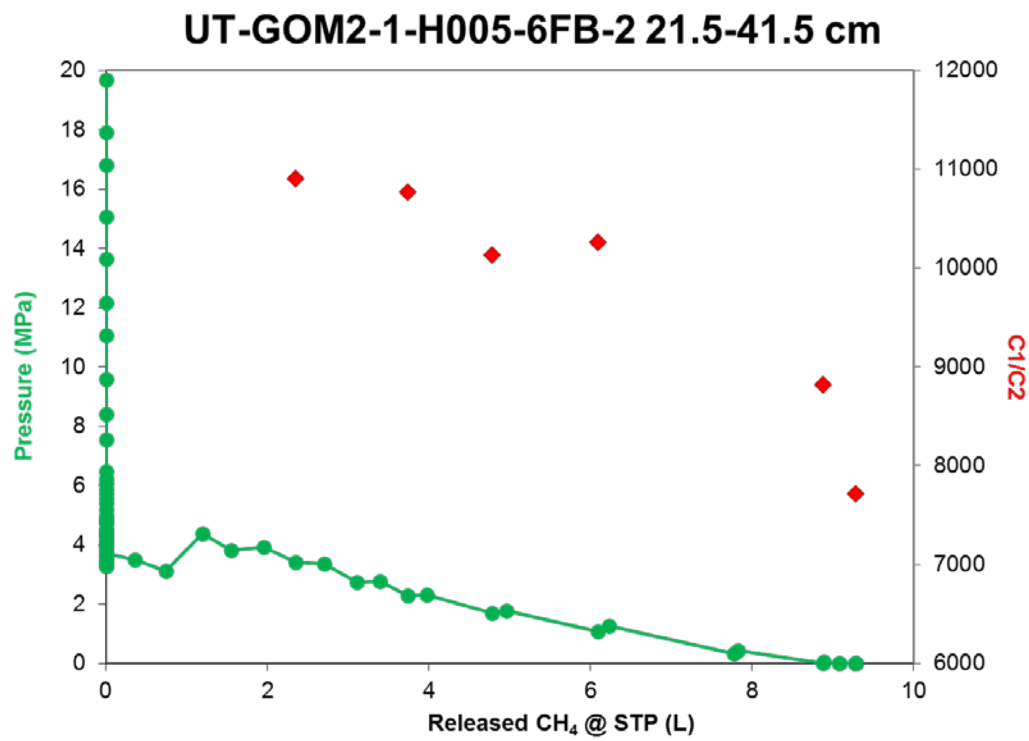

Figure 3-16: Results from a recent degassing experiment in the UT Pressure Core Center. During progressive degassing a decrease in the C1/C2 ratio is observed. We are currently analyzing samples collected before and after the bubbling chamber to determine if C1/C2 fractionation is a result of hydrate dissociation or a sampling artifact from the bubbling chamber.

Ohio State also measured carbon isotope, hydrogen isotope, and noble composition of collected gases using a Thermo Fisher Helix Split Flight Tube Mass Spectrometer. These analyses are key for understanding noble and hydrocarbon gas partitioning into/between the hydrates and pore fluids, evaluating the residence time of natural gases/hydrate formation.

Gas analysis preliminary conclusions are as follows:

- Methane in this core is dominantly formed via microbial methanogenesis based on the depleted $\delta^{13}C$-CH_4 and C1/C2 ratio. These measurements along with $\delta^{13}C$-CO_2 measurements suggest a primary methanogenesis source from sedimentary organic matter.
- We interpret trace thermogenic components based on the presence of low concentrations of C3-C5 hydrocarbons.
- The fluids associated with hydrate formation appear to have residence times ranging from 2×10^4 to ~5.6×10^5 years (Figure 3-17) based on the ^4He and a noble gas diffusion/production model (Hunt, 2000). Residence time refers to the time since the fluids have last been in contact with seawater. This residence time range overlaps with the age of the sediment. We are currently working to constrain the uncertainty in this calculation and interpret this result in terms of fluid flow at GC 955. Noble gas content is highest in gas samples collected at the start of dissociation (Figure 3-18).

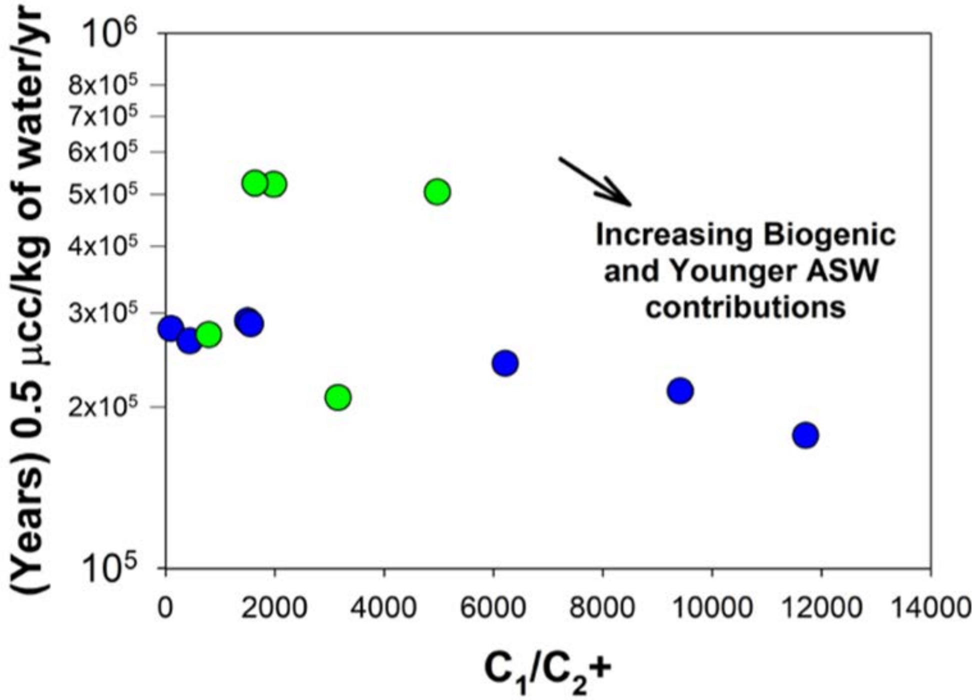

Figure 3-17: Predicted residence time range of reservoir fluids from noble gas measurements (time since fluids were in equilibrium with seawater) versus methane/ethane and larger hydrocarbons (C1/C2+). G These results suggest the fluids in the hydrate reservoir were last in contact with sweater sometime in the Pleistocene. Green dots represent Hole H002 and blue dots Hole H005. Air-saturated water (ASW) is the expected atmospheric gases in crustal fluids (waters) as determined by Henry's Law equilibrium between the atmosphere and water (assumed to be seawater in this case) (see Hunt, 2000 for methodology).

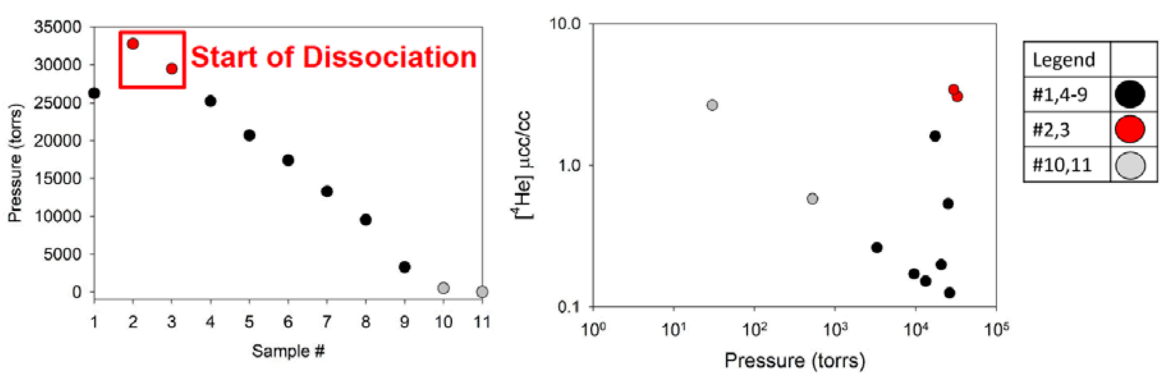

Figure 3-18: Significant enrichment in He and other heavy noble gasses occurs at the beginning of hydrate dissociation

Table 3-5: (next page): Major gas, hydrocarbon gas, and noble gas abundances and isotopic composition for a controlled core depressurization experiment of core H005-6FB. Note significantly lower levels of atmospheric gases compared to previous studies and changes in gas composition by more than a factor of 10 according to the stage of depressurization. Mean residence time estimates vary from ~1.8 x 10^4 to 5.6 x 10^5 years.

Sample	Project Name	Client	H_2 ccSTP/cc	CH_4 ccSTP/cc	C_2H_6 ccSTP/cc	C3 ccSTP/cc	Ci-4 ccSTP/cc	Cn-4 ccSTP/cc	Ci-5 ccSTP/cc
H005-6FB-2 #2_MM+GW	GoM	DOE	8.76E-03	0.679	4.74E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #2 ABC_MM+GW	GoM	DOE	1.21E-03	0.974	1.19E-04	8.36E-06	4.57E-06	1.87E-06	b.d.l.
H005-6FB-2 #10_MM+GW	GoM	DOE	3.55E-03	0.947	8.24E-04	5.01E-04	2.90E-04	4.01E-04	2.35E-04
H005-6FB-2 #8_MM+GW	GoM	DOE	3.84E-03	0.974	1.03E-04	1.15E-05	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #6_MM+GW	GoM	DOE	3.88E-03	0.938	2.27E-04	9.45E-05	5.56E-05	8.62E-05	4.50E-05
H005-6FB-2 #3_MM+GW	GoM	DOE	8.41E-03	0.957	5.83E-05	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #7_MM+GW	GoM	DOE	1.36E-03	0.979	8.78E-05	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #9_MM+GW	GoM	DOE	4.03E-03	0.977	1.36E-04	1.44E-05	8.24E-06	4.08E-06	4.32E-06
H005-6FB-2 #1_MM+GW	GoM	DOE	4.03E-03	0.977	1.03E-04	1.09E-05	4.40E-06	2.42E-06	2.34E-06
H005-6FB-2 #4_MM+GW	GoM	DOE	2.56E-03	0.963	1.32E-04	3.34E-05	1.75E-05	1.99E-05	1.09E-05
H005-6FB-2 #5_MM+GW	GoM	DOE	7.00E-03	0.957	6.84E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #11_MM+GW	GoM	DOE	4.04E-03	0.858	2.08E-06	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2 #1 ABC_MM+GW	GoM	DOE	2.33E-03	0.903	4.95E-07	b.d.l.	b.d.l.	b.d.l.	b.d.l.
H005-6FB-2, #3 ABC	GoM	DOE	2.35E-03	0.969	6.27E-07	b.d.l.	b.d.l.	b.d.l.	b.d.l.

Sample	Cn-5 ccSTP/cc	C-6 ccSTP/cc	N_2 ccSTP/cc	O_2 ccSTP/cc	CO_2 ccSTP/cc	TOTAL	GROSS BTU (BEFORE CO_2 REMOVAL)	NET BTU (BEFORE CO_2 REMOVAL)	^3He pcc/cc
H005-6FB-2 #2_MM+GW	b.d.l.	b.d.l.	0.274	0.00	0.027	0.991	687.4	618.8	3.85
H005-6FB-2 #2 ABC_MM+GW	b.d.l.	b.d.l.	0.011	0.00	0.001	0.987	985.5	887.2	0.54
H005-6FB-2 #10_MM+GW	2.74E-04	6.65E-05	0.037	0.00	0.002	0.993	964.8	868.6	0.66
H005-6FB-2 #8_MM+GW	b.d.l.	b.d.l.	0.011	0.00	0.003	0.992	985.9	887.5	0.15
H005-6FB-2 #6_MM+GW	7.12E-05	b.d.l.	0.015	0.00	0.035	0.993	950.5	855.7	0.49
H005-6FB-2 #3_MM+GW	b.d.l.	b.d.l.	0.019	0.00	0.007	0.992	968.3	871.7	0.58
H005-6FB-2 #7_MM+GW	b.d.l.	b.d.l.	0.006	0.00	0.001	0.987	990.9	892.0	0.16
H005-6FB-2 #9_MM+GW	2.52E-06	b.d.l.	0.009	0.00	0.003	0.993	988.7	890.1	0.15
H005-6FB-2 #1_MM+GW	b.d.l.	b.d.l.	0.009	0.00	0.002	0.992	988.5	889.8	0.11
H005-6FB-2 #4_MM+GW	1.58E-05	b.d.l.	0.023	0.00	0.001	0.990	975.2	877.9	0.34
H005-6FB-2 #5_MM+GW	b.d.l.	b.d.l.	0.014	0.00	0.014	0.992	968.1	871.5	0.33
H005-6FB-2 #11_MM+GW	b.d.l.	b.d.l.	0.129	0.00	0.002	0.993	868.6	781.9	3.44
H005-6FB-2 #1 ABC_MM+GW	b.d.l.	b.d.l.	0.079	0.00	0.003	0.991	913.6	822.4	4.91
H005-6FB-2, #3 ABC	b.d.l.	b.d.l.	0.018	0.00	0.001	0.991	981.1	883.1	0.44

Sample	^4He μcc/cc	^{20}Ne μcc/cc	^{21}Ne μcc/cc	^{22}Ne μcc/cc	^{20}Ne ncc/cc	^{21}Ne ncc/cc	^{22}Ne ncc/cc	Ne μcc/cc	^{36}Ar μcc/cc
H005-6FB-2 #2_MM+GW	3.06	6.209	0.0179	0.636	6209.39	17.89	636.19	6.86	7.35
H005-6FB-2 #2 ABC_MM+GW	0.70	0.654	0.0020	0.067	654.23	2.05	67.31	0.72	1.24
H005-6FB-2 #10_MM+GW	0.58	1.044	0.0032	0.111	1044.26	3.17	111.18	1.16	6.68
H005-6FB-2 #8_MM+GW	0.17	0.195	0.0006	0.021	194.78	0.60	20.57	0.22	0.83
H005-6FB-2 #6_MM+GW	1.61	0.324	0.0005	0.018	324.27	0.55	17.96	0.34	1.02
H005-6FB-2 #3_MM+GW	3.43	0.214	0.0006	0.023	213.91	0.63	22.56	0.24	2.52
H005-6FB-2 #7_MM+GW	0.15	0.128	0.0004	0.013	127.95	0.39	13.33	0.14	0.50
H005-6FB-2 #9_MM+GW	0.26	0.102	0.0003	0.011	102.07	0.31	10.78	0.11	0.45
H005-6FB-2 #1_MM+GW	0.13	0.113	0.0003	0.012	112.64	0.35	11.95	0.12	0.40
H005-6FB-2 #4_MM+GW	0.53	0.465	0.0014	0.049	465.26	1.35	48.73	0.52	0.93
H005-6FB-2 #5_MM+GW	0.20	0.209	0.0006	0.022	209.11	0.65	22.14	0.23	0.94
H005-6FB-2 #11_MM+GW	2.66	4.498	0.0131	0.470	4497.76	13.08	470.26	4.98	6.41
H005-6FB-2 #1 ABC_MM+GW	4.65	4.152	0.0125	0.429	4152.13	12.49	429.03	4.59	5.43
H005-6FB-2, #3 ABC	0.57	0.618	0.0018	0.064	618.08	1.78	64.12	0.68	1.34

Sample	^{38}Ar μcc/cc	^{40}Ar μcc/cc	Ar μcc/cc	Kr ncc/cc	^{84}Kr ncc/cc	^{132}Xe ncc/cc	Xe ncc/cc	R/R_A	R_C/R_A
H005-6FB-2 #2_MM+GW	1.41	2104.41	2113.17	393.48	223.89	24.05	89.40	0.9081	0.83
H005-6FB-2 #2 ABC_MM+GW	0.23	352.55	354.02	83.84	47.70	5.25	19.50	0.5540	0.42
H005-6FB-2 #10_MM+GW	1.26	1935.33	1943.27	471.37	268.21	18.00	66.92	0.8193	0.68
H005-6FB-2 #8_MM+GW	0.16	245.90	246.88	50.15	28.54	2.30	8.56	0.6294	0.48
H005-6FB-2 #6_MM+GW	0.19	300.08	301.29	87.93	50.03	4.35	16.18	0.2195	0.18
H005-6FB-2 #3_MM+GW	0.48	746.62	749.63	205.03	116.66	8.20	30.50	0.1231	0.11
H005-6FB-2 #7_MM+GW	0.09	145.06	145.65	30.06	17.11	0.93	3.45	0.7630	0.70
H005-6FB-2 #9_MM+GW	0.09	131.17	131.71	38.69	22.02	1.56	5.79	0.4052	0.34
H005-6FB-2 #1_MM+GW	0.07	115.47	115.94	30.47	17.34	1.33	4.96	0.6116	0.50
H005-6FB-2 #4_MM+GW	0.17	268.70	269.81	36.12	20.55	0.96	3.56	0.4616	0.31
H005-6FB-2 #5_MM+GW	0.18	278.21	279.33	101.00	57.47	7.17	26.66	1.2147	1.30
H005-6FB-2 #11_MM+GW	1.20	1834.91	1842.53	363.22	206.67	18.50	68.76	0.9340	0.90
H005-6FB-2 #1 ABC_MM+GW	0.99	1526.69	1533.11	192.38	109.46	6.51	24.21	0.7620	0.70
H005-6FB-2, #3 ABC	0.25	375.11	376.70	74.78	42.55	5.83	21.65	0.5668	0.41

Sample	(He/Ne)	$(He/Ne)_{AIR}$	(He/Ne) X-Factor	$^{20}Ne/^{22}Ne$	$^{21}Ne/^{22}Ne$	$^{38}Ar/^{36}Ar$	$^{40}Ar/^{36}Ar$	$^{4}He/^{20}Ne$	$^{20}Ne/^{36}Ar$
H005-6FB-2 #2_MM+GW	0.45	1.55	1.29	9.760	0.0281	0.1926	286.487	0.49	0.845
H005-6FB-2 #2 ABC_MM+GW	0.97	3.36	2.80	9.719	0.0304	0.1887	284.214	1.07	0.527
H005-6FB-2 #10_MM+GW	0.50	1.73	1.45	9.393	0.0285	0.1883	289.651	0.55	0.156
H005-6FB-2 #8_MM+GW	0.79	2.75	2.29	9.470	0.0290	0.1892	297.961	0.88	0.236
H005-6FB-2 #6_MM+GW	4.69	16.29	13.57	18.051	0.0305	0.1869	293.818	4.96	0.317
H005-6FB-2 #3_MM+GW	14.45	50.17	41.81	9.482	0.0281	0.1902	295.811	16.01	0.085
H005-6FB-2 #7_MM+GW	1.07	3.72	3.10	9.599	0.0289	0.1866	288.410	1.19	0.254
H005-6FB-2 #9_MM+GW	2.32	8.05	6.71	9.473	0.0286	0.1885	288.590	2.57	0.225
H005-6FB-2 #1_MM+GW	1.01	3.49	2.91	9.423	0.0290	0.1842	290.680	1.12	0.284
H005-6FB-2 #4_MM+GW	1.04	3.60	3.00	9.548	0.0277	0.1879	289.490	1.15	0.501
H005-6FB-2 #5_MM+GW	0.86	2.98	2.48	9.445	0.0291	0.1897	294.479	0.95	0.221
H005-6FB-2 #11_MM+GW	0.53	1.85	1.54	9.564	0.0278	0.1874	286.045	0.59	0.701
H005-6FB-2 #1 ABC_MM+GW	1.01	3.52	2.93	9.678	0.0291	0.1827	281.279	1.12	0.765
H005-6FB-2, #3 ABC	0.83	2.88	2.40	9.639	0.0277	0.1869	280.398	0.92	0.462

Sample	$^{4}He/^{36}Ar$	$^{84}Kr/^{36}Ar$	$^{132}Xe/^{84}Kr$	$^{4}He/^{21}Ne^*$	$^{4}He/^{40}Ar^*$	$CO_2/^{3}He$	$CH_4/^{3}He$	$CH_4/^{4}He$	$^{4}He/CH_4$
H005-6FB-2 #2_MM+GW	0.42	0.0305	0.107	-0.01	-0.05	6.95E+09	1.76E+11	2.22E+05	4.51E+00
H005-6FB-2 #2 ABC_MM+GW	0.56	0.0385	0.110	0.01	-0.05	1.03E+09	1.82E+12	1.39E+06	7.19E-01
H005-6FB-2 #10_MM+GW	0.09	0.0401	0.067	-0.01	-0.01	3.29E+09	1.44E+12	1.64E+06	6.11E-01
H005-6FB-2 #8_MM+GW	0.21	0.0346	0.081	0.10	0.08	1.69E+10	6.54E+12	5.70E+06	1.76E-01
H005-6FB-2 #6_MM+GW	1.57	0.0490	0.087	0.06	-0.94	7.16E+10	1.92E+12	5.83E+05	1.71E+00
H005-6FB-2 #3_MM+GW	1.36	0.0462	0.070	-0.20	4.37	1.25E+10	1.64E+12	2.79E+05	3.58E+00
H005-6FB-2 #7_MM+GW	0.30	0.0340	0.054	1.16	-0.04	3.62E+09	6.10E+12	6.45E+06	1.55E-01
H005-6FB-2 #9_MM+GW	0.58	0.0484	0.071	-0.07	-0.08	2.09E+10	6.64E+12	3.72E+06	2.69E-01
H005-6FB-2 #1_MM+GW	0.32	0.0436	0.077	0.12	-0.07	1.46E+10	9.17E+12	7.77E+06	1.29E-01
H005-6FB-2 #4_MM+GW	0.58	0.0221	0.047	-0.01	-0.10	2.97E+09	2.82E+12	1.80E+06	5.55E-01
H005-6FB-2 #5_MM+GW	0.21	0.0608	0.125	0.04	-0.21	4.08E+10	2.86E+12	4.81E+06	2.08E-01
H005-6FB-2 #11_MM+GW	0.41	0.0322	0.090	-0.01	-0.04	4.95E+08	2.50E+11	3.23E+05	3.10E+00
H005-6FB-2 #1 ABC_MM+GW	0.86	0.0202	0.059	0.05	-0.06	5.61E+08	1.84E+11	1.94E+05	5.15E+00
H005-6FB-2, #3 ABC	0.42	0.0318	0.137	-0.01	-0.03	1.72E+09	2.18E+12	1.71E+06	5.85E-01

Sample	$CH_4/^{36}Ar$	N_2/Ar	CH_4/C_2H_6+	CH_4/CO_2	Liters of Water Equivalent	Terrigenic ^{4}He	Terrigenic ^{4}He per kg	Age years	Clathrate Age (yrs)
H005-6FB-2 #2_MM+GW	9.25E+04	129.64	143181	25.36	0.00413	3.06	7.42E+02	1.48E+03	1.78E+04
H005-6FB-2 #2 ABC_MM+GW	7.85E+05	32.17	7278	1754.38	0.00044	0.70	1.60E+03	3.20E+03	3.84E+04
H005-6FB-2 #10_MM+GW	1.42E+05	19.08	365	438.40	0.00072	0.58	8.02E+02	1.60E+03	1.92E+04
H005-6FB-2 #8_MM+GW	1.18E+06	43.07	8510	386.09	0.00013	0.17	1.28E+03	2.56E+03	3.07E+04
H005-6FB-2 #6_MM+GW	9.18E+05	51.01	1618	26.84	0.00012	1.61	1.38E+04	2.76E+04	3.31E+05
H005-6FB-2 #3_MM+GW	3.79E+05	25.11	16412	130.72	0.00015	3.43	2.34E+04	4.68E+04	5.61E+05
H005-6FB-2 #7_MM+GW	1.95E+06	40.27	11146	1684.92	0.00009	0.15	1.76E+03	3.51E+03	4.21E+04
H005-6FB-2 #9_MM+GW	2.15E+06	65.61	5769	317.85	0.00007	0.26	3.75E+03	7.50E+03	9.00E+04
H005-6FB-2 #1_MM+GW	2.46E+06	81.93	7952	628.42	0.00008	0.13	1.62E+03	3.24E+03	3.89E+04
H005-6FB-2 #4_MM+GW	1.04E+06	85.15	4193	950.46	0.00032	0.53	1.69E+03	3.38E+03	4.06E+04
H005-6FB-2 #5_MM+GW	1.01E+06	51.13	139886	70.14	0.00014	0.20	1.38E+03	2.76E+03	3.32E+04
H005-6FB-2 #11_MM+GW	1.34E+05	69.85	413571	505.01	0.00305	2.66	8.71E+02	1.74E+03	2.09E+04
H005-6FB-2 #1 ABC_MM+GW	1.66E+05	51.41	1822769	328.08	0.00279	4.65	1.67E+03	3.34E+03	4.01E+04
H005-6FB-2, #3 ABC	7.25E+05	47.79	1545492	1270.02	0.00042	0.57	1.36E+03	2.72E+03	3.27E+04

Sample	4He μcc/cc	20Ne ncc/cc	36Ar μcc/cc	84Kr ncc/cc	132Xe ncc/cc
H005-6FB-2 #2_MM+GW	3.06	6209.39	7.35	223.89	24.05
H005-6FB-2 #2 ABC_MM+GW	0.70	654.23	1.24	47.70	5.25
H005-6FB-2 #10_MM+GW	0.58	1044.26	6.68	268.21	18.00
H005-6FB-2 #8_MM+GW	0.17	194.78	0.83	28.54	2.30
H005-6FB-2 #6_MM+GW	1.61	324.27	1.02	50.03	4.35
H005-6FB-2 #3_MM+GW	3.43	213.91	2.52	116.66	8.20
H005-6FB-2 #7_MM+GW	0.15	127.95	0.50	17.11	0.93
H005-6FB-2 #9_MM+GW	0.26	102.07	0.45	22.02	1.56
H005-6FB-2 #1_MM+GW	0.13	112.64	0.40	17.34	1.33
H005-6FB-2 #4_MM+GW	0.53	465.26	0.93	20.55	0.96
H005-6FB-2 #5_MM+GW	0.20	209.11	0.94	57.47	7.17
H005-6FB-2 #11_MM+GW	2.66	4497.76	6.41	206.67	18.50
H005-6FB-2 #1 ABC_MM+GW	4.65	4152.13	5.43	109.46	6.51
H005-6FB-2, #3 ABC	0.57	618.08	1.34	42.55	5.83

3.4.1.4 Pressure Core: Steady-State Permeability Tests

UT completed steady-state permeability tests on pressure cores (Table 3-6). We also measured the index properties (porosity, capillary pressure, and grain size distribution of each pressure core) of the dissociated pressure cores.

Table 3-6: Steady-state permeability tests completed from Jan 2018 to Oct 2019

No.	Sample Name	Lithofacies	Depth Interval (mbsf)	Core Status	Experiment Status	Starting Date	End Date	Laser Grain Size Test	Mercury Porosim etry Test
1	6FB2-1	Sandy silt	428.74 – 428.82	Compromised	Completed	3/17/2018	6/8/2018	Yes	Yes
2	6FB2-2	Sandy silt	429.06 – 429.14	Compromised	Failed (Sealing)	6/15/2018	6/15/2018	No	No
3	4FB8-1	Sandy silt	423.61 – 423.69	Intact	Completed	8/23/2018	9/20/2018	Yes	Yes
4	4FB8-2	Sandy silt	423.74 – 423.82	Intact	Failed (Pump)	10/16/2018	11/5/2018	Yes	No
5	6FB1	Sandy silt	428.24 – 428.31	Compromised	Completed	2/21/2018	3/17/2019	Yes	Yes
6	4FB8-3	Sandy silt	423.87 – 423.93	Intact	Completed	3/26/2019	4/25/2019	Yes	Yes
7	13FB1	Sandy silt	447.45– 447.52	Intact	Completed	5/8/2019	6/13/2019	Yes	Yes
8	7FB3-1	Sandy silt	431.44 – 431.50	Intact	Completed	10/7/2019	11/13/2019	Yes	Yes

The experimental setup consists of two components: a cutting tool (Figure 3-19) and a permeameter configured with 4 pumps (Figure 3-20). The cutting tool, known as mini pressure core analysis and transfer system (mini-PCATS) is used for subsampling (or cutting) and transporting core. The permeameter is used for measuring the permeability of pressure core at consolidated state. The test chamber, schematically shown with details in Figure 3-21, is capable of supplying both a horizontal (or lateral) effective stress σ'_h and a vertical (or axial) effective stress σ'_v to the core. For hydrostatic or constant effective horizontal stress boundary condition, the horizontal stress is positively controlled by an external pump, which is continuously connecting to the confining fluid chamber. For uniaxial loading condition, the confining fluid chamber is filled with water of a constant volume, forming an incompressible rigid wall against the core sample under the vertical effective stress. The horizontal stress is therefore equal to the water pressure and is passively monitored by a pressure sensor. Under such a constraining condition, the core sample is assumed to have a zero-lateral strain under a vertical effective stress (also known as uniaxial consolidation).

Pressure core analysis contains a series stages of operations: (1) Core sample manipulation (also known as cutting and transfer) (2) Consolidation, (3) steady-state permeability measurements, and (4) post-test characterization (Figure 3-22).

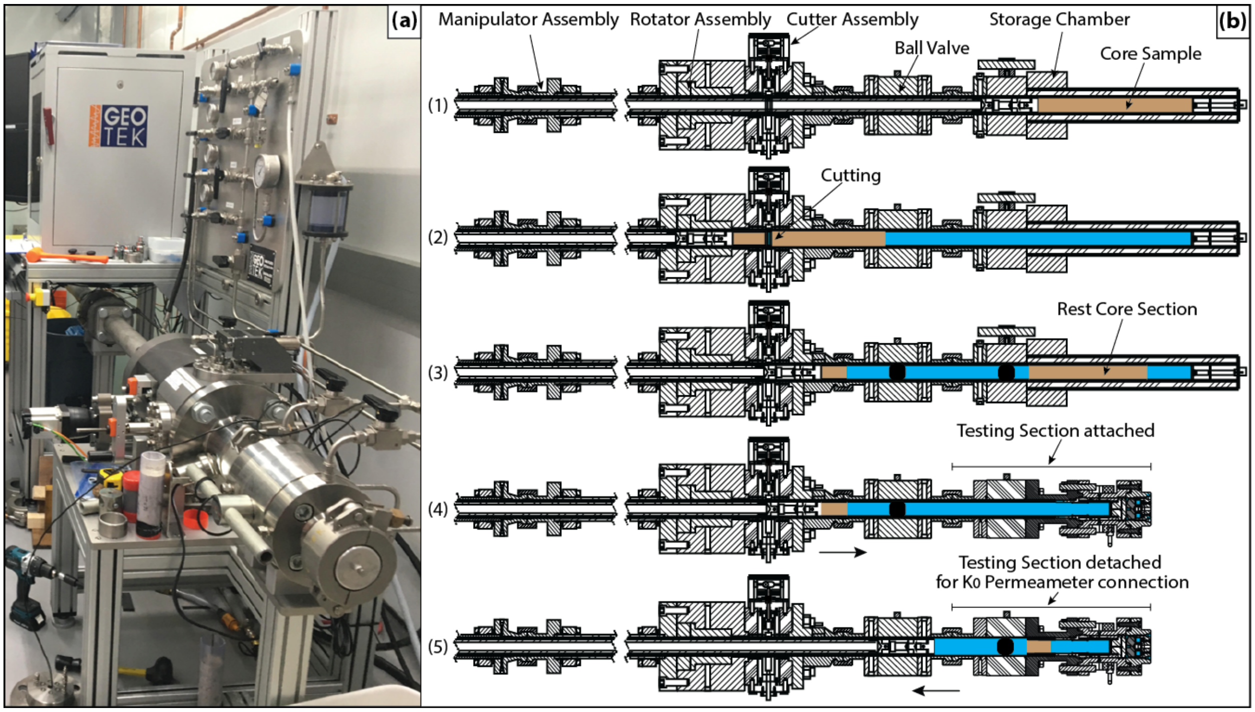

Figure 3-19: Pressure core subsampling and transfer system and procedures. (a) GEOTEK mini pressure core analysis and transfer system (mini-PCATS) in UT pressure core center storage room. (b) Schematic of pressure core cutting and transportable procedures using mini-PCATS (modified from GEOTEK).

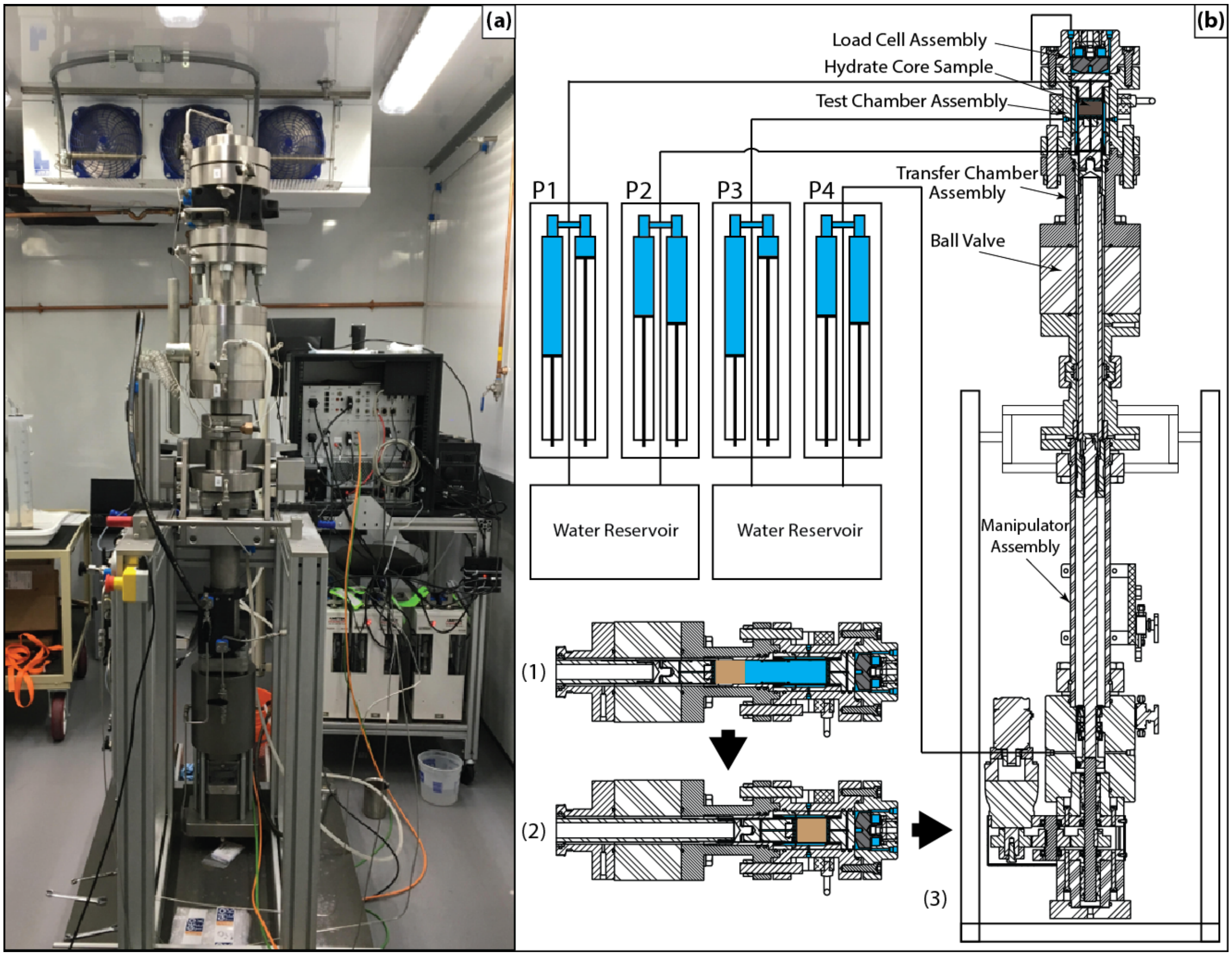

Figure 3-20: Pressure core permeability analysis system. (a) Permeameter apparatus in UT Pressure Core Center experimental room. (b) Schematics of permeameter with pumping system (4 QX-6000 pumps): pump 1 (P1) controls the pressure in load cell chamber and downstream pore pressure; pump 2 (P2) controls the upstream flow rate; pump 3 (P3) controls the radial confining pressure of the core sample, and pump 4 (P4) controls the actuator backpressure.

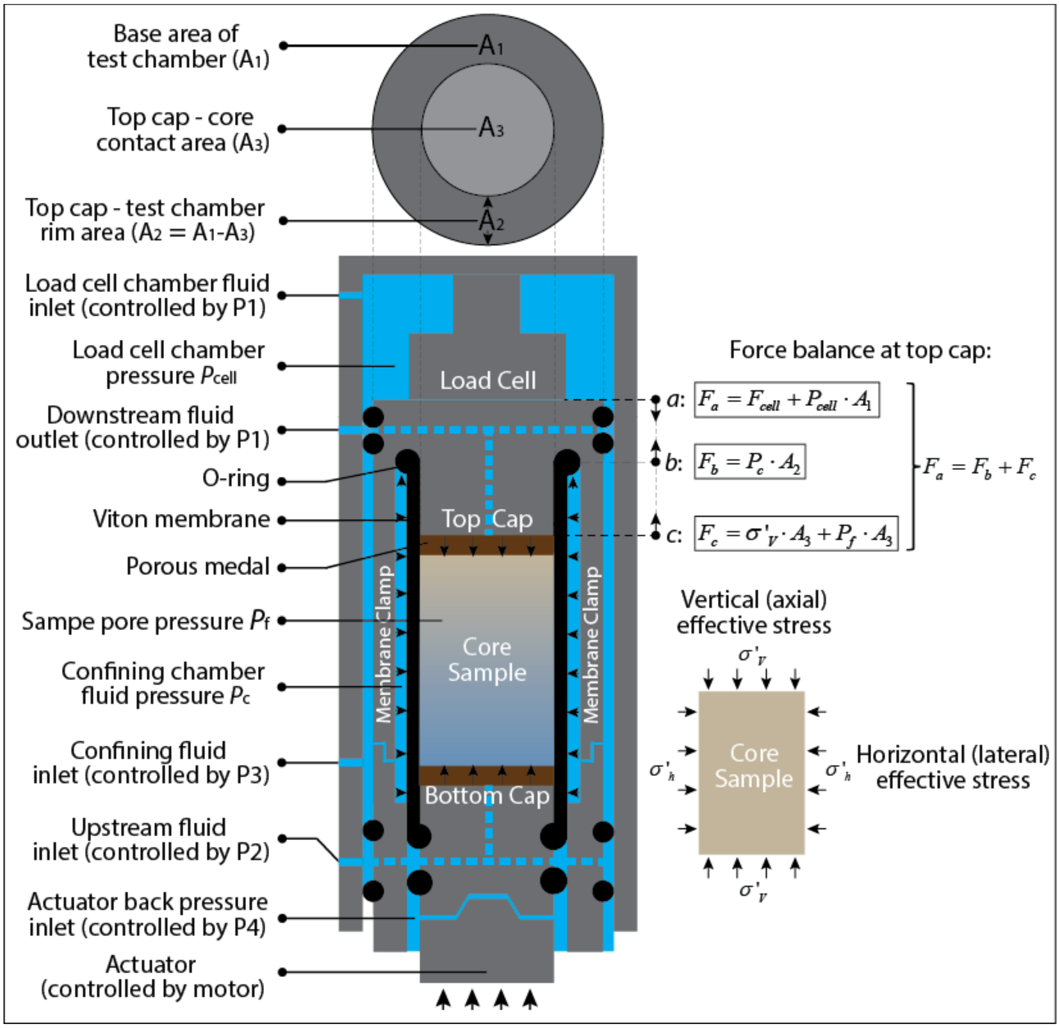

Figure 3-21: A schematic diagram of permeameter test chamber. The load cell force and applied fluid pressures are correlated via the balance of forces (F_a=F_b+F_c) that acted at three different locations of the top cap (reference point a refers to the base surface of top cap; point b refers to top cap rim; point c refers to the top cap-sample contact surface). The effective stress configuration on core sample is illustrated on the right bottom corner.

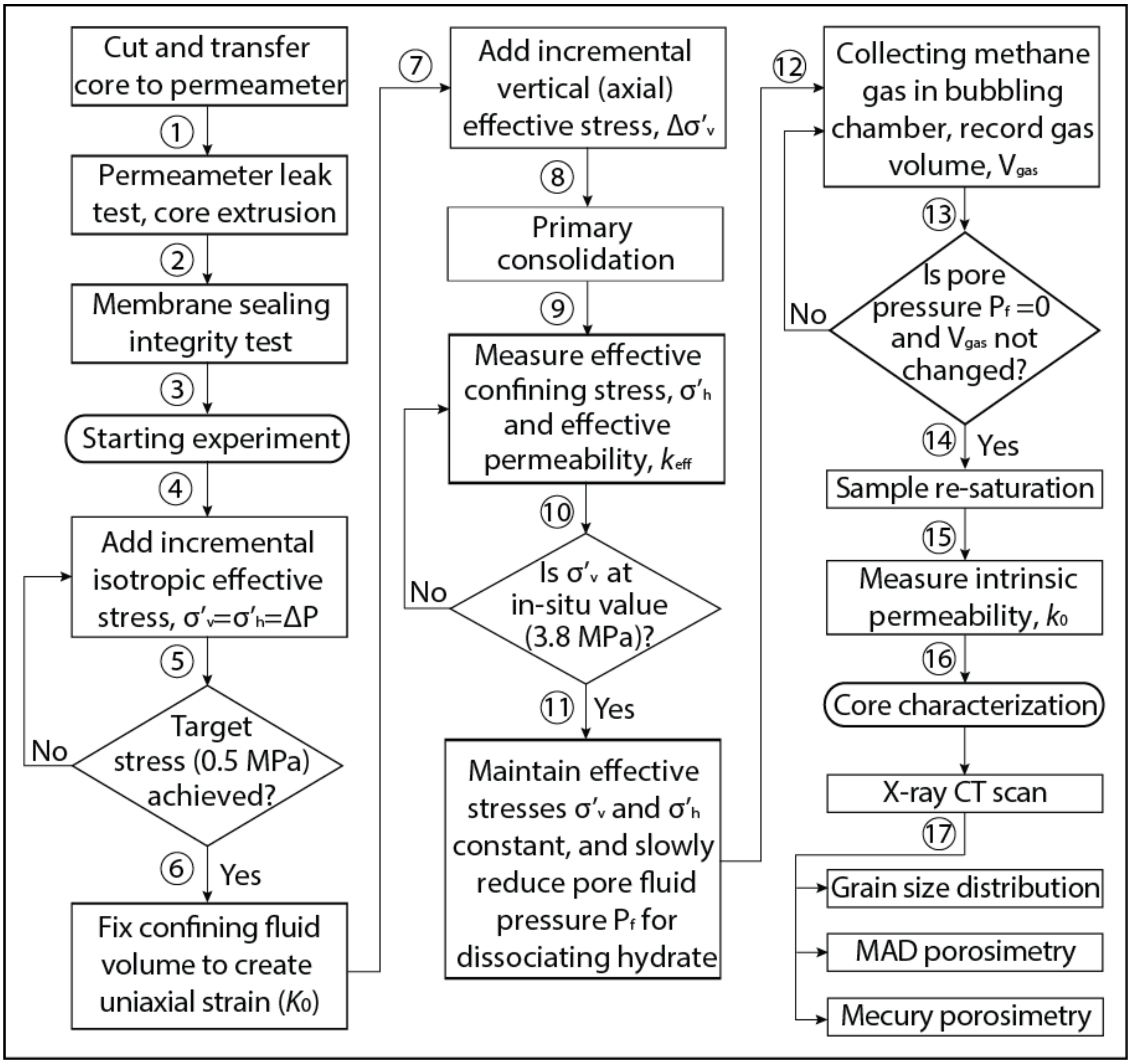

Figure 3-22: A flow chart illustrating the pressure core analysis protocol. Step 1: pressure core cutting and transfer; step 2-3: system integrity and stability validation; step 4-15: consolidation, effective and intrinsic permeability measurement; step 16-17: post-test core characterization.

We show 6 successful permeability tests. 5 of these tests were run under uniaxial strain conditions (K0) and one was run under isostatic conditions (ISO). All of the tests were run up to the in-situ effective stress of 3.8 MPa (Figure 3-23).

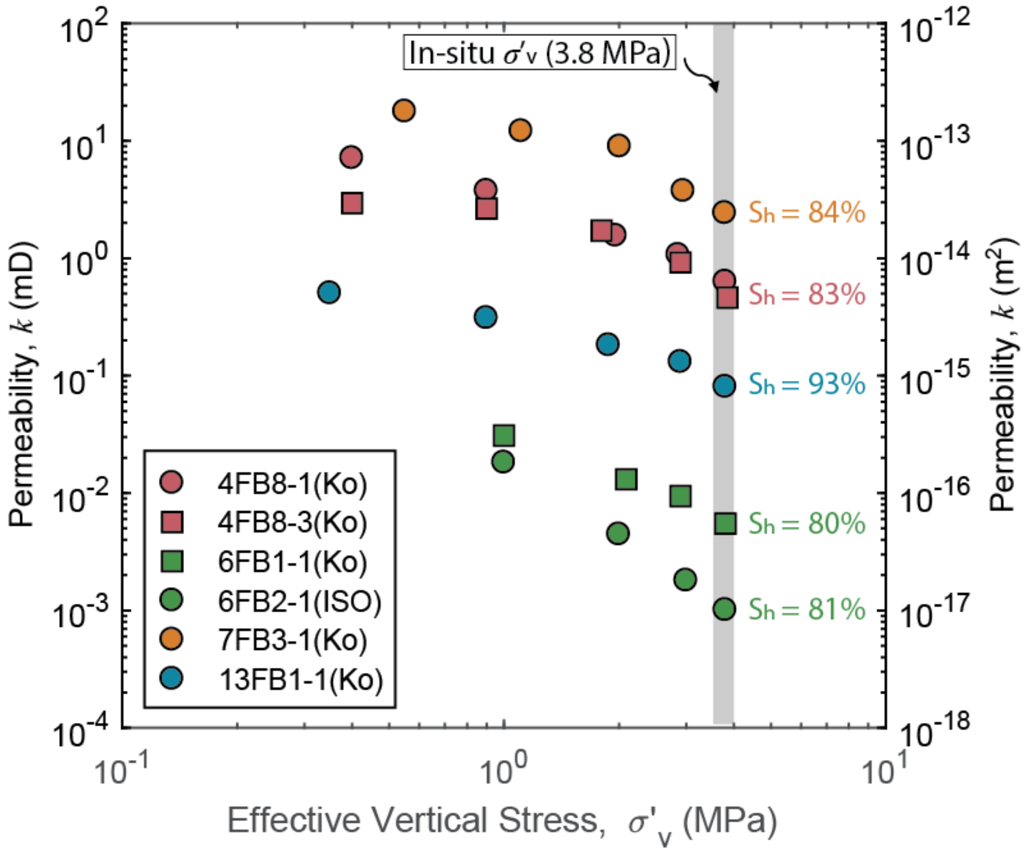

Figure 3-23: Effective permeabilities of pressure cores with vertical effective stress.

3.4.1.5 Intrinsic Permeability of GC 995 Lithofacies through Reconstitution

In Phase 3, UT initiated a new effort to use reconstituted sediment to study the intrinsic permeability of two distinct lithofacies (sandy silt vs. clayey silt) in the UT-GOM2-1 pressure cores. The physical properties of parent materials (UT-GOM2-1-H005-4FB-8 and UT-GOM2-1-H005-11FB-1) are summarized in Table 3-7.

Table 3-7: PCATS scan derived parameters, and the LWD inferred in-situ properties of the parent materials of the reconstituted samples

Sample Name	4FB-8	11FB-1
Lithofacies	Sandy silt	Clayey Silt
Sample Depth (mbsf)	423.61 – 423.69	441.32 – 441.47
Location in Core (cm)	207 – 215	5 – 20
PCATS P-wave Velocity, V_p (m/s)	2947.7	1665.8
Core Liner Volume, V_t (cm^3)	160	430
Bulk Core Volume, V_b (cm^3)	129	310
Average Core Diameter, D_c (cm)	46.55	51.25
PCATS Bulk Density, ρ^*_b (g/cm^3)	1.83	1.906
Best-estimated Bulk Density, ρ_b (g/cm^3)	2.03	2.15
LWD Bulk Density, ρ_b (g/cm^3)	1.99	2.11
PCATS Porosity, n (-)	0.38	0.36
Calibrated PCATS Porosity, n (-)	0.38	0.33
LWD Porosity, n (-)	0.38	0.35
Hydrate Saturation, S_h (-)	0.83	0.02

We reconstituted samples using two different techniques: undercompaction technique for sandy silt (Figure 3-24 a to c) and resedimentation technique for clayey silt (Figure 3-25 a to h) (Fang et al., in press). The steady state permeability of sandy silt sediments was measured by the constant flow of water and observation of the pressure gradient in a triaxial cell (Figure 3-24d). The intrinsic permeability of clayey silt was measured with uniaxial constant rate-of-strain (CRS) consolidation experiment (Figure 3-25i).

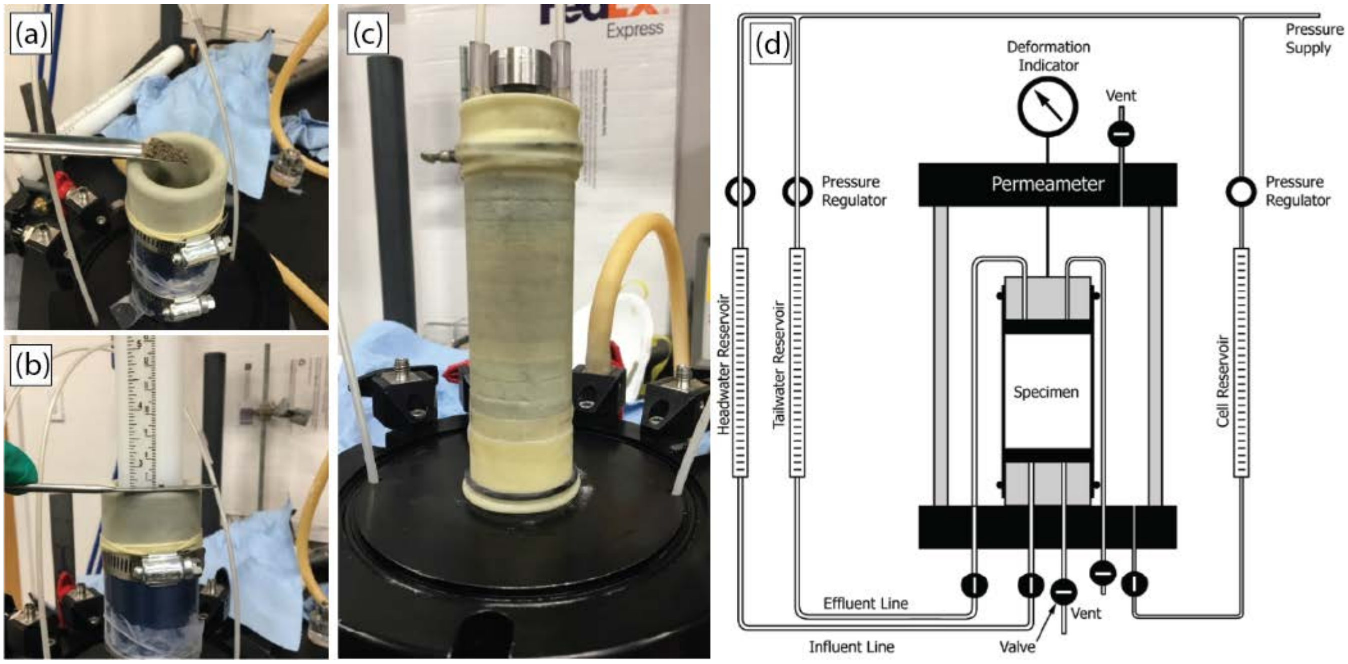

Figure 3-24: Undercompaction technique for reconstituting a sandy silt material. (a, b) A sandy silt material is fully disaggregated and then moisture by 10% brine (3.5% salinity). The sediment progressively poured in the rubber sleeve and packed with a controlled thickness to achieve a particular porosity target. (c) The reconstituted sample is sealed by the rubber membrane and O-rings, and then applied by a hydrostatic effective stress (0.1 MPa). (d) The triaxial cell used for measuring the steady-state fluid permeability.

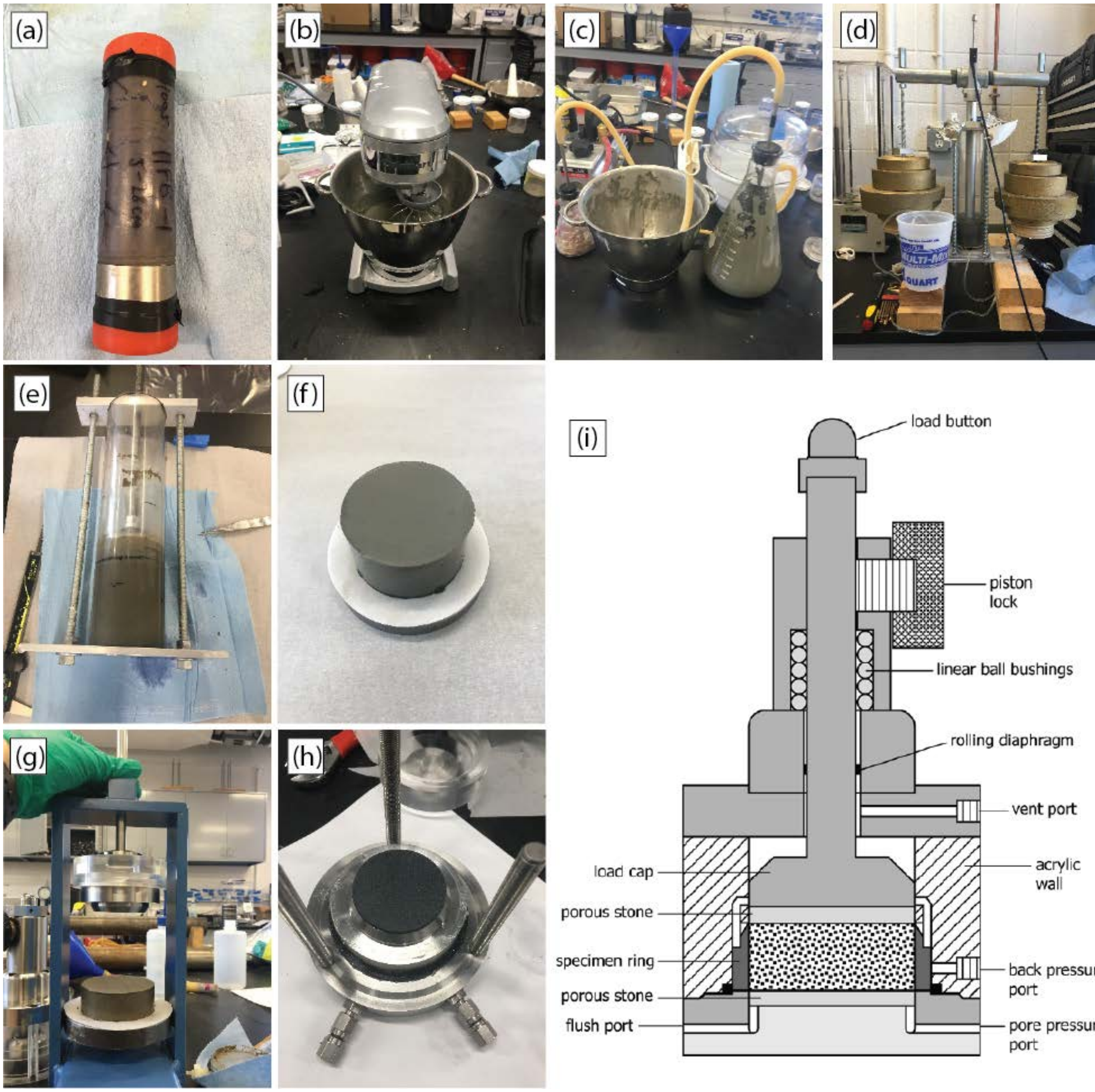

Figure 3-25: Resedimentation technique for reconstituting a clayey silt material. (a) A depressurized clayey silt stored in the core liner, (b) the clayey silt sediment is removed from the core liner and is mixed using a particular water content (twice the liquid limit) and salinity (3.5%). The sediment slurry is fully aggregated and uniformly mixed using an electrical stand mixer. (c, d) The slurry is then vacuumed and uniaxially incrementally loaded in a core liner to an initial vertical effective stress (0.1 MPa). (e, f, g, h) The resedimented specimen is then extruded from the core liner and trimmed into a steel ring for constant-rate-of-strain (CRS) consolidation experiment. (i) The experimental apparatus for CRS test.

The permeability of clayey silt varies from 2.7×10^{-2} mD to 3.84 $\times10^{-4}$ mD over a porosity range from 0.516 (0.02 MPa) to 0.306 (3.8 MPa). These data also follow a log linear trend with γ = 8.38 and β = -21 (Figure 3-26). The permeability at the predicted in-situ effective stress ($\sigma'v$ = 3.8 MPa) is 3.84 ×10-4 mD.

The permeability of sandy silt was ~12 mD at a porosity of 39% (the in-situ porosity). The porosity-permeability relationship also follows a log linear trend with γ = 11.2 and β = -18.3 (Figure 3-26). This intrinsic permeability is similar to the intrinsic permeabilities measured in intact cores from hydrate reservoirs of similar grain size offshore Japan (Nankai Trough) and offshore India (Figure 3-27).

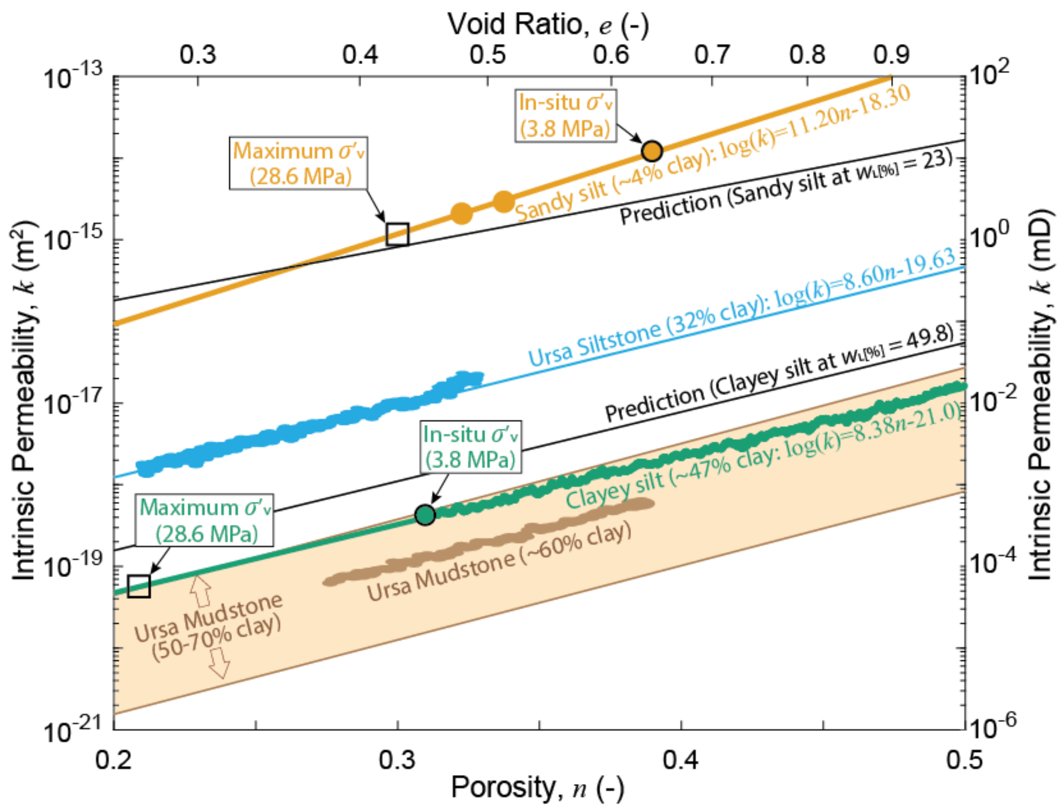

Figure 3-26: The permeabilities of reconstituted sandy silt (4FB-8) and clayey silt (11FB-1) The sandy silt permeabilities were obtained at n = 0.39, 0.34, and 0.32 respectively (orange dots). The clayey silt permeabilities were measured by the CRS experiment (bluish-green dots). The porosity-permeability behavior of GOM Ursa Siltstone is marked by the blue line, and GOM Ursa mudstones with clay from 50% to 70% are marked in the tannish-yellow zone (Reece et al., 2012). The black lines are the predicted intrinsic permeabilities using k - w_L[%] correlations (w_L[%] = 23 for sandy silt lithofacies and w_L[%] = 49.8 for clayey silt lithofacies) summarized from all mudrocks in Casey et al. (2013).

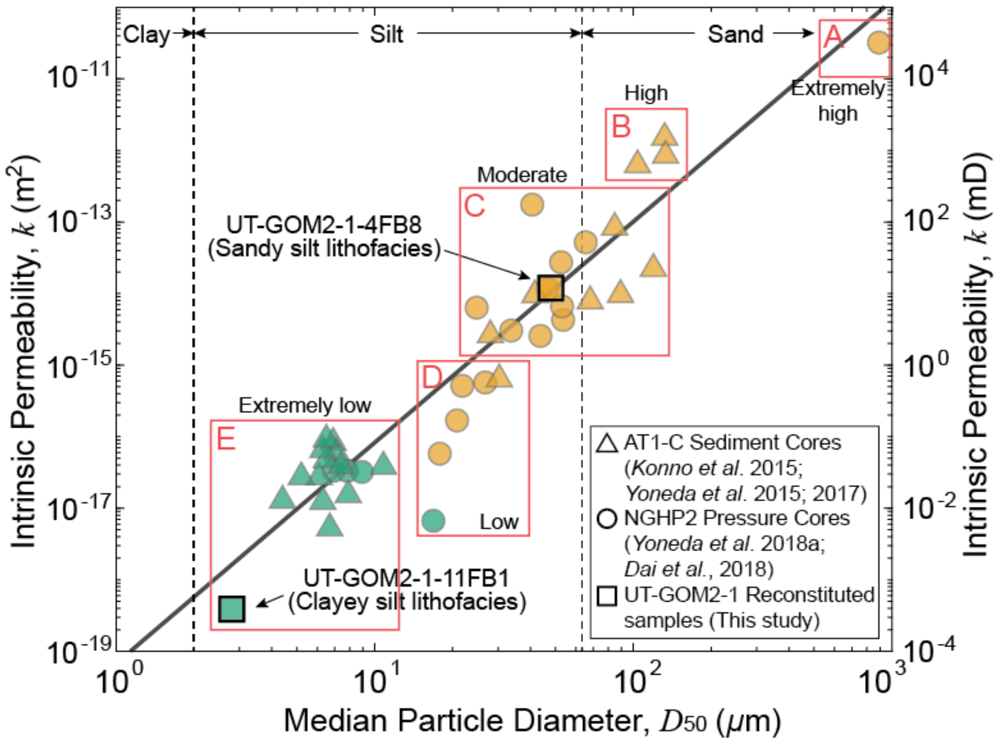

Figure 3-27: The vertical intrinsic permeabilities (k) of reconstituted sediments correlate with the median grain sizes (D50) of sediments. GC955 data are compared to permeability measurements on hydrate-dissociated cores from Eastern Nankai Trough, Japan, Konno et al. (2015), Yoneda et al. (2015), Yoneda et al. (2017)), and from Krishna-Godavari Basin, Indian Ocean, Yoneda et al. (2015); (Yoneda et al., 2018). The solid black line is a fit of the log-log linear relationship between k and D_{50} ($log_{10}(k) = 3.087 \cdot log_{10}(D_{50}) - 19.173$; $R^2 = 0.89$). The dash lines define the silt/clay boundary and silt/sand boundary. Bluish-green refers to clayey silt and orange refers to silt, sandy silt, silty sand or sand. The figure is modified from (Yoneda et al., 2018).

3.4.1.6 Depressurized Core Analysis

3.4.1.6.1 Specific Surface Area

Surface area and pore size were measured on two sediment samples acquired on samples collected from UT-GOM2-1 as reported by (Wei et al., in press). Each sample was measured using standard N2 adsorption/desorption isotherms for multiple runs. Surface area data were obtained using Brunauer, Emmett and Teller (BET) technique and pore size data were obtained using Barrett-Joyner-Halenda (BJH) theory.

Both BET samples were measured in sandy silt from cores H002 6CS-3 (1.1 g sample) and H005 3FB-3-1 (0.44 g sample). For the surface area, we found 5.0 m^2/g-6.5 m^2/g for the sample from 6CS-3 and 3.9 m^2/g-4.7 m^2/g for the sample from 3FB-3-1. Both surface area results are typical for a coarse silt.

Below (Figure 3-28) is a pore size distribution for the sample from 6CS-3. The results for both samples were very similar.

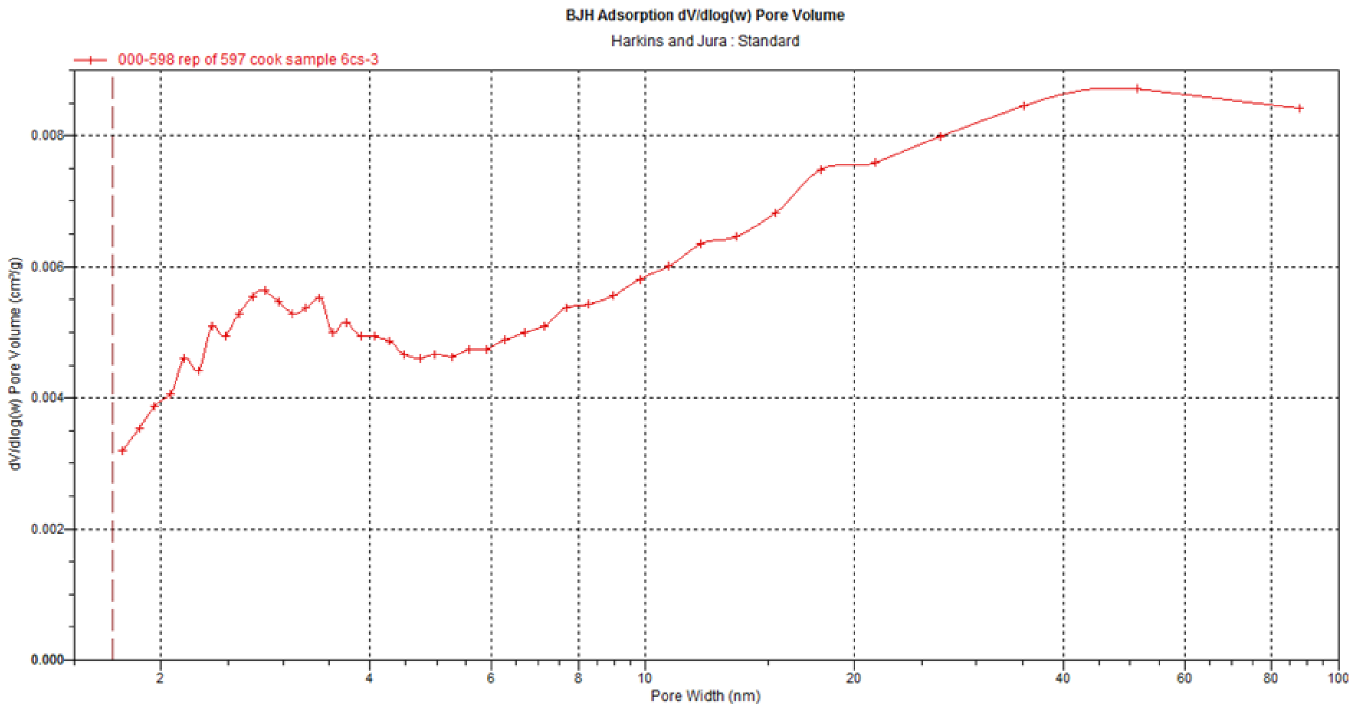

Figure 3-28: Pore size distribution of sediment sample H002 6CS-3 from measurement 000598. Pore size is calculated using Harkins and Jura model.

3.4.1.6.2 Pore Water Chemistry

The University of Washington (UW) extracted the pore water from all whole-round samples received from UT-GOM2-1 and characterized their geochemistry (Solomon, in press). Characterization included salinity, Cl, Br, SO4, Ca, Mg, K, Na, B, Li, Sr, Ba, Fe, and Mn concentration analyses, as well as δ18O and δD stable isotope ratios. UW also assessed the pore water contamination from coring and the use of PCATS.

__Assessing Contamination__

A cesium tracer was added to the water used during PCATS operation. The three pore water samples that were degassing in PCATS had measured tracer (Cs) concentrations ranging from 0 to 0.014 µM. Assuming the correct concentration of Cs tracer was used during UT-GOM2-1, the pore water samples exhibited very low contamination ranging from <0.003-0.02%). This result suggests that core samples that have been processed through PCATS and/or quantitative degassing are appropriate for porewater squeezing and analysis.

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

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

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

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

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

Assessing the Geochemistry

UW was only able to extract a limited amount of pore water from the UT-GOM2-1 samples, and so the allocation of pore water was prioritized, and some samples were only analyzed for select solutes and isotope ratios. Results of the geochemistry measurements are shown in **Appendix B**. The uncorrected geochemical data are shown in **Appendix B**, Table 1, and the corrected data based on the composition of the drill water collected during coring at Sites H002 and H005 are presented in **Appendix B**, Table 2. There is large variability in the drill water composition in drilling fluid samples collected between the two sites, and it was significantly altered with respect to surface seawater composition. The corrected data assuming the drilling fluid had a composition of average seawater are presented in **Appendix B**, Table 3.

Some pore water subsamples were preserved for a range of analyses, and are available to the science party. Sub-samples include 1-2 ml in sealed glass ampoules, 1-2 ml frozen in amber bottles, 1-2 ml in glass vials, 1-4 ml acidified to pH <2 and stored in acid-cleaned plastic bottles, and 1-4 ml un-acidified samples stored in plastic bottles. Likewise, squeezed sediment whole-round cores have been sectioned into three sub-samples and 1) stored at room-temperature and are available to the science party, 2) frozen and are available to the science party, and 3) sent to UNH for analysis of grain size, TC, TN, TS, TOC, and derived CaCO3.

3.4.1.6.3 Total carbon, hydrogen, nitrogen, and sulfur (CHNS) Elemental and Isotopic Analysis

In periods ending June 30, 2018 and September 30, 2018 the University of New Hampshire (UNH) continued work on total carbon, hydrogen, nitrogen, and sulfur (CHNS) elemental and isotopic analysis (Johnson and Divins, in press) (Figure 3-29).

At the University of New Hampshire (UNH), 40 sediment samples were analyzed for CHNS, C isotopes, N isotopes, and S isotopes from holes H002 and H005. Samples were prepared by grinding into a fine powder using a mortar and pestle and acidification (sulfurous acid) to remove inorganic carbon ($CaCO_3$) (Figure 3-30). Preliminary results are shown in Figure 3-31. These preliminary results show a moderate amount of organic matter ~0.35 to 1.5 wt% of a mixed marine and terrestrial origin. Most intervals show low total sulfur <0.2 wt% with a few intervals of high total S (> 1 wt%) suggesting precipitation of sulfide minerals (e.g. pyrite) due to anaerobic oxidation of methane during early burial.

Ongoing efforts will focus on running additional samples/replicates, and relating the elemental results to grain size/lithofacies. Lithofacies-specific sediment samples from quantitative degassing sections are shown in Figure 3-32.

Sulfurous acid treated samples are currently in the queue for TOC measurement at UNH. Non-acid treated samples are currently being weighed and will be sent to the University of California Berkeley for TS, TN, and TC measurements and S and N stable isotopes.

Figure 3-29: CHNS Elemental Analyzer at UNH

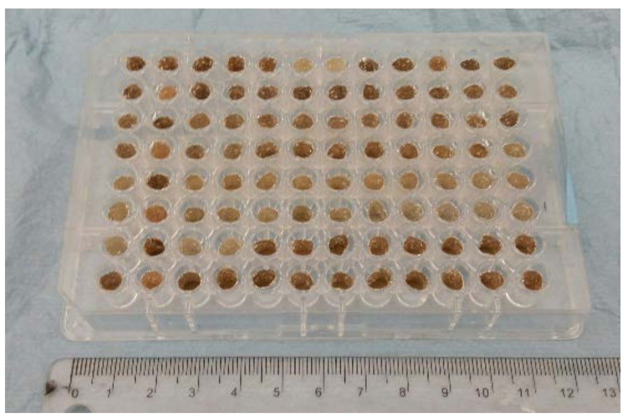

Figure 3-30: Bulk sediment samples, replicates, and standards weighed into in silver capsules in preparation for sulfurous acid additions.

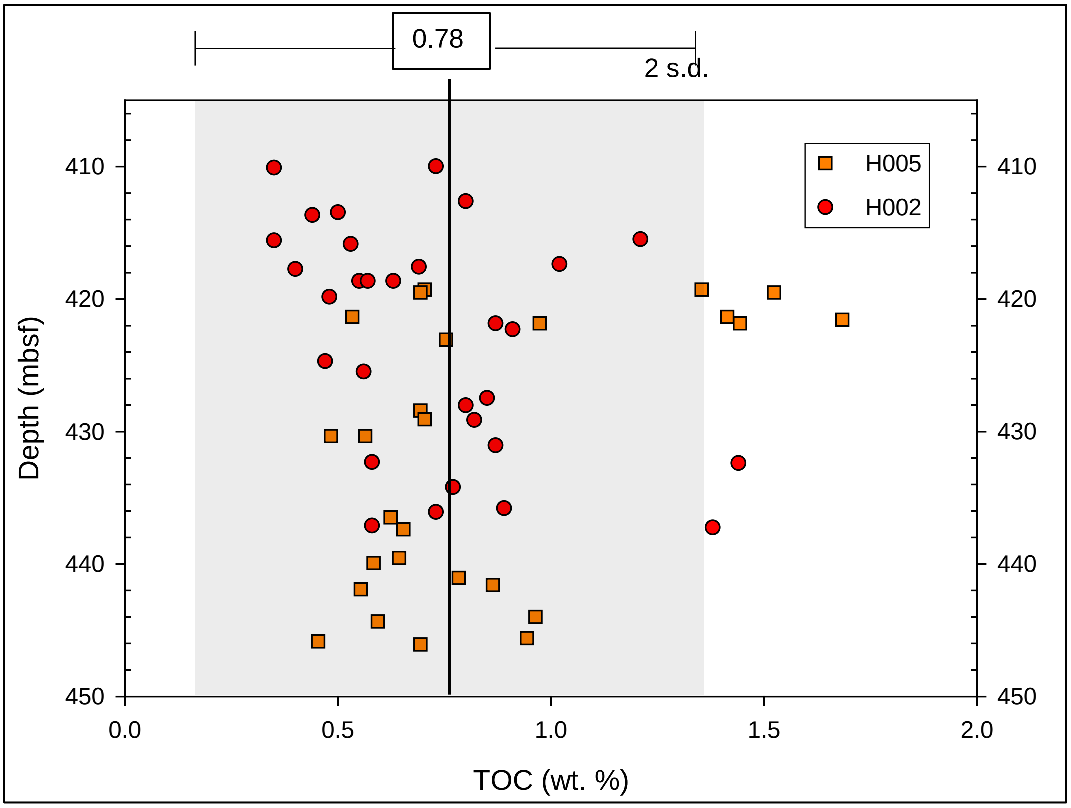

Figure 3-31: TOC results of Bulk sediment samples after acidified from CHNS Elemental Analyzer at UNH from Holes H002 and H005, mean TOC is 0.78 with two standard deviations shown.

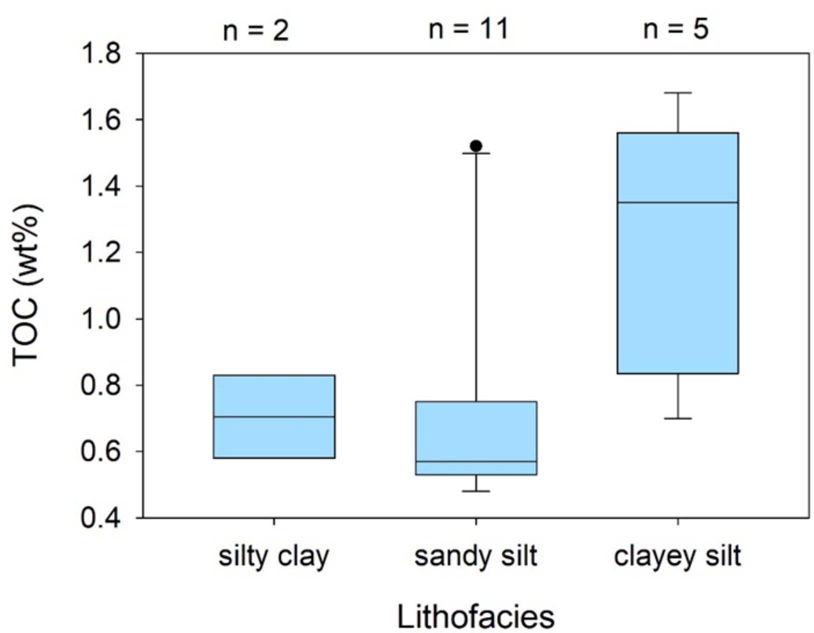

Figure 3-32: Box plots of total organic carbon (TOC) weight % of lithofacies-specific samples from quantitative degassing. Mean TOC in the silty clay (core H005-01FB) is 0.71 wt%. Within the hydrate reservoir TOC is lower in the sandy silt (mean: 0.74 wt%) than in the clayey silt (mean: 1.23 wt%).

3.4.1.6.4 Laser-Particle Grain-Size Analysis

UNH measured the grain size of several sediment samples using a Malvern Mastersizer 2000 laser particle size analyzer (Figure 3-33) were measured with and without removing Total Organic Carbon (TOC) using hydrogen peroxide (Johnson et al., in press). This was done because, over the course of several weeks, visible reaction of the samples continued to persist after repeated additions of hydrogen peroxide, suggesting an unrealistic amount of organic carbon was still present in the samples (Figure 3-34). The additions were discontinued and the continued apparent reaction of the hydrogen peroxide is suspected to be occurring due to the catalyzing effect calcium carbonate has on the dissolution of hydrogen peroxide. Once TOC content has been measured in each of these samples, the hydrogen peroxide treated sample set can be revisited to confirm additional additions of peroxide are not needed. 52 samples from holes H002 and H005 were measured twice, (bulk sediment and TOC-free sediment) using the UNH Malvern Mastersizer 2000 Laser Particle Size Analyzer. The TOC-free results are shown in Figure 3-35.

Figure 3-33: Malvern Mastersizer 2000 Laser Particle Size Analyzer in lab at UNH

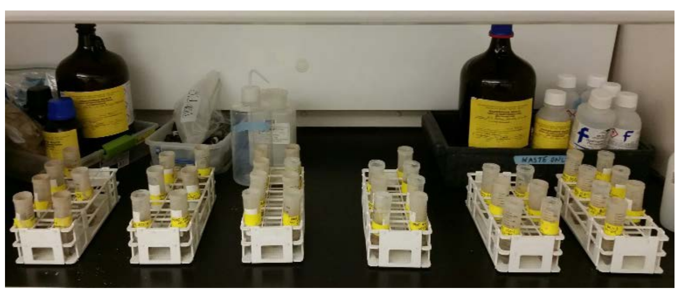

Figure 3-34: Sediment samples receiving hydrogen peroxide treatments in the chemical hood to remover organic carbon prior to measurement

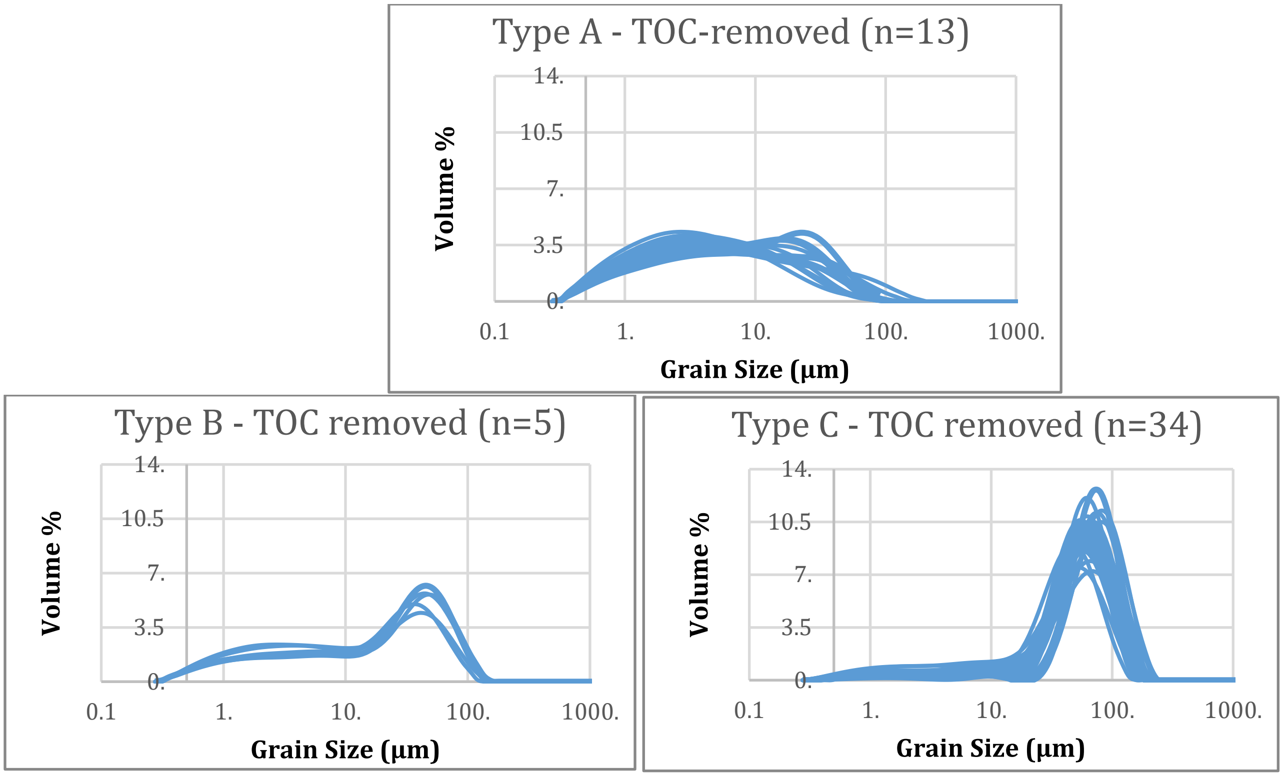

Figure 3-35: Malvern Mastersizer 2000 Laser Particle Size Analyzer Grain Size Distribution Plots by sample. UNH measured 52 samples (shown above) and 18 duplicates (not shown above) and binned the results into three profile types (A, B, and C), reflective of their sorting characteristics and dominant grain size (Johnson et al., in press)..

3.4.1.6.5 Biostratigraphy

UNH with UT completed nannofossil biostratigraphy analysis (sediments 0.43 to 0.91 Ma) report. The report included the description and interpretation of 30 samples examined from UT-GOM2-1; 22 samples from Hole H002, and 8 samples from H005 (Purkey, in press).

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

All samples examined from holes H002 and H005 are interpreted to be Middle Pleistocene (Calabrian). The sample from H005-1FB-3_163-184, 284.18 mbsf (150 m above the reservoir in the overlying clay), is interpreted to be approximately 0.43 Ma. Samples within the hydrate reservoir, between 436.93 and 445.28 are interpreted to be between 0.8 and 0.91 Ma (Figure 3-36).

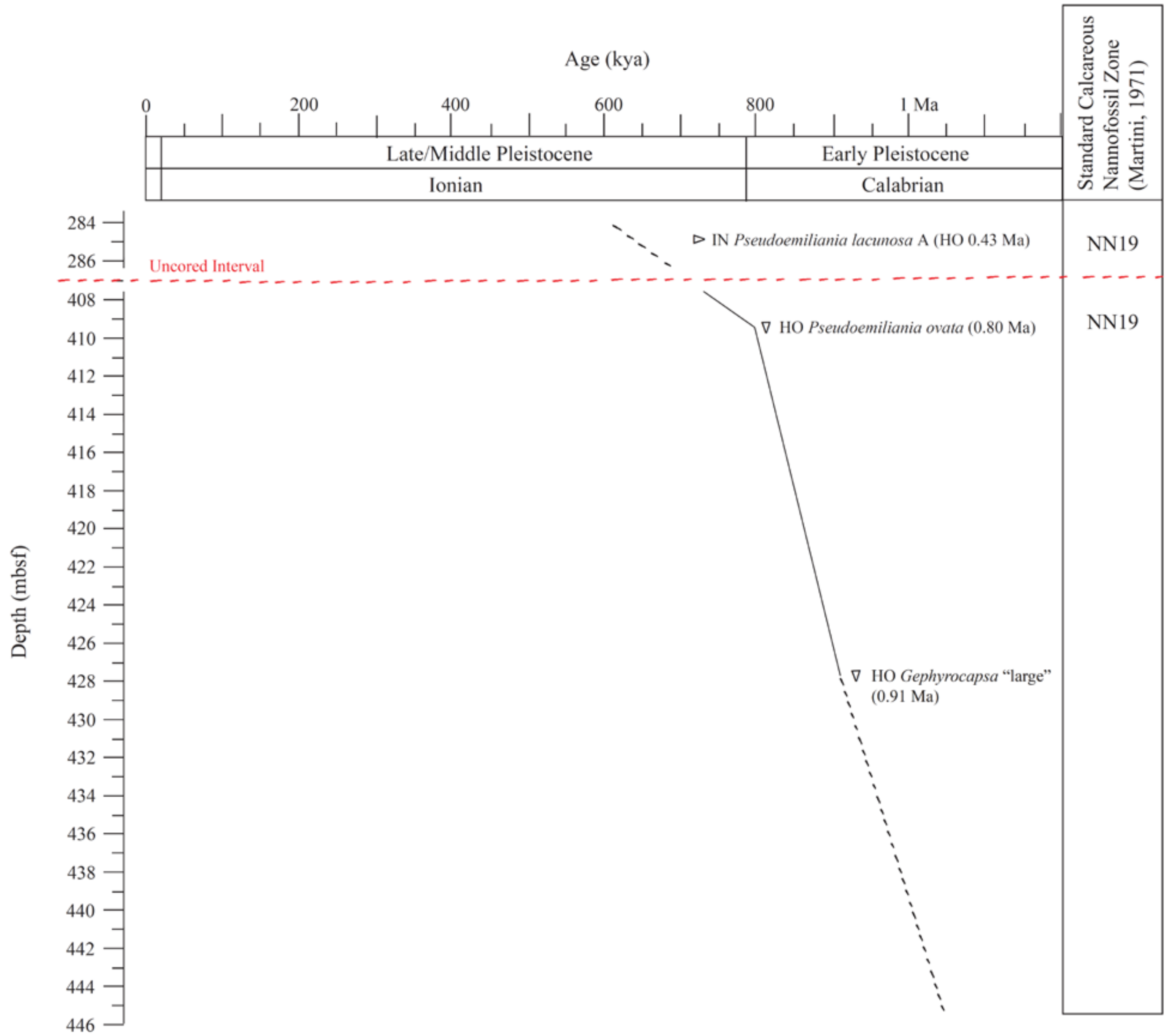

Figure 3-36: A composite time-depth plot of UT-GOM2-1 holes H002 and H005. Calcareous nannofossil events are from the Biostratigraphic Chart – Gulf Basin, USA produced by Paleodata, Inc. (Waterman, 2017). The geologic time scale is that of (Ogg et al., 2016).

3.4.1.6.6 Microbiology

Limited biomass has been extracted from the UT-GOM2-1 samples using a number of protocols. Oregon State assisted with the data analysis of microbial communities based on interpretation of DNA extractions and sequencing performed by ExxonMobil, which appear to be mainly composed of highly alkaliphilic bacterial members.

Oregon State University (Oregon State) worked on determining whether CT-scanning of geological cores alters the microbial community profiles in the cores which is important to optimize success of the microbiological component of the upcoming coring expedition. A CT-scanned image of one of the cores is shown in Figure 3-37.

The premise of the study was that X-ray CT scanning may cause changes in native microbial communities in geological cores with the potential that microbial community analyses would reveal different species (also called “taxa” or “operational taxonomic units” or “OTUs”) in scanned versus un-scanned cores. This question has not been examined in detail and yet X-ray CT scanning is routinely used by geologists to characterize core lithology.

To test this premise, Oregon State collected paired, 1.5 m-long, shallow sediment cores each of which intersected three distinct geological intervals that varied between being organic-rich and sandy. Immediately after sample collection, one of each of the paired cores was submitted to X-ray CT scanning, as used for typical geological core analysis, while the other paired core was not exposed to X-ray CT scanning. After scanning, each of the paired cores was held at approximate in situ temperature and at several time intervals over a month of storage samples were taken from distinct lithologic intervals. After sampling, microbial community DNA was extracted from each of the samples (54 total), and then the 16S rRNA gene was sequenced in each sample as a way to determine the number of microbial taxa (species) present as well as the microbial diversity in each sample.

Alpha-diversity is a measure of the average species diversity or number of different species in a single location or sample interval. Using two-way test and one-way analysis of variance (ANOVA) we found no evidence that x-ray CT scanning has any effect on the key microbial species in these core samples (Table 3-8).

Alpha-diversity did not change in samples that were scanned compared to their unscanned replicates. Furthermore, the alpha-diversity of scanned samples did not change over time of sample storage after scanning. When the data are examined using non-metric multidimensional scaling (data not shown) it is apparent that core location, depth of an individual sample (i.e., geological strata), and sediment lithology are the primary factors that control community structure which is consistent with past studies. Our general conclusion is that x-ray CT scanning such as that used to examine geological cores does not alter microbial community diversity as determined by DNA sequence-based studies.

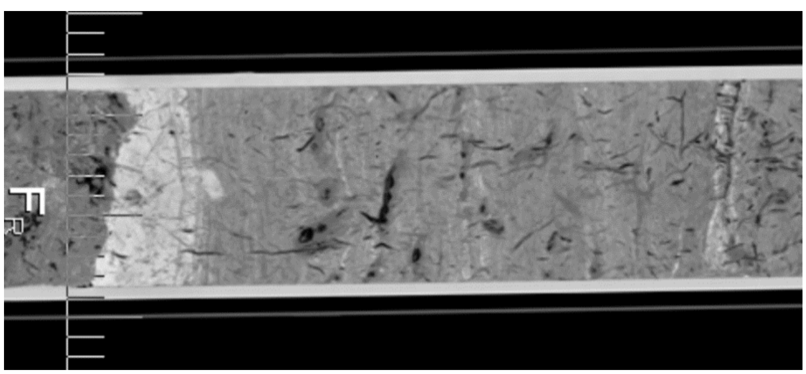

Figure 3-37: X-ray CT scan of geological core used for determining the effect of X-ray CT scanning on microbial communities. Organic-rich sediments are evident above and below bright sandy layer. (Photo obtained from Netarts Bay marsh).

Table 3-8: Statistical tests performed on core samples to determine effect of scanning on microbial diversity. OTUs = operational taxonomic units.

Does scanning change community α-diversity?			
metric	test	p-value	conclusion
OTUs observed	two-way t	0.989	no
inverse Simpson index	two-way t	0.180	no
Does α-diversity change over time after scanning?			
metric	test	p-value	conclusion
OTUs observed	one-way ANOVA	0.785	no
inverse Simpson index	one-way ANOVA	0.644	no

3.4.2 Subtask 10.5: Continued Hydrate Core-Log-Seismic Synthesis (UT-GOM2-1)

Objectives

The Recipient will perform, or facilitate performance by others, analysis on the hydrate pressure core data acquired in Phase 2.

- *The measurements of hydrate concentration from Core Analysis will be compared to estimates derived from logging data and anisotropy models of the logging data.*
- *Petrophysical models will be developed to predict the physical and acoustic behavior of the hydrate reservoir as a function of hydrate and pore fluid saturation.*

Accomplishments

3.4.2.1 Linking Pressure Core Data to Log Data:

Ohio State undergraduate Kathryn Smart worked with Dr. Cook and used UTAPWels, a well log forward-modeling software package, to link PCATS data at H005 with well log data measured in H001. We used the PCATs data and developed a model for H005 in the main sand reservoir because there was no log data over the hydrate reservoir interval. We used the PCATS data to identify bed and hydrate boundaries and construct a likely resistivity model for H005. Then the electromagnetic wave resistivity response was calculated from the model for H005. Figure 3-38 shows the model results for H005 and the possible sections that tie between the two wells. The results were not showing a strong tie between the two wells. The results suggest there may be a 1.8 to 3 m offset between wells. Cook has started to re-examine these data to see if it could be improved.

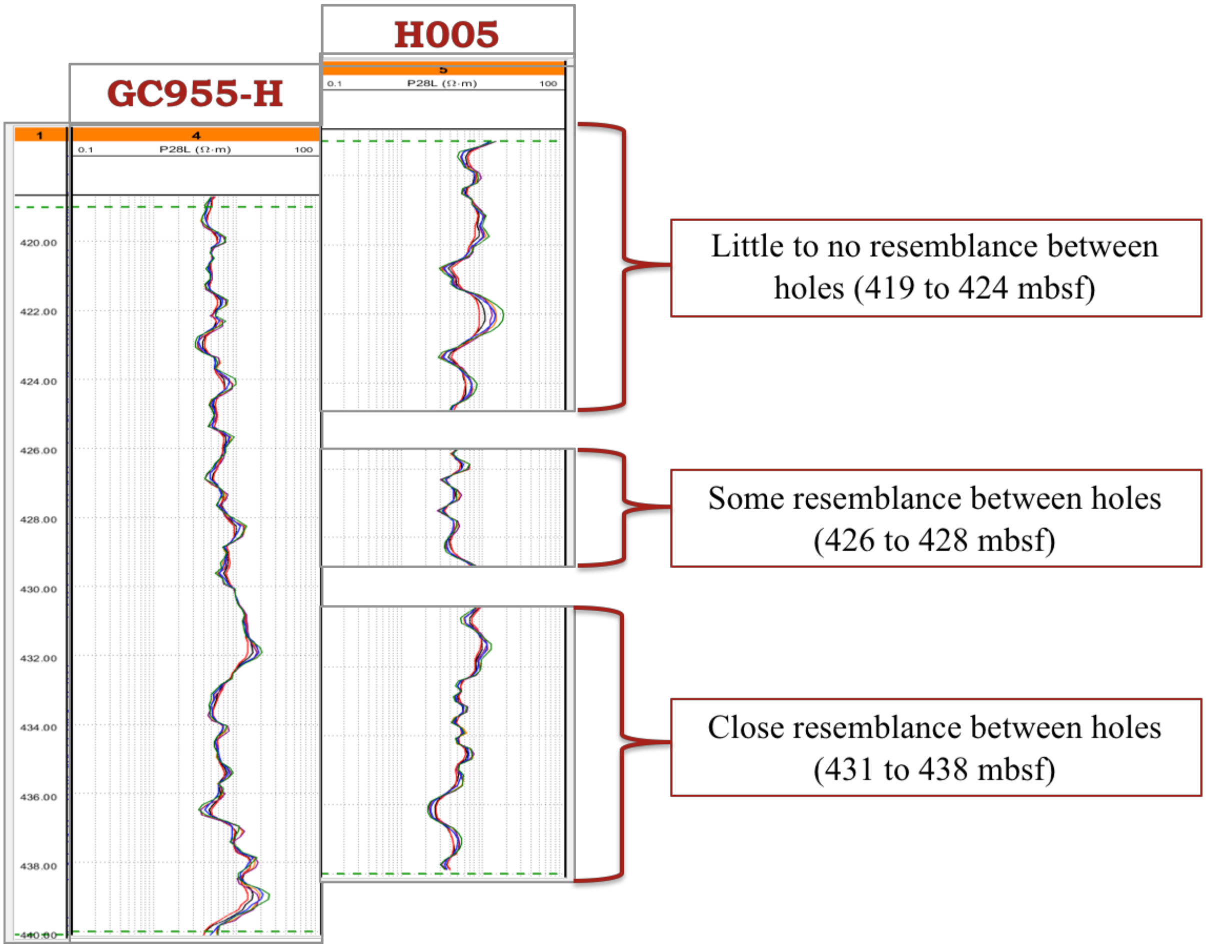

Figure 3-38: Electromagnetic-wave resistivity modeling by undergraduate Kathryn Smart using UTAPWeIs to try to link GC955H-001 to H005.

3.4.2.2 Analysis of Reservoir-Bounding Units

Boswell et al. (2012b) identified 4 water-bearing units (1 through 4, Figure 3-39, track I) that bound the hydrate-bearing intervals. In these intervals, the gamma ray is lower than that within the hydrate intervals, and the resistivity, density, and p-wave velocity are reduced relative to the overlying clay prone section (above 391 mbsf, Figure 3-39). The borehole is enlarged in these intervals as indicated by the enlarged borehole (caliper) and low density (Figure 3-39, track b, d). Given the data available, Boswell et al. (2012a) and Boswell et al. (2012b), suggested that it was not possible to discern whether 1) the water-bearing intervals are actually finer grained than the reservoir interval and that the reduced gamma ray response was due to washout out, or 2) that the bounding water-bearing units are actually composed of relatively clean reservoir rock as recorded by the low gamma ray values.

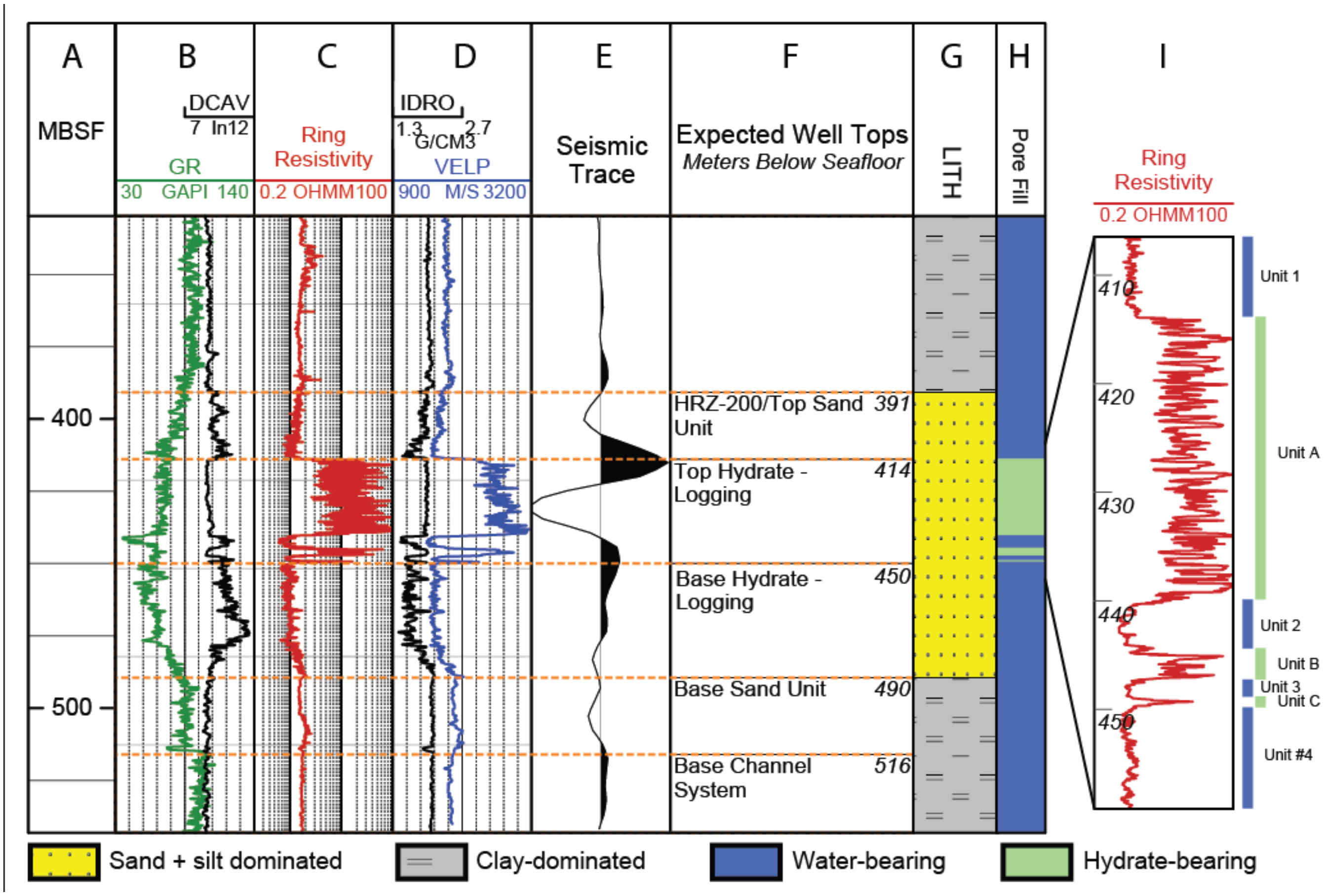

Figure 3-39: Logging-while-drilling data at GC-955. Logging-while-drilling data (LWD) from JIP II expedition at GC 955 H001 revealed concentrated gas hydrate in a coarse-grained reservoir between 414 and 450 mbsf. A) Depth in meters below sea floor (MBSF). B) Gamma ray (green) and caliper log (black). C) Ring resistivity log. D) Density (IDRO) and P wave velocity (VELP) log. E) Seismic trace from the H001 location. F) Mapped depths in meters below seafloor (mbsf). G) A broad zone of more silt- or sand-rich sediment (yellow) is bounded above and below by clay rich (grey) sediment. H) The majority of the section is interpreted to have only water in the pore space (blue zones) whereas the intervals with high resistivity and high velocity are interpreted to be hydrate-bearing (green zones). I) Expanded view of the ring resistivity. Water-bearing units (1, 2, and 3) and hydrate-bearing units (A, B, C) defined by Boswell et al. (2012b).

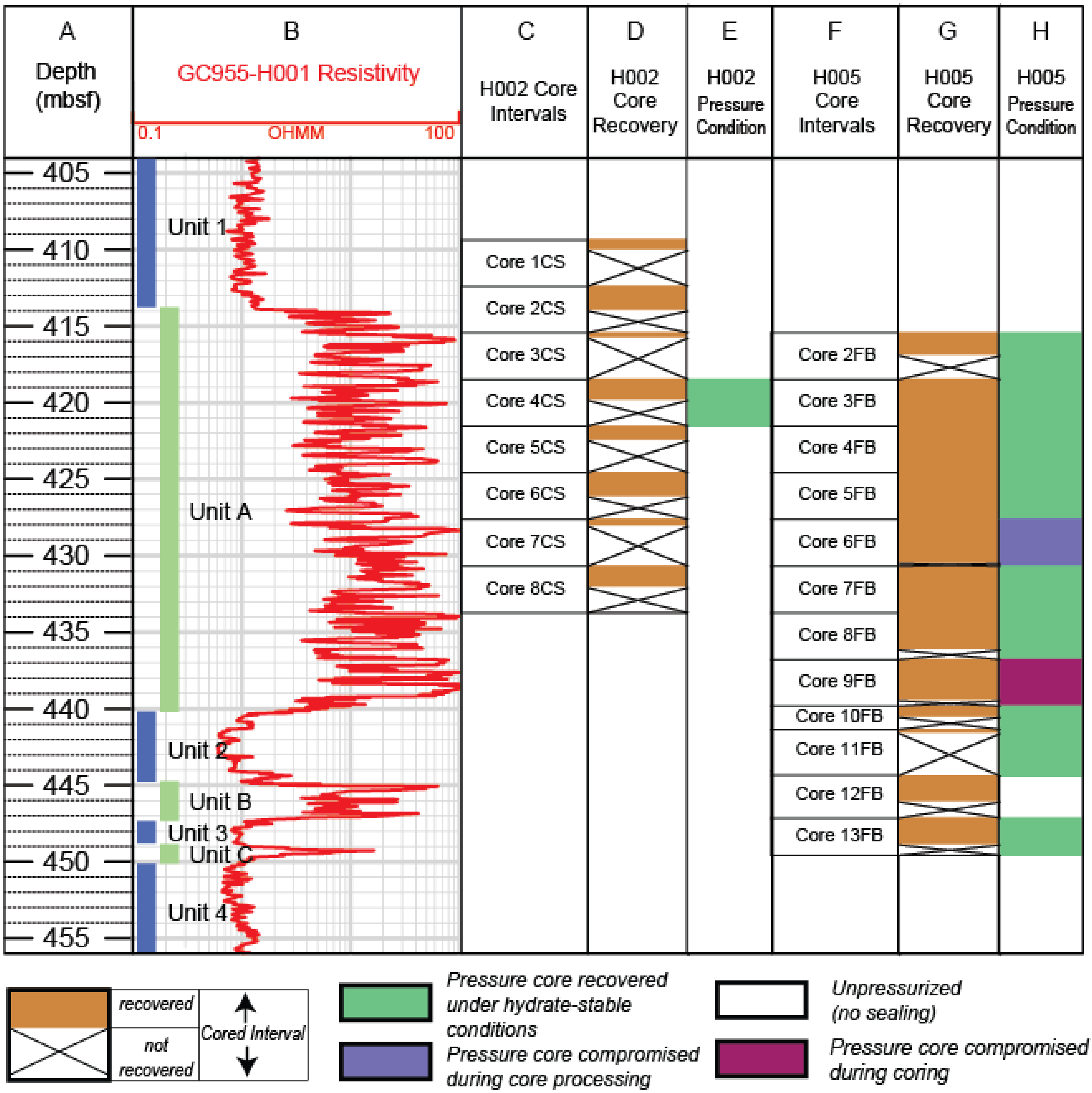

Figure 3-40: Pressure coring intervals at GC-955. Pressure coring depths, sediment recovery, and pressure condition at H002 and H005 wells. A) Depth in meters below seafloor (mbsf). B) High resistivity from H001 LWD well records the hydrate-bearing interval (see also Figure 3). C) H002 cored intervals. D) H002 core recovery. Brown records recovered sediment thickness; white zone with 'x' records unrecovered fraction. E) H002 pressure condition; only core 04CS was recovered at pressures within the hydrate stability zone. F) H005 core intervals. G) H005 core recovery. H) H005 pressure condition: 09FB lost pressure during coring while 06FB lost pressure during core processing.

Correlation of the core data with the log data provides insight into the composition of the water-bearing units as discussed by (Flemings et al., In press). Pressure cores 1CS and 2CS were attempted in water-bearing Unit 1, yet neither of these pressure cores sealed and there was low recovery (Figure 3-40, track d). However, the core that was recovered is composed of interbedded sandy silt and clayey silt, as is interpreted for the hydrate-bearing intervals.

Core 13FB is within Unit 3 (Figure 3-40, track G, Figure 3-41, track 5). It is made up of thin- to medium-bedded sandy silt and clayey silt. The average sandy silt bed thickness is 11 cm (4.3 inch), the average clayey silt bed thickness is 6 cm (2.4 inches), and the net to gross is 65%. Thus water-bearing Unit 3 is more thinly bedded (Figure 3-41, track 13) than the overlying hydrate-bearing Layer B, which contains several sandy silt layers that are over 30 cm thick (1 ft). The silty sand within Unit #3 has a high hydrate saturation because it has a low density (Figure 3-41, track 10) and a very high p-wave velocity (Figure 3-41, track 11).

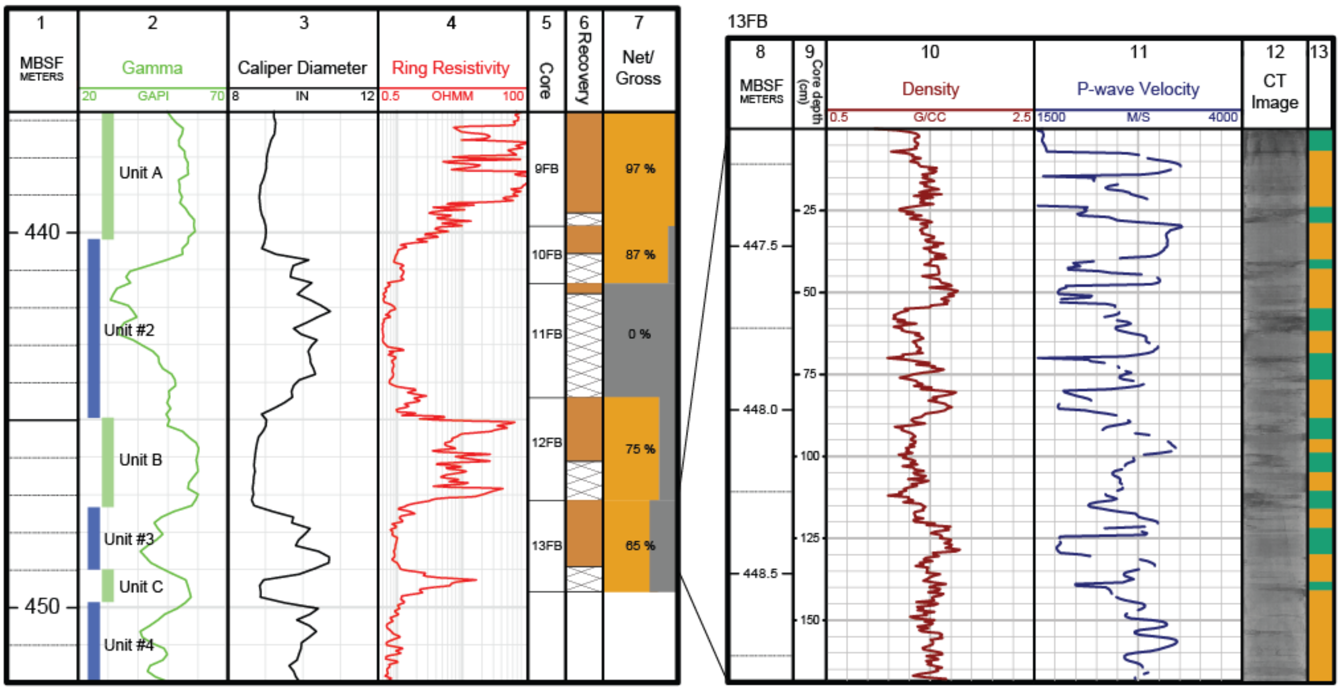

Figure 3-41: Reservoir-bounding intervals at base of GC-955 reservoir. Water-bearing Unit #2 and Unit #3. 1) Depth below seafloor in meters, 2) LWD Gamma Ray, 3) LWD Caliper, 4) LWD Ring Resistivity, 5) Core Name, 6) Core Recovery, 7) Net to gross (fraction of sandy silt to entire thickness over the core). 8) Depth (mbsf) of Core 13FB. 9) Core depth in cm. 10) PCATS density. 11) PCATS velocity. 12) XCT Image. 13) Lithofacies.

In summary, water-bearing Unit 3 is composed of hydrate-bearing sandy-silt beds interbedded with non-hydrate-bearing clayey silt (Figure 3-41, track 13). We interpret that the low net to gross in this layer, and the relatively thin bedding, either result in borehole washout, or reduction in the observed log response due to the thin bedded nature of the hydrate. The overlying Unit 1 and Unit 2 are also composed of interbedded clayey silt and sandy silt with a low net to gross. Unfortunately, we do not know if there is hydrate present in these units because no pressurized cores were recovered. However, by analogy to Unit 3, we infer that Unit 1 and Unit 2 are also composed of interbedded hydrate-bearing sandy silt and clayey silt with a low net to gross.

3.4.2.3 GC 955 Lithofacies Characterization

We solidified the lithofacies identification for GC 955. Three lithofacies were previously distinguished and referenced using the generic names of lithofacies 1, 2 and 3 (Figure 3-42). They are now more accurately classified based on physical properties, and named according to grain size as silty clay, sandy silt, and clayey silt, respectively. Further details and geologic interpretations will be published in (Flemings et al., In press), and (Meazell et al., in press).

The silty clay is composed of 55% clay-sized particles, and has D 0.50 of 1.4 um when measured by the hydrometer method. It is poorly sorted, and massive to laminated, with thin fractures containing 3% or less hydrate saturation. It has a sonic velocity of 1700 m/s and a density of 2.0 g/cm3. This lithology was only found in the shallow core 130 m above the main reservoir (Core 1FB).

The sandy silt is composed of 15-40% sand-sized particles and less than 10% clay-sized particles when measured by the hydrometer method. It has a D 0.50 of 35-55 um. It is well-sorted, and contains abundant ripple laminations. Some ripples contain mud drapes. Individual beds of sandy silt are up to 90 cm thick. The sandy silt has a sonic velocity of 2500-3500 m/s, and density of 1.9 g/cm3. This lithology makes up the majority of the hydrate reservoir, and contains hydrate saturations up to 95%.

The clayey silt is composed of less than 10% sand-sized particles and 38-52% clay-sized particles when measured by the hydrometer method. It has a D 0.50 of 2-4.6 um. It is a poorly-sorted, structureless clayey silt that can contain silt layers less than 0.5 cm thick. Individual beds of clayey silt are 2-3 cm thick. The clayey silt has a sonic velocity of 1600-2400 m/s, and a density of 2.0-2.1 g/cm3. This lithology is found interbedded throughout the hydrate reservoir, and contains low to negligible hydrate saturations.

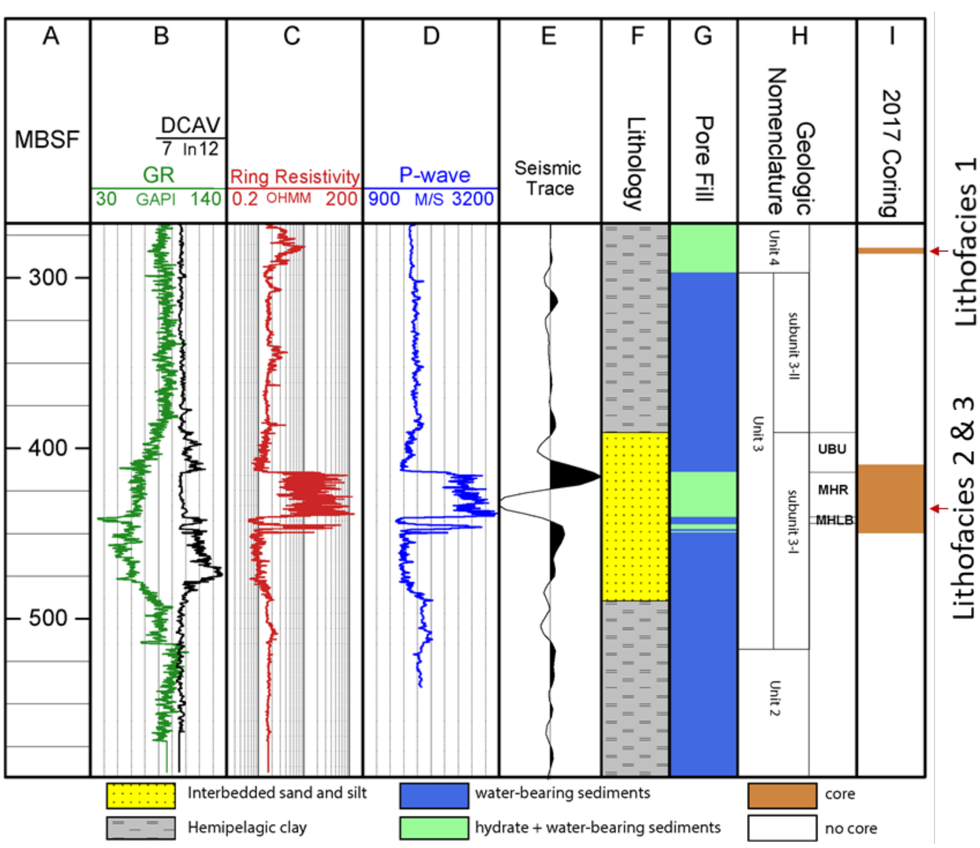

Figure 3-42: Location and previous generic names (far right) of GC 955 lithofacies.

3.4.3 Subtask 10.6: Additional Core Analysis Capabilities

Objectives

The Recipient may develop additional core analysis capabilities including, but not limited to:

- *Mercury porosimetry for both porosity and pore throat analysis.*
- *Scanning Electron Microscope (SEM) for sediment fabric and microstructure.*
- *X-ray Diffraction (XRD) for sediment mineralogy*
- *Grain size analysis using a hydrometer or sieves*
- *Carbon isotopes of organic matter in mud samples.*

Accomplishments

We have developed a suite of analysis approaches to illuminate the material and petrophysical behavior of our cored samples.

3.4.3.1 Liquid and Plastic limit

The sandy silt has a liquid limit (w_L) of 23 % and plastic Index (Ip) of 3.5%. The clayey silt has a w_L = 49.8%, and Ip = 28%. Sandy silt (4FB-8) sediments are inorganic silts and clayey silt (11FB-1) are classified as lean clay (CL) (Figure 3-43) confirming that the index properties of GOM2 sandy silt and 3 sediments are accurately measured and fit the characteristic index properties of the Gulf of Mexico sediment.

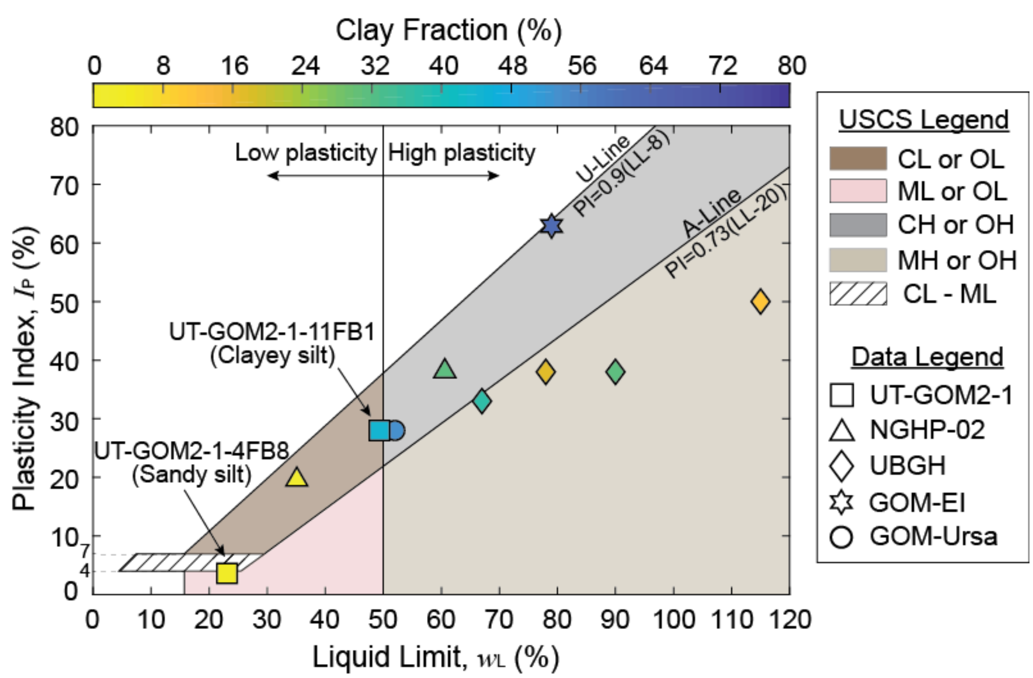

Figure 3-43: The Casagrande plasticity chart of core sediments. The clay fraction of each sample is color coded. The background colors record the soil classifications of the Unified Soil Classification System (USCS) (i.e., CL - lean clay; OL - organic silt or clay with low liquid limit; CH - fat clay, OH - organic silt or clay with high liquid limit; ML - silts; MH - elastic silt), which are defined and interpreted in ASTM D2487 (ASTM International, 2017). Atterberg limits of our samples are compared to other gas hydrate reservoirs: NGHP02 samples are from NGHP B&C areas, Krishana-Godavari Basin of Eastern India (Dai et al., 2018); UBGH samples are from Ulleung Basin, Sea of Japan (Yun et al., 2011). Characteristic samples from non-hydrate reservoir locations in the Gulf of Mexico also included for comparison: GOM-EI is a clay from Eugene Island, Gulf of Mexico, and GOM-Ursa is a siltstone from Ursa Basin, Gulf of Mexico (Casey et al., 2019).

3.4.3.2 Particle Size Distribution

- Sandy silt sediments are well-sorted. Core 7FB3 has the largest grain size while core 13FB1 has the smallest grain size (Figure 3-44 and Table 3-9).

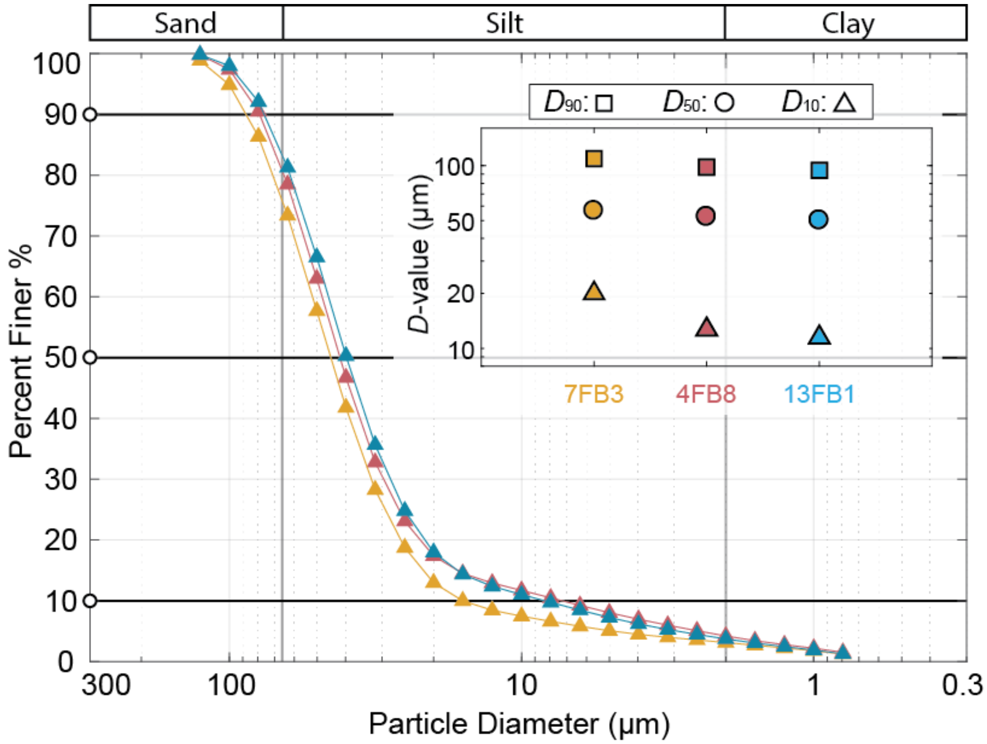

Figure 3-44: Laser diffraction grain size distribution analysis of three sandy silt pressure cores. Inset: comparison of the D-values (D10, D50, and D90) which are the intercepts for 10%, 50% and 90% of the cumulative mass.

Table 3-9: Statistical grain size parameters of bulk material from pressure cores.

Sample Name	4FB8-3	7FB3-1	13FB1
GSD Method	laser	laser	laser
D_{10} (µm)	13	20	11
D_{50} (µm)	53	57	50
D_{90} (µm)	98	109	94
D < 10 µm (%)	11	7	10
10 µm < D < 63 µm (%)	37	43	34
D > 63 µm (%)	52	51	56

3.4.3.3 Mercury Porosimetry

- The capillary curves for three sandy silt cores (4FB8-3, 7FB3-1 and 13FB1) are very close (Figure 3-45). The samples 4FB8-3 and 7FB3-1 have almost identical displacement pressures ($P_{de}^{Hg\text{-}air}$, $P_d^{gas\text{-}water}$, and $P_{modal}^{gas\text{-}water}$, see Table 3-10) and an identical modal pore throat radius (5.09 µm vs. 5.09 µm).
- The capillary behavior of one reconstituted clayey silt sample that show much higher displacement $P_{de}^{Hg\text{-}air}$ (6.84 MPa) and a smaller modal pore throat radius (0.054 µm) (Figure 3-45, Table 3-10).

- At the observed 90% hydrate saturation in sandy silt, the methane solubility is defined by the smallest pores filled with hydrate (*e.g.*, red filled circle in Figure 3-46, where S_w = 10%, d_p = ~ 0.35μm). This solubility is less than that necessary to form hydrate in the very largest pores of clayey silt (*e.g.*, green filled circle in Figure 3-46, where S_w = 100%, d_p = 0.18 μm).

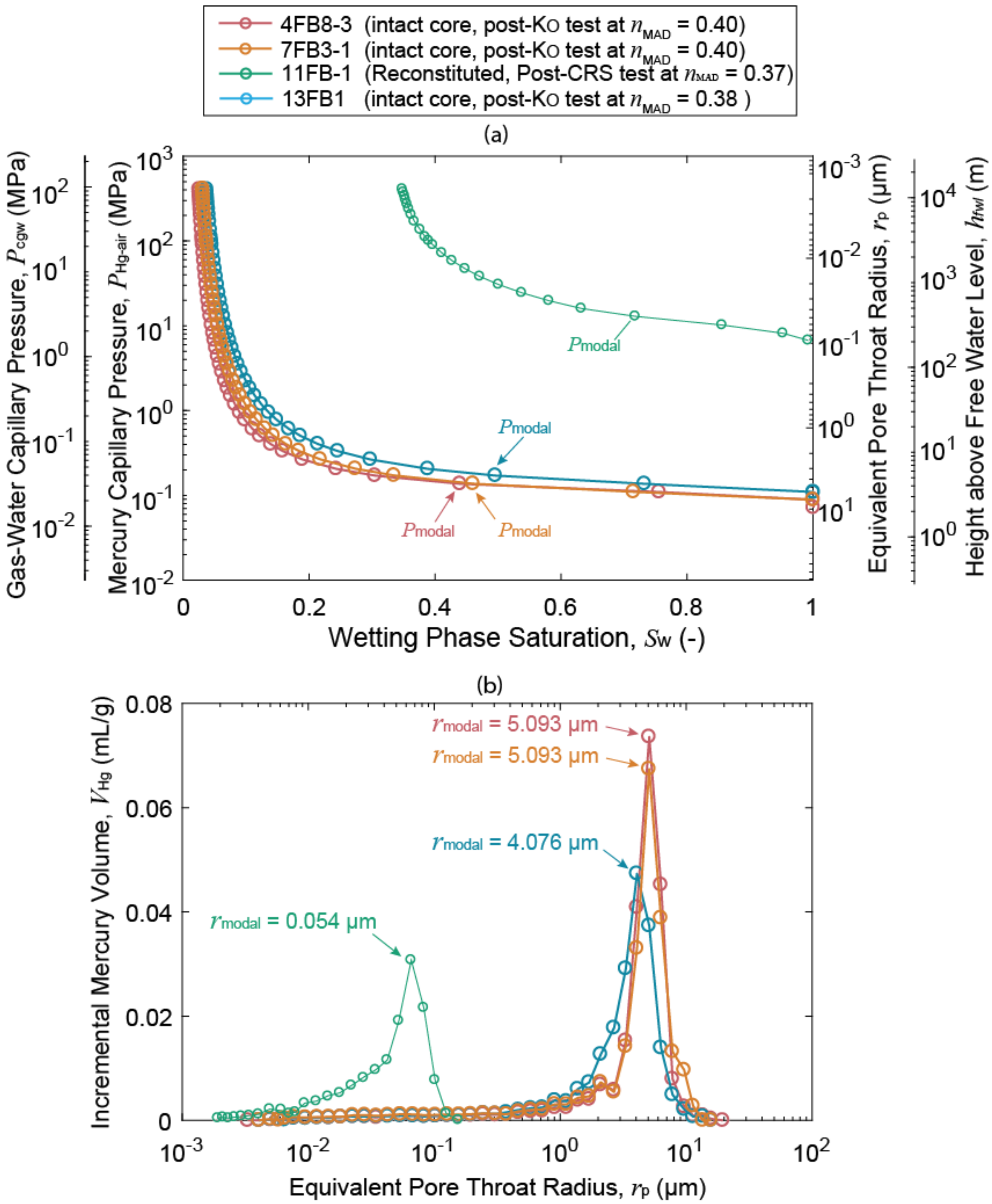

Figure 3-45: Mercury injection capillary pressure measurement. (a) Capillary pressure curves. The wetting phase saturation is calculated as $Sw = 1\text{-}V_{Hg}/V_{pore}$. The calculation of MICP porosities (n_{Hg}), displacement pressure (P_d) and the extrapolated displacement pressures (P_{de}) are described in Fang et al., in review. (b) Incremental mercury injection volume with pore throat radius. Values of modal pore throat radius r_{modal}, displacement pressure P_d, extrapolated displacement pressures P_{de}, and modal displacement pressure P_{modal} are listed in Table 3-10.

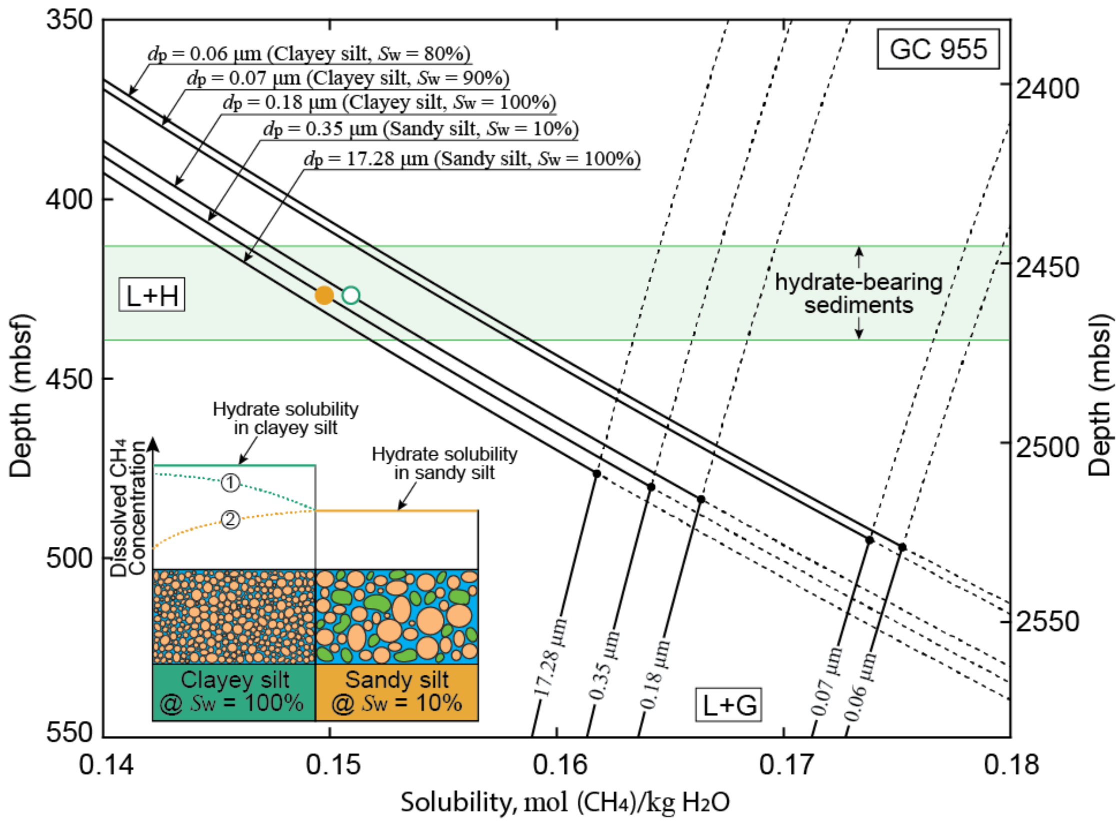

Figure 3-46: The L(liquid) + G(gas) and L + H(hydrate) solubilities (black lines) in fine pores. At any depth in hydrate-bearing sediment zone (light green zone), the hydrate solubility in fine pores of sandy silt (red filed circle, Sw = 10%, dp = 0.35 μm) is always less than that in the largest pore of clayey silt (green filled circle, Sw = 100%, dp = 0.18 μm).

Table 3-10: Interpreted data of Mercury injection capillary pressure measurements. The porosity types and measurements have been described in Fang et al. (2020).

Sample Name	4FB8-3	7FB3-1	11FB1	13FB1
Lithofacies	Sandy silt	Sandy silt	Clayey silt	Sandy silt
Core Integrity	Intact	Intact	Reconstituted	Intact
Stress	0 -3.8 MPa	0 -3.8 MPa	0 -3.8 MPa	0 -3.8 MPa
n_{MAD} (-)	0.40	0.40	0.37	0.38
n_{Hg} (-)	0.39	0.38	0.28	0.38
$P_d^{Hg\text{-}air}$ (MPa)	0.11	0.11	8.26	0.14
$P_d^{gas\text{-}water}$ (MPa)	0.025	0.025	1.91	0.032
$P_{de}^{Hg\text{-}air}$ (MPa)	0.094	0.089	6.84	0.108
$P_{de}^{gas\text{-}water}$ (MPa)	0.022	0.021	1.58	0.025
$P_{modal}^{Hg\text{-}air}$ (MPa)	0.14	0.14	13.08	0.17
$P_{modal}^{gas\text{-}water}$ (MPa)	0.032	0.032	3.02	0.04
d_m (μm)	30.14	21.34	0.18	24.19
r_{modal} (μm)	5.093	5.093	0.054	4.076
h^d_{fwl} (m)	3.092	3.091	231.69	3.861
h^{de}_{fwl} (m)	2.65	2.49	191.80	3.031
h^{modal}_{fwl} (m)	3.86	3.86	366.95	4.828
S_{rw} (-)	0.026	0.031	0.35	0.038

3.4.3.4 Porosity Determination

- We determined and summarized 4 different porosity measurements to systematically explore the in situ porosity of each lithofacies from the hydrate reservoir. Different porosity values may result from porosity measurements using PCATS (CT, p-wave, and gamma density), LWD, moisture and density (MAD) measurements, and mercury porosimetry. A combination of these measurements would contribute to isolating the effect of sample material deformation occurred during sample recovery, transfer and storage. The method of each measurement is described in *Fang et al. (2020).*
- PCATS porosity is calculated from the best-estimated bulk density (ρ_b) of the core sediments assuming only water and hydrate are present in the pores. The best-estimated bulk density (ρ_b) is adjusted from PCATS bulk density ($\rho^*{}_b$) that is an apparent value because the core sediments (i.e., bulk core volume V_b) do not occupy all of the volume with the core liner (V_t). The PCATS porosity is not measured in situ.
- The LWD porosity is calculated from the LWD bulk density (ρ_b) of the core sediments assuming only water and hydrate in the pores. The LWD porosity is an in-situ porosity as the LWD bulk density is measured in situ. But LWD porosity is subject to limitations because the LWD porosity is based on LWD values that average over a considerable vertical data sampling interval resolution.
- The moisture and density (MAD) porosity is measured after pressure core analysis, where no hydrate is present. It assumes only water is present and the sample is 100% saturated.
- The mercury injection capillary pressure (MICP) porosity is the porosity from our mercury porosimetry measurements. MICP porosity is the volume of mercury intruded into the reconstituted sample divided by the bulk volume of the sample. MICP porosity estimation is more accurate in sandy silt material because mercury can easily infiltrate and occupy more pore volume in sandy silt than in clayey silt.
- The estimated in situ porosity of sandy silt is in the range within 0.38 and 0.40 with consistency in each measurement. The porosity of clayey silt ranges is estimated at 0.33 at an in situ effective stress of 3.8 MPa (Table 3-11).

Table 3-11: Results of 4 different porosity measurements. The methods have been described in Fang et al. (2020).

Sample Name	4FB-8	11FB-1
Lithofacies	Sandy silt	Clayey Silt
PCATS Porosity, *n* (-)	0.38	0.36
Calibrated PCATS Porosity, *n* (-)	0.38	0.33
LWD Porosity, *n* (-)	0.38	0.35
n_{MAD} (-)	0.40	0.37
n_{Hg} (-)	0.39	0.28
Hydrate Saturation	0.83	0.02

3.4.3.5 Depressurized Core: X-ray Diffraction

Additional X-ray diffraction (XRD) measurements of bulk and clay mineralogy were made at James Hutton Limited Analytical Laboratory using minerology standards. The samples were analyzed in two separate runs, bulk and clay (<2 micron) fraction (Table 3-12 and Table 3-13), and the results were then combined as cumulative percentages as shown in Table 3-12.

Table 3-12: XRD results for five UT-GOM2-1 sediment samples measured at James Hutton Limited Analytical Laboratory using minerology standards.

Core section	Lithofacies	Quartz	Plagioclase	K-feldspar	Amphibole	Calcite	Dolomite	Siderite	Pyrite	Anatase	Halite	Illite + Smectite	Chlorite	Kaolinite
1FB-3	SC	20	15.9	8.4	1.8	11.7	8.4	0.8	0.4	0	0.7	26.9	2.9	2.1
3FB-3	SS	47.6	20.9	8.4	1.3	5.9	9.7	0.2	0	0	0.1	5.9	0	0
4FB-2	SS	46.7	22.3	8	1	6.1	9.7	0.2	0	0	0	6	0	0
3FB-2	CS	34.4	18.7	7.4	1.3	8.4	10.7	0.5	0.3	0	2	15.2	0.8	0.3
4FB-3	CS	25.6	15	6.5	1.4	9.7	9.3	0.9	0.2	0.1	0.9	25.8	1.2	3.4
Silty Clay (SC) avg		20	15.9	8.4	1.8	11.7	8.4	0.8	0.4	0	0.7	26.9	2.9	2.1
Sandy Silt (SS) avg		47.15	21.6	8.2	1.15	6	9.7	0.2	0	0	0.05	5.95	0	0
Clayey Silt (CS) avg		30	16.85	6.95	1.35	9.05	10	0.7	0.25	0.05	1.45	20.5	1	1.85

Table 3-13: Relative abundance of clay minerals (< 2µm fraction). I + I/S MIL is undifferentiated illite + illite/smectite mixed layered clay. %Exp is the percent expandability of illite/smectite mixed layered clays.

Sample	Lithofacies	Chlorite	Kaolinite	Illite-8	I/S-MIL	%Exp
1FB-3	Silty clay	10	4	14	72	75
3FB-2	Clayey silt	5	3	15	77	75
3FB-3	Sandy silt	3	2	10	85	75
4FB-2	Sandy silt	3	2	9	86	75
4FB-3	Clayey silt	6	4	13	77	75

3.4.3.6 Carbon Isotopes of organic matter in mud samples

Carbon isotopes are discussed in Section 3.4.1.6.3 Total carbon, hydrogen, nitrogen, and sulfur (CHNS) Elemental and Isotopic Analysis.

3.5 Task 11.0: Update Operational Plan for UT-GOM2-2

Objectives

The Recipient will continue to develop, in consultation with the project Advisory Team, the pre-expedition drilling / logging / coring / sampling Operation Plan for the UT-GOM2-2 Scientific Drilling Program. The Recipient will document the developed Operational Plan as a dedicated Operational Plan report.

Accomplishments

Upon recognition that UT-GOM2-2 would be executed by UT independently, UT began taking steps to update the UT-GOM2-2 operational and science plan. There were two key implications of a UT-led expedition:

1. A revised budget would be required that includes all expedition-related and operational costs that would have been otherwise been absorbed by IODP or ECORD. This would inevitably result in a reduction of the original program as envisioned in CPP-887.
2. A revised operational and science plan would be required that optimize the science that can be done with the revised expedition budget.

The UT-GOM2-2 planning teams initiated at the Ohio State workshop September, 2018 were charged with addressing the need for a new UT-GOM2-2 expedition program that achieves the maximum amount of science is within the revised expedition budget. UT with Ohio State integrated recommendations from the UT-GOM2-2 planning teams and developed multiple possible UT-GOM2-2 operational plans. Recommendations provided by the various UT-GOM2-2 planning teams were condensed into a list of eight possible UT-GOM2-2 science objectives (Table 3-14). Five possible operational plans were then outlined, budgeted, and evaluated against the current UT-GOM2-2 budget to assess what is feasible with the current funding.

Table 3-14: Recommended UT-GOM2-2 Science Objectives.

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

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

Advisory Team feedback from the January 24 meeting:

1. Agreed that the highest priority is reservoir characterization of the main target: the TBONE-01B (WR3213H) hydrate-bearing Orange Sand.

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

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

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

On March 18, 2019, UT met with the Advisory Team and Technical Experts to discuss the Decision Document. It was agreed that maximizing the potential for scientific achievement within the funding originally allocated for the coring expedition could best be accomplished by combining two of the seven existing plans.

The UT-GOM2-2 operations plan was based on the following recommendations from the GOM2 Advisory Team:

- <u>Recommendation 1:</u> WR313 H002 (WR 313-H) should be drilled first with the face-bit bottom hole assembly (BHA) to provide maximum time and budget to reach and acquire pressure core samples in the Orange Sand (Objective 1) and within overlying hydrate reservoirs (Objective 7). This maximizes the probability of meeting the primary objectives (Objective 1 and 7).
- <u>Recommendation 2:</u> Meet Objective 8 by comparing the Blue Sand at WR313 H002 and at WR313 G002. This is not as desirable as comparing the Orange Sand at up-dip and down-dip locations. However, the costs of drilling the LWD hole and the associated core hole (Objective 3) in order to penetrate the up-dip location for the Orange Sand, was felt to exceed the scientific opportunity.

- Recommendation 3: Acquire pressure cores intermittently to obtain dissolved methane concentrations (Objective 5) in both holes (WR313 H002 and WR313 G002). These data will complement T2P data (Objective 4) and conventional coring (Objective 6) in the second hole (WR313 G002). It is understood that the number of pressure and conventional core is contingent on field conditions and budget. Enough dissolved methane samples should be acquired in the first hole to provide guidance on the expected dissolved methane profile in the second hole.
- Recommendation 4: Do not perform in-situ measurements by large diameter wireline logging and Modular Dynamics Testing (MDT) over the Orange Sand. This objective (Objective 2) is of high scientific value. However, there is considerable risk that deployment of the MDT will not successfully measure permeability, or take fluid samples within the hydrate reservoir. The elevated scientific risk lead to the decision not to pursue this objective.

In period ending September 30, 2019, UT with Ohio State and Pettigrew Engineering completed a draft UT-GOM2-2 Scientific Drilling Program Operations Plan. The UT-GOM2-2 Operations Plan is provided in **Appendix C**.

In this period, UT also began to develop the UT-GOM2-2 Science and Sample Distribution plan including detailed science objectives, core types and coring locations, core cutting and preservation, core analyses and methodology, and distribution of cores and other samples.

3.6 Task 12.0: UT-GOM2-2 Scientific Drilling Program Vessel Access

Objectives

The Recipient will notify DOE and the Project Advisory Team whether the IODP Science Evaluation Panel (SEP) has forwarded the Complementary Program Proposal (CPP) submitted by the Recipient to the JOIDES Resolution Facility Board (JRFB) for consideration for implementation. The Recipient will notify DOE within 1 week of their notification by IODP. Notification will include, at a minimum, an indication of whether IODP has forwarded the CPP to the JRFB and if so, the anticipated timing of ship availability and approximate ship costs (as available).

If the CPP is not forwarded to the JRFB (or in parallel with the CPP process if deemed to be needed by mutual agreement of Recipient and DOE), the Recipient, in coordination with the project Advisory Team, will investigate alternate potential means of gaining access to a mutually acceptable vessel suitable for conducting the planned UT-GOM2-2 Scientific Drilling Program. This may include, but is not limited to, the Recipient contracting a vessel independently, investigating plausibility of accomplishing drilling program with 'vessels of opportunity' as directed by the Sponsor.

Accomplishments

IODP Expedition 386

Recognizing that the *JR* had not operated in the Gulf of Mexico outer continental shelf (OCS) since a change in regulations in 2010, UT conducted an independent review of vessel requirements for conducting deep water drill tests in the Gulf of Mexico OCS, as required by the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE), and the United States Coast Guard (USGC).

UT met in-person with the IODP and members of the JRFB on February, 22, 2018 at Texas A&M University to share the findings of the vessel requirement review, assist in a compliance review of the *JR*, and discuss potential compliance concerns.

UT held a web conference on March 30, 2018 with IODP, members of JRFB, JRSO, National Science Foundation, and DOE, to discuss path forward for permitting the *JR* and ability to meet regulations promulgated by BSEE, BOEM, and USCG to operate in the Gulf of Mexico as a drilling vessel.

A critical outcome of this meeting was recognition that the *JR* would be required to meet the 1989 International Maritime Organization (IMO) MODU Code or 46 Code of Federal Regulation (CFR) part 108, required by the USCG and BSEE for drilling and conducting deep stratigraphic testing (boreholes deeper than 500 feet below seafloor) on the OCS. This would require substantial modifications to be made to the ship, including, potential thickening of the hull, building blast walls, and elimination of ignition sources on the deck.

UT and the IODP US Implementing Organization (IODP-USIO) performed further review to determine if it would be possible to modify the *JR* or receive 'alternative compliances' to meet the 1989 IMO MODU Code. However, the JRSO was later informed by the USCG that the *JR* must fulfill all requirements of the 1989 IMO MODU Code in order to be permitted for drilling and conducting deep stratigraphic tests on the Gulf of Mexico OCS.

The UT GOM2 team and the DOE emphasized that they were willing to seek review of any potentially inappropriate regulations. However, UT was not provided with an accounting of specific issues from the JRSO or OD-SIEMS for which a discussion with Federal regulators would be worthwhile. In April 2018, the JRSO and ODL-

SIEMS withdrew from performing IODP Expedition 386 in 2020 in the Gulf of Mexico. On May 21, 2018, UT received formal notification that that JRFB had canceled IODP Expedition 386 and removed it from the *JR's* 2020 schedule. The JRFB cited high costs and insufficient available time for ship upgrades required for the *JR* to meet the 1989 IMO MODU Code.

Support of CPP2-887 with IODP is further discussed in Task 6.0: Technical and Operational Support of CPP Proposal.

ECORD Mission Specific Platform

In the May 21, 2018 notification that Expedition 386 had been removed from the *JR's* 2020 schedule, the JRFB proposed that UT-GOM2-2 could be considered for implementation by the IODP's European component, the European Consortium for Ocean Research Drilling (ECORD), a Mission Specific Platform (MSP). The JRFB suggested that UT should start working with ECORD to assess this possibility.

UT fulfilled all obligations to transfer CPP-866 from IODP to ECORD for consideration as an MSP, including developing alterative science plans and budgets to reduce cost, responding to numerous requests for technical, logistical, and budgetary information, and hosting numerous web-conferences.

Ultimately, the ECORD Council and ESSAC determined that previously-postponed Arctic and Antarctic expeditions would be prioritized for implementation in 2021-2022. Therefore, the ECORD Council determined it was not possible to implement CPP-887 as an MSP.

Support of CPP-887 with ECORD is further discussed in Task 6.0: Technical and Operational Support of CPP Proposal.

Independently-Contracted Vessel

As a result of the JRFB and ECORD Council's decisions, there is no longer a path forward for UT-GOM2-2 within the IODP. Therefore, UT, will contract a vessel for UT-GOM2-2 independently, as was done for UT-GOM2-1.

UT began a detailed analysis to assess how UT-GOM2-2 could be pursued through available commercial vessels. UT prioritized the science program and revised the UT-GOM2-2 Operational Plan to lower the total cost to the program.

Refer to Task 11.0: Update Operational Plan for UT-GOM2-2 for further discussion.

Vessel of Opportunity for LWD Program (Pacific Khamsin)

At the request of DOE, UT approached Equinor ASA (Equinor) in May, 2019, to explore the feasibility of a logging-while-drilling (LWD) program in February 2020 aboard the Pacific Drilling Pacific Khamsin drillship at a reduced cost while under long-term lease to Equinor.

UT took numerous steps towards exploring this potential, including developing a draft operations plan, developing a draft cost estimate, developing lists of issues that need to be vetted, and engaging Equinor in preliminary planning discussions for possible LWD expedition. UT personnel attended in-person meetings with Equinor on May 16 and June 5.

UT provided Equinor with a list of succinct questions and issues to be resolved on June 11, 2019. UT requested a feedback and a formal decision by mid-July in order to complete necessary contracting and permitting for an early 2020 LWD program to be possible. Throughout June and July, UT continued efforts to obtain resources and information from Equinor to allow for further planning and a feasibility-study of a 2020 LWD program.

UT attended an in-person meeting with Equinor on June 20, 2019. In this meeting, Equinor informed UT that at the time they did not have time or resources to commit to further discussions with UT. Furthermore, Equinor indicated that any further information or discussion should be at Equinor's discretion once their path forward with the Pacific Khamsin became clear, and only then if they had a large gap in the schedule that would allow evaluation for further options.

In July, 2019, UT determined that it was not feasible to pursue a logging-while-drilling (LWD) program during the proposed window of early 2020. UT required a go/no-go decision my mid-July in order to initiate and complete required contracting and permitting for a 2020 LWD program. Because, by this time, Equinor had not indicated further interest in continuing with negotiations or committed resources to assist UT with cost estimates and project planning. UT determine that if, in the near future, Equinor does commit resources towards further discussions with UT, the LWD program could not be accomplished in early 2020.

3.7 Task 13.0: Maintenance and Refinement of Pressure Core Transport, Storage, and Manipulation Capability

3.7.1 Subtask 13.1: Hydrate Core Manipulator and Cutter Tool

Objectives

The Recipient will maintain the ability to use the Manipulation and Cutting Tool (developed under Phase 2, Subtask 9.5) and implement appropriate design modifications to improve the capability of the tool as determined to be necessary by mutual agreement of the Recipient and DOE.

Accomplishments

UT conducted regular system maintenance and teardowns of the Mini-PCATS cutter, rotation, and viewing units after sample cutting. UT also conducted bi-annual teardowns of the Power Balance Drive were conducted for preventative maintenance. The system was cleaned and cutter blades replaced after each sampling.

All teardowns have the following steps:

- Removal of sediment from sample cutting
- Removal and mitigation of corrosion
- Complete replacement of all bearings, seals, and O-rings
- Lubrication of necessary bearings and components

UT maintained active utilization of the Mini-PCATS and associated equipment to advance the laboratory-based experiments and pressurized core sample distribution:

- **Period ending June 30, 2018:**
    - Cut two pressure core samples for the K0
    - Cut three pressure core samples for quantitative degassing
- **Period ending September 31, 2018:**
    - Received four NETL pressure chambers and cut four 30 cm pressure core samples from 3 cores
    - Cut one sample for K_0 from core 4FB-8.
- **Period ending December 31, 2018:**
    - Received two USGS pressure chambers and transferred two, 1.2-meter pressure cores (4FB-6 and 3FB-1) in December, 2018.
    - Cut one sample for K_0 from core 4FB-8.
- **Period ending March 31, 2019:**
    - Three cores scanned and subsampled with the aid of the new CT scanner system
        - Core H005-6FB-1 – K0, Degas samples
        - Core H005-13FB-1 – Degassed and sampled w/ Ohio State
        - Core H005-4FB-8 – K0, Degas samples
    - One core scanned and degassed
        - Core H005-9FB-3 – Fully degassed
- **Period ending June 30, 2019:**
    - One core scanned and subsampled with the aid of the new CT scanner system

        - Core H005-13FB-1 – K0, Degas samples, May 2019.
    - Accepted delivery of USGS BIO sampler chamber.
    - Accepted delivery of two AIST pressure chambers for BIO sampling transfers.
- **Period ending September 30, 2019:**
    - Six cores scanned and subsampled with the aid of the new CT scanner system:
        - Core H005-1FB-4 – BIO Chamber, K0 samples
        - Core H005-5FB-2 – BIO Chamber, Degas samples
        - Core H005-5FB-3 – BIO Chamber, AIST samples
        - Core H005-6FB-3 – BIO Chamber, Degas, Raman Chamber samples
        - Core H005-3FB-5 – AIST, Degas samples
        - Core H005-7FB-3 – Scanned in preparation for K0 sample cutting
    - Core 1FB-4 K0 sample placed in Preconsolidation System, system functioned well.
    - AIST Storage Chambers
        - Pressure tested for BIO sampling run. Chambers held pressure.
        - Two samples transferred, each approximately 35 cm in length
    - USGS BIO sampler chamber
        - Four core sections sample under pressure, each approximately 16 cm in length
        - Same sections sampled at atmospheric pressure, in an anoxic environment

UT implemented design modifications to improve the capability of the tool as determined to be necessary by mutual agreement of the Recipient and DOE.

- **Period ending December 31, 2018:**
    - Prepared system to receive Geotek X-ray system upgrade to Mini-PCATS

- **Period ending March 31, 2019:**
    - Installation of the Mini-PCATS 3D X-ray CT system
    - X-ray system underwent critical inspection by UT EHS and Geotek
        - No adverse radiation leakage was detected, and all limits were found to be within normal range
- **Period ending June 30, 2019:**
    - Accepted delivery of the Pre-Consolidation System for long term storage of pressure core permeability samples.
    - Installation of vertical PMRS pump stand to accommodate new Pre-Consolidation System.

3.7.2 Subtask 13.2: Hydrate Core Effective Stress Chamber

<u>Objectives</u>

The Recipient will maintain the ability to use the Effective Stress Chamber (developed under Phase 2, Subtask 9.6) and implement appropriate design modifications to improve the capability of the tool as determined to be necessary by mutual agreement of the Recipient and DOE.

Accomplishments

UT conducted regular system maintenance of the hydrate core effective stress chamber and related components. The hydrate core effective stress chamber and actuator motor were disassembled, cleaned of all debris, replaced seals and O-rings, and reassembled as needed. Valve solenoids were replaced as needed. Test sections were cleaned and reset as needed.

UT maintained active utilization of the hydrate core effective stress chamber and associated components to advance the laboratory-based experiments:

- **Period ending June 30, 2018:**
  - Two pressure cores samples have been tested in the effective stress chamber. Both samples are from core 6FB-2.
  - Both 6FB-2 samples were removed intact from the K0 at atmospheric pressure for additional grain size, porosity, and pore size analysis.
- **Period ending September 31, 2018:**
  - One pressure core sample from core 4FB-8 was tested and degassed in the effective stress chamber.
- **Period ending December 31, 2018:**
  - One pressure core sample from core 4FB-8 was tested and dissociated in the effective stress chamber in Late October-November, 2018. Sediments from sample collected for additional analysis.
- **Period ending March 31, 2019:**
  - One pressure core sample from core H005-6FB-1 was tested and dissociated in the effective stress chamber in Late February-March, 2019. Sediments from sample collected for additional analysis.
  - One pressure core sample from core H005-4FB-8 was tested and dissociated in the effective stress chamber in Late March-April, 2019. Sediments from sample collected for additional analyses
- **Period ending June 30, 2019:**
  - One pressure core sample from core H005-13FB-1 was tested and dissociated in the effective stress chamber from May-June, 2019. Sediments from sample collected for additional analysis.
- **Period ending September 30, 2019:**
  - One pressure core sample from core H005-1FB-4 was extruded and sealed for storage on the Preconsolidation System.

UT implemented design modifications to improve the capability of the tool as determined to be necessary by mutual agreement of the Recipient and DOE:

- **Period ending March 31, 2018:**
  - A fourth pump was acquired and the manifold altered, allowing us to operate the load cell chamber independently from the pore and radial confining pumps.

- **Period ending June 30, 2018:**
    - K0 system software was updated four times with minor changes to the software and user interface.
    - Multiple system tests run with a Delrin rod sample to validate length measurements and load cell output from new software versions.
- **Period ending September 31, 2018:**
    - Consulted with Ingersoll-Rand to upgrade PCC compressed air system to reduce moisture in air lines.
- **Period ending June 30, 2019:**
    - Installation of new K0 software, Version April 2019 from Geotek.

3.7.3 Subtask 13.3: Hydrate Core Depressurization Chamber

Objectives

The Recipient will maintain the ability to use the Depressurization Chamber (developed under Phase 2, Subtask 9.7) and implement appropriate design modifications to improve the capability of the tool as determined to be necessary by mutual agreement of the Recipient and DOE.

Accomplishments

In period ending March 31, 2018, UT successfully transferred a section of pressure core from Mini-PCATS to a small storage chamber and then attached to the degassing manifold. UT performed a slow quantitative degassing while quantifying the amount of gas and liquid released, collecting gas samples, and monitoring pressure and temperature conditions within the sample chamber.

UT continued to utilize and refine their capability to use the hydrate core depressurization chamber:

- **Period ending September 31, 2018:**
    - H005-6FB-2, 0-21.5 cm was degassed in August, 2018.
    - K_0 sample from 4FB-8 was degassed in September, 2018.
- **Period ending December 31, 2018:**
    - H005-08FB-2, 60.8-77.3 cm was degassed in October, 2018
    - H005-03FB-4, 104.1-118.1 cm was degassed in November, 2018
- **Period ending March 31, 2019:**
    - H005-09FB-3, was degassed in February, 2019
    - H005-06FB-1, was degassed in Late February, 2019
    - H005-13FB-1, was degassed in Early March, 2019
- **Period ending June 30, 2019:**
    - H005-4FB-8 - 40-54 cm
    - H005-13FB-1 - 33.5-52 cm
- **Period ending September 30, 2019:**
    - H005-5FB-2
    - H005-3FB-5

3.7.4 Subtask 13.4: Develop Hydrate Core Transport Capability for UT-GOM2-2

Objectives

The Recipient will continue to refine, maintain and /or develop the ability to transport pressure cores, as determined to be necessary through mutual determination of the Recipient and DOE, for the core to be acquired in Phase 5 (Task 16) of the project.

Accomplishments

UT continued to assess current capabilities and requirements for transporting pressure cores that will be acquired in during UT-GOM2-2 based on the revised UT-GOM2-2 Science Plan and Operations Plan.

3.7.5 Subtask 13.5: Expansion of Pressure Core Storage Capability for UT-GOM2-2

Objectives

The Recipient will develop capacity to store pressure cores resultant from the Research Expedition in Phase 4 (Task 16) of the project. The Recipient will identify a specific technology for storing pressure core at research institutions in the United States. The Recipient will either build or lease the capability to store a minimum of 36 meters of pressure cores.

Accomplishments

UT continued to assess current capabilities and requirements for storing pressure cores that will be acquired in during UT-GOM2-2 based on the revised UT-GOM2-2 Science Plan and Operations Plan.

3.7.6 Subtask 13.6: Continued Storage of Hydrate Cores from UT-GOM2-1 Marine Field Test

Objectives

The Recipient will continue to store (under hydrate stable conditions) pressure core acquired from UT-GOM2-1 Marine Field Test in Phase 2 (Task 8).

Accomplishments

UT continued to store, stabilize, and perform tests on pressure core acquired from the UT-GOM2-1 Marine Field Test (May-June 2017).

- UT performed weekly pressure checks on pressure chambers.
- UT completed drawings to redesign the pressure chamber storage bases to increase capacity.
- UT completed a preliminary budgetary analysis to expand the pressure, maintenance, and relief system (PMRS) to accommodate the increased capacity described above.

3.8 Task 14.0: Performance Assessment, Modifications, and Testing of PCTB

3.8.1 Subtask 14.1: PCTB Lab Test

Objectives

The Recipient will perform laboratory-based testing of the PCTB to discover the range of conditions in which pressure retention is inconsistent, duplicate and analyze difficult unlatching scenarios, analyze performance of the inner tube plug, and analyze performance of inner and outer latch systems to obtain a high degree of confidence in overall PCTB operation. Testing will include, but is not limited to, a Pressure Function Testing (PFT) and Pressure Actuation Testing (PAT). Computational Fluid Dynamics modeling will also be conducted to simulate tool response under field conditions. As a result of tool performance during this testing, the Recipient will recommend modifications and/or upgrades of the PCTB to be conducted in Task 14.2.

Accomplishments

Pressure Coring Tool Evaluation

In period ending June 30, 2018, the PCTB Development Team conducted a technical comparison of the PCTB to the High-Temperature/Pressure Corer (HPTC) to develop consensus on the path forward for the GOM2 project pressure coring technology.

UT has worked with Aumann & Associates and later, Geotek, to develop, test, and deploy the PCTB since 2014. In 2017 UT tested the PCTB in two boreholes in the Gulf of Mexico (UT-GOM2-1), during which some significant challenges were encountered due to failure of the PCTB autoclave to seal at core-point pressure. In 2018, the Japanese Oil, Gas and Metals National Corporation (JOGMEC) utilized an alternate pressure-coring tool developed by Geotek (HPTC) in the Nankai Accretionary Wedge off the coast of Japan, with high success. The PCTB Development Team conducted a technical review of tool performance and reviewed whether the HTPC is a possible alternative to the PCTB.

As a result of the review, the PCTB Development Team felt that the best decision for UT-GOM2-2 is to continue to test, develop, and deploy the PCTB. The reasons for this decision include lower cost, significant risk inherent in developing a new, untested, tool, and both tools sharing the same fundamental problem of pressure-sealing.

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

Computational Fluid Dynamics Modeling

UT procured the services of Reaction Engineering International (REI) to conduct computational fluid dynamics (CFD) modeling of the PCTB.

In period ending December 31, 2018, Geotek completed 3-dimensional CAD model of the PCTB to be used as input for computational fluid dynamics (CFD) modeling, and coordinated with UT and Pettigrew Engineering to produce a matrix of proposed input variables for the CFD model.

In period ending March 31, 2019, REI completed the first phase of the CFD modeling task. REI developed a CFD model of the to simulate flow of sea water through PCTB, and conducted baseline simulations to assess flow and pressure fields in PCTB at lower and middle range of typical PCTB coring parameters

The CFD analysis (**Appendix E**) verified that the PCTB flow diverter is performing as designed (eliminates high pressure differentials from forming across core liner and inner tube walls, eliminating collapse of core liner). It also provided magnitudes for various pressure drops throughout the tool during coring operations. These results were used to more accurately define the overall pressure drop throughout the PCTB, leading to more accurate predictions of pump pressures while coring.

<u>PCTB Bench Test Program</u>

Seven PCTB failure modes were identified to have occurred in the 2017 UT-GOM2-1 Marine Field Test. Of these, three were resolved during UT-GOM2-1. The four failure modes that were unresolved after the expedition were:

1. Repeated high-tension efforts to unlatch the PCTB from the BHA.
2. With above in-situ boost setting, possible on-time seal of autoclave but no recorded boost.
3. With above in-situ boost setting, very late seal of autoclave with no recorded boost.
4. With below in-situ boost setting, seal of autoclave after sea floor dwell with probable boost recorded.

Geotek performed bench-tests of the PCTB in an effort to understand and correct these failure modes (**Appendix F, Appendix G**).

In period ending March 31, 2019, Geotek completed development of a vertical testing capability at the Geotek Coring Inc. facility in Salt Lake City, Utah. This capability allows the PCTB to be fully assembled in the optimal configuration, suspended vertically in the test hole, and undergo tests that include latching, drilling simulation, and retrieval in field-like conditions.

In April-May, 2019, Geotek performed the following tests:

- Latch Tests
    - In the UT-GOM2-1 Marine Test, we occasionally encountered significant difficulty unlatching from the BHA. The latch components were tested individually, with the PCTB assembled in a vertical configuration, in attempt to troubleshoot individual components. Twenty-three latch tests were performed in various configurations. No difficulties unlatching were encountered in these tests, however later in the testing program, it was found that a proposed overtravel spring modification resulted in dramatically higher pull weights, some beyond the capability of a typical wireline.
- Pressure Function Tests (PFT)
    - Pressure Function Tests are designed to test proper function of the individual components of the autoclave assembly. In this test the autoclave is suspended vertically in open air, pressurized, and actuated at 1000/4000 psi. Sixteen PFTs were performed.
    - All pressure function tests with diverter seals installed were either aborted due to hydraulic lock, or were successful with manipulation of the actuation pressure. Geotek has stated that the hydraulic lock observed was due to unique parts required by the test fixturing sealing with the diverter and are not indicative of a new hydraulic lock issue. After removing the diverter seals all pressure function tests were successful without having to manipulate the lubricator pressure. A new Point Contact Sleeve Valve Seal did not suffer the damage as seen on the previously used

lip seal. The Single-Trigger-Mechanism was tested in PFTs 1-10 and functioned well with no malfunctions or loss of boost.

- Pressure Actuation Tests (PAT)
  - Pressure Actuation Tests are designed to replicate tool performance at pressure conditions similar to those encountered in deep ocean drilling. The entire PCTB assembly is deployed with a mock BHA in a test pressure chamber capable of 5000 psi. The PCTB is then pressurized, actuated, and retrieved. Ten PATs were performed.
  - The PATs revealed an issue with the overtravel spring compressing and allowing the PCTB to unlatch from the BHA prior to full stroke of the PCTB when a slow wireline pull is applied, and the new shear pin is installed. The addition of the shear pin in the IT plug, allowing for a dwell in the stroking process for the ball to have more time to close, has introduced issues associated with the overtravel spring.

The PCTB Development Team (including members of UT, DOE, USGS, and Pettigrew Engineering) held a web-conference on July 18, 2019 to review the results of the PCTB bench tests. The PCTB Development Team reviewed PCTB performance issues observed during 2017 UT-GOM2-1 Marine Test, reviewed the methodologies and results of the bench tests performed by Geotek in 2019, reviewed Geotek's recommendations for PCTB modifications, and agreed upon which proposed PCTB modifications to authorize.

In addition to identifying which modifications to incorporate into the PCTB design, a key outcome of the PCTB bench tests results was identifying the need for additional bench testing to be completed prior to the PCTB Land Test. The PCTB Development Team determined that it would be critical to bench test the final PCTB configuration that will be land-tested and eventually deployed at sea during the UT-GOM2-2 Scientific Drilling Program. Therefore, once approved modifications to the PCTB have been made, supplemental bench testing will be required to:

1. Confirm the final shear pin design,
2. Confirm the flow diverter seals work as intended, and
3. Determine the effect of seawater and drilling mud on the performance of the upgraded PCTB.

The additional bench tests will be conducted in the next project phase (BP4) after modifications have been made to the PCTB, based on the results of the bench tests conducted in April-May, 2019.

3.8.2 Subtask 14.2: PCTB Modifications/Upgrades

Objectives

The Recipient will recommend modifications and/or upgrades of pressure coring and core analysis tools to assure the readiness of the system for use in the UT-GOM2-2 Scientific Drilling Program during Phase 5, Task 16, based on the outcomes of the PCTB Lab Test (Subtask 14.1) and in coordination with DOE and the Project Advisory Team. The recommended modifications will be implemented based on the outcomes of the laboratory-based testing and by mutual agreement of the Recipient, DOE and the Project Advisory Team.

Accomplishments

Potential modifications that were tested in the PCTB bench test include the following:

1. A prototype Single-Trigger-Mechanism design was tested that combines the seal on the top of the PCTB and the firing of the boost into a single action. The intent of this design is to increase the reliability and performance of the PCTB by eliminating unnecessary complexity. The Single-Trigger Mechanism behaved as anticipated throughout the testing program.
2. A shear pin was designed to allow a pause in activation after the ball valve is released from the activation spring. The intent of this design is to provide additional time for the ball valve to close before continuing the actuation sequence.
3. Lip seals were replaced with point seals during the testing.

Geotek proposed six permanent modifications be incorporated into the PCTB, based on the results of the bench tests performed in April-May, 2019. UT, with consultation from the PCTB Development Team approved five of the proposed modifications (Table *3*-15). The approved modifications will be fully incorporated in the PCTB design early in the next project period (BP4).

Table 3-*15: Proposed/approved modifications to the PCTB as a result of the 2019 PCTB Bench Test program*

No.	Proposed Modification	Decision
1	All sliding parts should be coated with a friction reducing coating.	**Accept** - All sliding parts should be coated.
2	Single Trigger Mechanism is vetted and should be kept.	**Accept** - The single trigger mechanism should be permanently incorporated in the PCTB.
3	Point seals should replace lip seals in the sleeve valve.	**Accept** - Point seals should replace lip seals
4	Modify the QLS, bearing housing, and lift sub to run the prototype diverter seal. Also modify the Regulator Sub so the seal cannot inadvertently seal and cause hydraulic lock	**Accept** - The issues with the diverter seal need to be corrected
5	Shear pin works as designed and allows a dwell after ball valve closure. It also may help unlatch and release the tool from the BHA by causing a slide hammer like action.	**Partially Reject** - We recognize the need of the shear pin to keep the IT plug from moving while sealing the autoclave but have concerns about the shear value necessary to see/create the dwell for ball closure. Request a lower yield shear pin design so that redesign of the overtravel spring is not required.
6	Overtravel Spring needs to be redesigned to prevent the PCTB from unlatching from the BHA before the tool is fully stroked, sealed, and pressure section fired. It additionally needs to unlatch from the BHA easily.	**Reject** - We are concerned about ramifications of redesigning overtravel spring. We do not think we need a shear value higher than 500-600lbs, thus we do not think we need to redesign the overtravel spring.

3.9 Task 15.0: UT-GOM2-2 Scientific Drilling Program Preparations

3.9.1 Subtask 15.1: Assemble and Contract Pressure Coring Team Leads for UT-GOM2-2 Scientific Drilling Program

Objectives

The Recipient, in consultation with the project Advisory Team, will identify, evaluate, and establish relationships / subcontracts with vendors, service companies, institutions or individuals as necessary to ensure the pressure coring and pressure core analysis portions of the planned GOM2-2 Scientific Drilling Program can be successfully accomplished. These contracts will result in the identification of specific groups / individuals to serve as coring team area leads.

Accomplishments

UT worked with Geotek to develop a detailed scope of work and execute a service agreement for continued services in accordance with the GOM2 Statement of Project Objectives. The contracted scope of work includes UT-GOM2-2 offshore pressure coring deployment, preliminary pressure core analysis using PCATS, handling and transportation of pressure cores, and contingency services including conventional coring.

3.9.2 Subtask 15.2: Contract Project Scientists and Establish Project Science Team for UT-GOM2-2 Scientific Drilling Program

Objectives

The Recipient, in coordination with the Project Advisory Team, will identify and select (through mutual agreement with DOE) Technical and Science Leads for the planned GOM2-2 Scientific Drilling Program, comprised of 5-7 individuals from academia, industry and/or government. The Technical and Science Leads will be chosen based on their expertise, experience, and availability to the project. The Recipient will identify, at a minimum, Technical and Science Leads for each of the following areas: Site Characterization, Drilling, Logging, Lithostratigraphy, Geochemistry / Microbiology, Physical Properties and Petrophysics, and Pressure Coring and Analysis.

In addition to the Technical and Science Leads, other areas of expertise necessary for a balanced shipboard science party may be contracted to make up the Science Team. These positions and individuals will be mutually agreed upon by the Recipient and DOE.

The combination of the Technical and Science Leads, key project personnel at the Prime Recipient, sub-award organizations, the project Advisory Team and other non-lead scientific personnel participating in the GOM2-2 Scientific Drilling Program, will be considered to makeup the project Science Team. The Recipient will document the full project Science Team as a part of normal project progress reporting

Accomplishments

UT negotiated a revised scope of work and budget for the Ohio State sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Ohio State act as the Site Characterization Technical and Science Lead for UT-GOM2-2 and will perform conventional core and gas geochemical analysis.

UT negotiated a revised scope of work and budget for the University of New Hampshire (UNH) sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. UNH will lead the lithostratigraphy effort for UT-GOM2-2.

UT negotiated a revised scope of work and budget for the Columbia University LDEO sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Lamont-Doherty will contribute to ensuring that the sampling and analytical plan is appropriate to fully address the expedition objectives, particularly in regard to the physical properties and geochemical observations needed to assess the relative contribution of in situ and migrating methane, long-range aqueous methane migration, and the temporal evolution of hydrate accumulations.

UT negotiated a revised scope of work and budget for the Oregon State sub-award based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. Oregon State University will lead the microbiology effort for UT-GOM2-2.

UT negotiated a revised scope of work and budget for the University of Washington (UW) sub-awards based on the revised UT-GOM2-2 Scientific Drilling Program, scope of work, and project timeline. UW will lead the geochemistry effort for UT-GOM2-2.

4 PRODUCTS DEVELOPED

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

4.1 UT-GOM2-1 Scientific Report

UT worked with the Science Party and UTIG staff to create, finalize, publish the UT-GOM2-1 expedition scientific volume. The volume contains preliminary pages, expedition summary, methods, and well reports, a digital database of the initial technical findings, and all supporting materials. The volume was modeled after similar IODP volumes. Table 4-1 presents the volume structure with links.

Table 4-1: UT-GOM2-1 Scientific Volume

Expedition Volume Cover / Home	https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/
Expedition Scientists	https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/expedition-scientists/
Preliminary Pages Volume Authorship, Publisher's Notes, Chapter links, Data Report links, Expedition Bibliography	https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/reports/
UT-GOM2-1 Hydrate Pressure Coring Expedition Chapter 1. Expedition Summary 1.1 Background and Objectives 1.2 Pre-Drill Operational Plan 1.3 Operational Overview 1.4 Scientific Results 1.5 Reporting 138 pages, 26 figures, 10 tables, 3 appendices	https://ig.utexas.edu/files/2018/02/1.0-UT-GOM2-1-Expedition-Summary.pdf
UT-GOM2-1 Hydrate Pressure Coring Expedition Chapter 2. Expedition Methods 2.1 Introduction 2.2 Rig Instrumentations 2.3 Pressure Coring 2.4 Physical Properties and Core Transfer 2.5 Quantitative Degassing 2.6 Lithostratigraphy	http://www-udc.ig.utexas.edu/gom2/Chapter%202%20-%20Methods.pdf

2.7 Geochemistry and Microbiology 2.8 Wireline Logging 41 pages, 12 figures, 6 tables	
UT-GOM2-1 Hydrate Pressure Coring Expedition Chapter 3. Hole GC 955 H002 3.1 Background and Objectives 3.2 Operations 3.3 Pressure Coring 3.4 Physical Properties and Core Transfer 3.5 Quantitative Degassing 3.6 Lithostratigraphy 3.7 Geochemistry and Microbiology 3.8 Wireline Logging 85 pages, 55 figures, 24 tables	http://www-udc.ig.utexas.edu/gom2/Chapter%203%20-%20H002.pdf
UT-GOM2-1 Hydrate Pressure Coring Expedition Chapter 4. Hole GC 955 H005 4.1 Background and Objectives 4.2 Operations 4.3 Pressure Coring 4.4 Physical Properties and Core Transfer 4.5 Quantitative Degassing 4.6 Lithostratigraphy 4.7 Geochemistry and Microbiology 4.8 Wireline Logging 164 pages,128 figures, 30 tables	http://www-udc.ig.utexas.edu/gom2/Chapter%204%20-%20H005.pdf
Data Directory	http://www-udc.ig.utexas.edu/gom2/

4.2 AAPG Special Volume on GC 955, Gulf of Mexico

During Phase 3, UT, Ohio State and NETL began work on the first of possibly three AAPG Special Volumes dedicated to the UT-GOM2-1 findings at GC 955, Gulf of Mexico. The Editors for the Special Volume are Ray Boswell (NETL), Ann Cook (Ohio State), Tim Collet (USGS), and Peter Flemings (UT). Seven papers were submitted for Volume 1 (Table 4-2) from GOM2 participants during Phase 3. These papers will be formally published in 2020 and most are available ahead of print.

Table 4-2: AAPG Special Volume on GC 955, Gulf of Mexico, papers and DOI links

No.	Primary Author	Working Title	Status as of April 15, 2020
1	Flemings	Pressure coring a Gulf of Mexico Deepwater Turbidite Gas Hydrate Reservoir: Initial results from the UT-GOM2-1 hydrate pressure coring expedition	Accepted/Online DOI:10.1306/02262019036
2	Thomas	Pressure-coring operations during the University of Texas Hydrate Pressure Coring Expedition, UT-GOM2-1, in Green Canyon Block 955, northern Gulf of Mexico	Accepted/Online DOI:10.1306/10151818125
3	Portnov	Salt-driven evolution of a gas hydrate reservoir in Green Canyon, Gulf of Mexico	Accepted/Online DOI:10.1306/04251918177
4	Santra	Evolution of Gas Hydrate-bearing Deepwater Channel-Levee System in Abyssal Gulf of Mexico – Levee Growth and Deformation	Accepted/Online DOI: 10.1306/01062018280
5	Phillips	High concentration methane hydrate in a silt reservoir from the deep-water Gulf of Mexico	Accepted
6	Meazell	Silt-rich channel-levee hydrate reservoirs 1of Green Canyon 955	Accepted/Online DOI:10.1306/01062019165
7	Fang	Petrophysical properties of the Green Canyon block 955 hydrate reservoir inferred from reconstituted sediments: Implications for hydrate formation and production	Accepted/With Layout Editor

4.3 Publications

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., 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. 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

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

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. https://ir.library.oregonstate.edu/catalog?utf8=%E2%9C%93&search_field=all_fields&q=Erica+ewton

Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, 2018, UT-GOM2-1 Hydrate Pressure Coring Expedition Summary. In Flemings, P.B., Phillips, S.C, Collett, T., Cook, A., Boswell, R., and the UT-GOM2-1 Expedition Scientists, UT-GOM2-1 Hydrate Pressure Coring Expedition Report. University of Texas at Austin Institute for Geophysics, Austin, TX. https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/reports/

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

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

Meyer, Dylan Whitney, (2018). Dynamics of Gas Flow and Hydrate Formation within the Hydrate Stability Zone, Department of Geological Sciences, doctoral dissertation, The University of Texas at Austin, Austin, TX. http://doi.org/10.15781/T2M03ZG8H

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

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., 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

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. The 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

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

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

4.4 Conference Presentations / Abstracts

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., 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., 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., 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., 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

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., 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., 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., 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.

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.

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., 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.

4.5 Websites or other Internet Sites

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

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

UT-GOM2-1 Website:
https://ig.utexas.edu/energy/genesis-of-methane-hydrate-in-coarse-grained-systems/expedition-ut-gom2-1/

4.6 Other Products

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

UTIG Methane Hydrates:
https://www.youtube.com/watch?v=DXseEbKp5Ak

5 ACRONYMS AND ABBREVIATIONS

A list of acronyms and abbreviations used in this document is presented in Table 5-1.

Table 5-1: List of Acronyms and Abbreviations

ACRONYM	ABBREVIATION
AAPG	The American Association of Petroleum Geologists
ABC	After-Bubbling Chamber
AGU	American Geophysics Union
AIST	National Institute of Advanced Industrial Science and Technology
ANOVA	Analysis of Variance
ASTM	American Society for Testing and Materials
BET	Brunauer-Emmett-Teller
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
CEREGE	*Centre de Recherche et d'Enseignement de Géosciences de l'Environnement*
CFD	Computation Fluid Dynamics
CFR	Code of Federal Regulation
CHNS	Carbon, Hydrogen, Nitrogen, & Sulfur
CL	Lean Clay
CNPL	Calcareous Nannofossil Plio-Pleistocene
CPP	Complimentary Project Proposal
CRS	Constant Rate of Strain
CT	Computed Tomography
CTTF	Cameron Test and Training Facility
DNA	Deoxyribonucleic Acid
DOE	U.S. Department of Energy
DW	Drill Water
ECORD	European Consortium for Ocean Research Drilling
EFB	ECORD Facility Board
EPSP	Environmental Protection and Safety Panel
ESO	European Science Operator
ESSAC	ECORD Science Support and Advisory Committee
fbsf	feet below sea floor
FID	Flame Ionization Detection
GC	Green Canyon
GHSZ	Has Hydrate Stability Zone
HPTC	High Pressure Temperature Corer
IMO	International Maritime Organization
IODP	International Ocean Discovery Program
JOGMEC	Japanese Oil, Gas and Metals National Corporation
JRFB	*JOIDES Resolution* Facility Board
JRSO	*JOIDES Resolution* Science Operator
LDEO	Lamont-Doherty Earth Observatory

LPA	Linear ply acrylamide
LWD	Logging-While-Drilling
mbsf	meters below sea floor
MDT	Modular Dynamics Testing
MICP	Mercury Injection Capillary Pressure
MODU	Mobile Offshore Drilling Unit
MSP	Mission-Specific Platform
NETL	National Energy Technology Laboratory
OCS	Outer Continental Shelf
PAT	Pressure Actuation Test
PBC	Pre-Bubbling Chamber
PCATS	Pressure Core Analysis and Transfer System
PCCT	Pressure Core Characterization Tool
PCS	Pressure Coring System
PCTB	Pressure Coring Tool with Ball
PF	Pore Fluid
PFT	Pressure Function Test
PMP	Project Management Plan
PMRS	Pressure Maintenance and Relief System
PNATS	Pressure-Core Nondestructive Analysis Tool
QRPPR	Quarterly Research Performance Progress Report
REI	Reaction Engineering, International
RNA	Ribonucleic Acid
SEM	Scanning Electron Microscope
SEP	Science Evaluation Panel
SOPO	Statement of Project Objectives
SSDB	Site Survey Data Bank
STC	Schlumberger Technology Corp
TAMU - CC	Texas A&M University, Corpus Christi
TC	Total Carbon
TCD	Thermal Conductivity
TN	Total Nitrogen
TOC	Total Organic Carbon
TS	Total Sulphur
UNH	University of New Hampshire
USCG	U.S. Coast Guard
USCS	Unified Soil Classification System
USGS	U.S. Geologic Survey
UT	The University of Texas at Austin
UTIG	UT Institute for Geophysics
UW	University of Washington
XCT	X-ray Computed Tomography
XRD	X-ray Diffraction

6 BIBLIOGRAPHY

ASTM International, 2017, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System): ASTM International. https://doi.org/https://doi.org/10.1520/D2487-17E01

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. https://doi.org/10.1016/j.marpetgeo.2011.10.003

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. https://doi.org/10.1016/j.marpetgeo.2011.08.010

Casey, B., Germaine, J. T., Flemings, P. B., Reece, J. S., Gao, B., and Betts, W., 2013, Liquid limit as a predictor of mudrock permeability: Marine and Petroleum Geology, v. 44, no. 0, p. 256-263. https://doi.org/10.1016/j.marpetgeo.2013.04.008

Casey, B., Reece, J. S., and Germaine, J. T., 2019, One-dimensional normal compression laws for resedimented mudrocks: Marine and Petroleum Geology, v. 103, no. May 2019, p. 397-403. https://doi.org/10.1016/j.marpetgeo.2019.02.023

Dai, S., Kim, J., Xu, Y., Waite, W. F., Jang, J., Yoneda, J., Collett, T. S., and Kumar, P., 2018, Permeability anisotropy and relative permeability in sediments from the National Gas Hydrate Program Expedition 02, offshore India: Marine and Petroleum Geology, v. 108, p. 705-713. https://doi.org/https://doi.org/10.1016/j.marpetgeo.2018.08.016

Fang, Y., Flemings, P. B., Daigle, H., Phillips, S. C., Meazell, K., and You, K., 2020, Petrophysical Properties of the GC 955 Hydrate Reservoir Inferred from Reconstituted Sediments: Implications for Hydrate Formation and Production: AAPG Bulletin.

Fang, Y., Flemings, P. B., Daigle, H., Phillips, S. C., Meazell, P. K., and You, K., in press, Petrophysical properties of the Green Canyon block 955 hydrate reservoir inferred from reconstituted sediments: Implications for hydrate formation and production: AAPG Bulletin. https://doi.org/10.1306/01062019165

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., In press, Pressure coring a Gulf of Mexico Deepwater Turbidite Gas Hydrate Reservoir: Initial results from the UT-GOM2-1 hydrate pressure coring expedition: American Association of Petroleum Geologist Bulletin.

Johnson, J. E., and Divins, D. L., in press, 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 Scientists, U.-G.-E., eds., UT-GOM2-1 Hydrate Pressure Coring Expedition Report: Austin, TX, University of Texas Institute for Geophysics, p. 30.

Johnson, J. E., MacLeod, D. R., and Divins, D. L., in press, 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 Scientists, U.-G.-E., eds., UT-GOM2-1 Hydrate Pressure Coring Expedition Report: Austin, TX, University of Texas Institute for Geophysics, p. 86.

Konno, Y., Yoneda, J., Egawa, K., Ito, T., Jin, Y., Kida, M., Suzuki, K., Fujii, T., and Nagao, J., 2015, Permeability of sediment cores from methane hydrate deposit in the Eastern Nankai Trough: Marine and Petroleum Geology, v. 66, Part 2, p. 487-495. https://doi.org/http://dx.doi.org/10.1016/j.marpetgeo.2015.02.020

Meazell, K., Flemings, P., and Santra, M., in press, Silt-rich channel-levee hydrate reservoirs 1of Green Canyon 955: American Association of Petroleum Geologist Bulletin.

Ogg, J. G., Ogg, G. M., and Gradstein, F. M., 2016, A Concise Geologic Time Scale, Elsevier, 240 p.

Phillips, S. C., Flemings, P. B., Holland, M. E., Schulthiss, P. J., Waite, W. F., Jang, J., Petrou, E. G., and H., H., in press, High concentration methane hydrate in a silt reservoir from the deep-water Gulf of Mexico: American Association of Petroleum Geologist Bulletin. https://doi.org/10.1306/01062018280

Purkey, M., in press, Data Report: UT-GOM2-1 Biostratigraphy, *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.

Reece, J. S., Flemings, P. B., Dugan, B., Long, H., and Germaine, J. T., 2012, Permeability-porosity relationships of shallow mudstones in the Ursa Basin, northern deepwater Gulf of Mexico: Journal of Geophysical Research: Solid Earth, v. 117, no. B12. https://doi.org/10.1029/2012jb009438

Santamarina, J. C., Dai, S., Jang, J., and Terzariol, M., 2012, Pressure Core Characterization Tools for Hydrate-Bearing Sediment: Scientific Drilling, v. 14, p. 44-48. https://doi.org/10.5194 1217/iodp.sd-14-44-2012

Solomon, E. A., in press, Data Report: Pore Water Geochemistry, *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, p. 11.

Waterman, A. S., 2017, Bioevent ages, Gulf of Mexico USA: Paleo-Data, Inc.

Wei, L., Cook, A. E., Sheets, J., and Sawyer, D., in press, Data report: Surface area and pore size measurements of two hydrate-bearing sediment samples from Green Canyon Block 955 (GC955), Gulf of Mexico, *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, p. 7.

Yoneda, J., Masui, A., Konno, Y., Jin, Y., Egawa, K., Kida, M., Ito, T., Nagao, J., and Tenma, N., 2015, Mechanical properties of hydrate-bearing turbidite reservoir in the first gas production test site of the Eastern Nankai Trough: Marine and Petroleum Geology, v. 66, Part 2, p. 471-486. https://doi.org/http://dx.doi.org/10.1016/j.marpetgeo.2015.02.029

-, 2018, Corrigendum to Mechanical properties of hydrate-bearing turbidite reservoir in the first gas production test site of the Eastern Nankai Trough JMPG 66 (Sep 2015); Pages 471-486: Marine and Petroleum Geology, v. 91, p. 659. https://doi.org/10.1016/j.marpetgeo.2018.02.025

Yoneda, J., Masui, A., Konno, Y., Jin, Y., Kida, M., Katagiri, J., Nagao, J., and Tenma, N., 2017, Pressure-core-based reservoir characterization for geomechanics: Insights from gas hydrate drilling during 2012–2013 at the eastern Nankai Trough: Marine and Petroleum Geology, v. 86, p. 1-16. https://doi.org/https://doi.org/10.1016/j.marpetgeo.2017.05.024

Yun, T. S., Lee, C., Lee, J. S., Bahk, J. J., and Santamarina, J. C., 2011, A pressure core based characterization of hydrate-bearing sediments in the Ulleung Basin, Sea of Japan (East Sea): Journal of Geophysical Research: Solid Earth, v. 116, no. B2. https://doi.org/doi:10.1029/2010JB007468

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Appendix A

Ref: IODP Proposal 887-CPP2 and Expedition 386

JOIDES Resolution Facility Board
21 May 2018

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

IODP
INTERNATIONAL OCEAN DISCOVERY PROGRAM

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May 21, 2018

Ref: IODP Proposal 887-CPP2 and Expedition 386

Dear Peter,

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

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

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

IODP
INTERNATIONAL OCEAN
DISCOVERY PROGRAM

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

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

All the best,

Anthony Koppers, Chair of the JOIDES Resolution Facility Board

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

Appendix B

Pore Water Results

University of Washington

Table 1. Distribution of Pore Water Samples

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

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

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

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

Table 1. Distribution of pore water samples

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

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

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

Note:

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

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

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

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

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

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

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

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

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

- indicates not corrected for drill water contamination

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

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

BDL = below detection limit

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

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

- indicates not corrected for drill water contamination

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

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

BDL = below detection limit

Appendix C

UT-GOM2-2 Operations Plan

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

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

December 20, 2019

Record of Revisions

REV.	DATE	AUTHORS	DESCRIPTION
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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.

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1 Executive Summary

This is the operational plan for the UT-GOM2-2 Scientific Drilling Program. This expedition will be accomplished with a deepwater drilling/intervention vessel that is commercially contracted. The expedition is currently planned for between 1/2/2022 to 6/1/2022.

Two wells will be drilled in Walker Ridge Block 313 in the northern Gulf of Mexico. The surface location of each well will be within approximately 100 feet of a well previously drilled with Logging While Drilling (LWD) technology as part of the 2009 JIP II Methane Hydrates LWD program. Water depths at the locations range between 6,460 and 6,580 feet msl. In the first well (H002), multiple pressure-cores will be obtained from three hydrate-bearing targets (Red, Blue, & Orange sands) using the PCTB-FB tool. The depth of the targets ranges from 957 to 2,710 feet below seafloor (fbsf). In addition, intermittent spot pressure-cores will be acquired throughout the borehole. In the second well (G002), both conventional cores (APC, and XCB tools), pressure cores (PCTB-CS and PCTB-FB tools), and temperature and pressure measurements (T2P tool) will be obtained using the PCTB-CS and PCTB-FB BHAs. The primary targets include the top hole to ~250 fbsf and three hydrate-bearing sands (Aqua, Blue, and Kiwi sands). The depths of the target hydrate-bearing sands range from 351 to 3,082 fbsf. In addition, intermittent spot pressure-cores, temperature & pressure measurements, and conventional cores will be acquired. 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 Ltd. 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, with a gas chromatograph, or preserved and shipped for future analysis at UT and other institutions. Pressure cores will be demobilized via supply vessel. PCATS and quantitative degassing will also be used dockside to complete the processing of any remaining pressure core not addressed onboard.

The Geotek Ltd MSCL-IR scanner will be used to scan conventional core as it reaches the rig floor. Core will be cut into 1.5 m sections. Pore water squeezing will be conducted on sections of conventional core onboard to assess ephemeral properties. Pore water samples will also be preserved for additional analysis on shore. Conventional core samples will also be cut and preserved for moisture and density, microbiology, and other physical properties. Dockside, conventional core will be scanned using the Geotek Ltd. MSCL and shipped for 3D CT imaging. After imaging, core will be split, photographed, and scanned. A team of scientist will conduct conventional core analysis and preserve plugs of material for future analysis at various institutions.

The scientific program will require approximately 11 weeks to complete (Table 1-1). The program begins with a one-week period for staging equipment in the port of embarkation. Mobilization, requiring 3.7 days, involves transporting equipment and personnel to the drilling vessel and preparing for field science operations. The onboard drilling and science program will require 32.3 days, followed by demobilization of personnel and equipment, requiring 2.9 days. A dockside core analysis program will then be initiated, requiring an estimated 30 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	Premobilization Staging	Port of Embarkation	7	7
2	Mobilization	Port of Embarkation	3.7	10.7
3	H002 Coring Program	Walker Ridge 313	15.2	25.9
4	G002 Coring Program	Walker Ridge 313	17.1	43
5	Stage 1 Demobilization	Walker Ridge 313	2.9	45.9
6	Dockside Core Processing	Port Fourchon, LA	30	75.9
7	Stage 2 Demobilization	Port Fourchon, LA	3	78.9

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 Gulf of Mexico Continental Margin. The UT-GOM2-2 Scientific Drilling Program fulfills Task 16.0 of the *Deepwater Methane Hydrate Characterization & Scientific Assessment* Statement of Project Objectives.

2 Science Objectives

The prioritized science objectives for the UT-GOM2-2 Scientific Drilling Program are as follows.

2.1 Characterize the primary (Orange sand) and secondary (Blue sand) hydrate reservoirs and their bounding units.

At the first hole, WR313 H002, we will perform pressure coring in the Orange sand and the Blue sand. We will characterize the 1) hydrate concentration, 2) lithology (grain size, mineralogy, sedimentary structures), 3) geochemistry (gas and pore water composition), 4) permeability and 5) mechanical properties (compressibility and strength). Conventional core analysis will be done on depressurized pressure cores.

At the second hole, WR313 G002, we will pressure core the hydrate-bearing Blue sand and its bounding units.

2.2 Contrast hydrate reservoir properties at different structural levels within a dipping sand (“up-dip to down-dip relationship”)

We will compare and contrast hydrate concentration, pore fluid composition, and gas composition at different distances above the BSR both within a single sand (the Blue sand) and within different sands. The Blue sand is the only significant hydrate-bearing sand penetrated in both WR313 H002 and WR313 G002.

2.3 Characterize dissolved methane concentration and gas molecular composition with depth

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. If the dissolved methane concentration is at saturation, we will know that hydrate is likely to be forming. To get the methane concentration, the total amount of gas and its molecular composition (e.g. C1 to C5) must be determined from degassing of pressure cores. This and associated measurements will illuminate whether the methane is of microbial origin. The isotopes of C and H in methane will also illuminate the pathways of methanogenesis. These measurements must be made on pressure cores because in conventional cores, gas comes out of solution, and fractionation occurs when the core is retrieved and undergoes depressurization.

2.4 Measure the in-situ temperature and pressure profile

We will measure pressure and temperature with a penetrometer to a depth of ~1640 feet below seafloor (fbsf) in hole WR313 G002. We will use the 'Temperature 2 Pressure' (T2P) probe, which is only compatible with PCTB-CS BHA, which is depth limited to approximately 1640 fbsf (lithology dependent). These data will allow us to estimate whether the base of the hydrate stability zone is at the three-phase boundary (methane hydrate-seawater-methane vapor) as is commonly assumed. Without the measurements, thermal gradients must be estimated from other thermodynamic models.

2.5 High resolution geochemical and sedimentary profiles: moving towards an exploration model

A sedimentary profile with high resolution pore water sampling and microbiological sampling will be acquired at hole WR313 G002. We will continuously core to 250 fbsf and then spot conventional cores and pressure cores to total depth. We will do the following:

1. Measure organic carbon with depth to constrain the degree of microbial biogenesis
2. Observe abrupt transitions in the first 250 fbsf and general behavior to total depth of the pore water composition to infer fluid flow, hydrate formation/dissociation, diagenesis.
3. Develop an age model from which we can characterize glacial-interglacial variation in sedimentation rates, organic carbon input, and physical properties (top-down drivers of hydrate system evolution)
4. Observe continuous record of lithologic properties in bounding seals and reservoirs.

2.6 Reservoir characterization—other targets of interest

WR313 H002 and WR313 G002 contain many other sands of interest that will be characterized given sufficient time. Coring these sands will provide insight on a variety of questions including: 1) does hydrate formation in thin sands via methane diffusion? What are the hydrate and gas saturations across the bottom-simulating reflector (BSR)? What is the form and concentration of fracture-filling hydrate in clay? What is the fluid and dissolved gas composition in sands below the BSR?

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 3-2). 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, Table 3-1). The WR313 G001, and WR313 H001 wells (Figure 3-1, Table 3-1) 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.

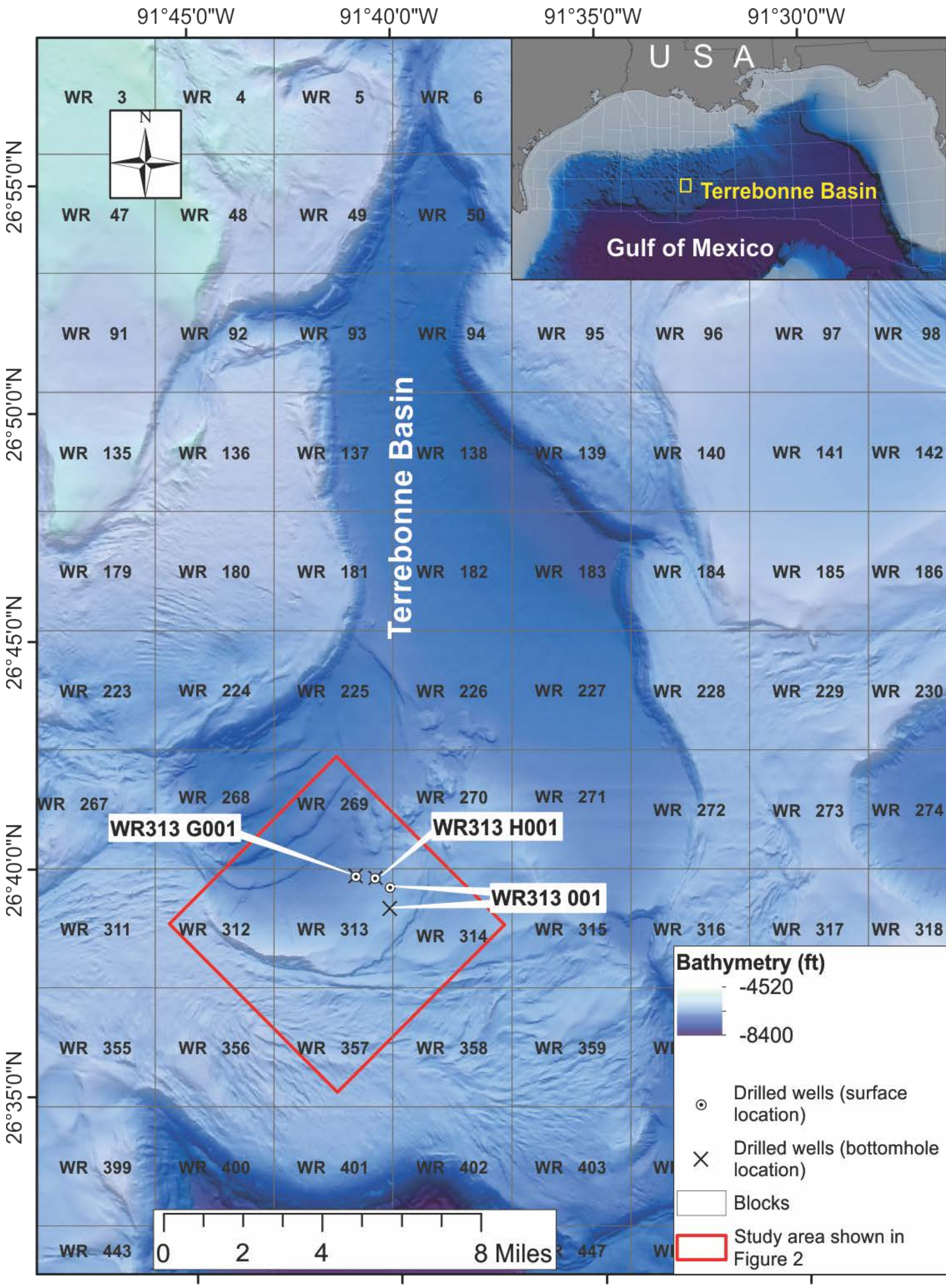

Figure 3-1. Shaded relief map of sea floor in the northwestern part of Walker Ridge Protraction Area showing Terrebonne Basin and existing wells in Walker Ridge Block 313 (WR313). Inset map shows the position of Terrebonne Basin in northern Gulf of Mexico. Bathymetry data are from BOEM Northern Gulf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

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

Well Name	API Well Number	Total MD (ft)	Total TVD (ft)	RKB (ft)	Water Depth (ft)	Surface Latitude (NAD27)	Surface Longitude (NAD27)	Bottom Latitude (NAD27)	Bottom Longitude (NAD27)
WR313 001	608124000700	16720	16072	72	6216	26.65912028	-91.6699055	26.65129418	-91.6700858
WR313 G001	608124003900	10200	10199	52	6562	26.66318997	-91.68387221	26.66330827	-91.68383651
WR313 H001	608124004000	9888	9887	51	6462	26.66245775	-91.67604082	26.66249835	-91.67588172

3.2 Proposed Well Locations

We will drill two locations in Walker Ridge Block 313: WR313 H002 and WR313 G002. WR313 H002 and WR313 G002 will be located within 100 ft of existing wells WR313 H001 and WR313 G001, respectively.

Table 3-2. 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	degree	(ft)	(ft)	(m)	(m)	(ft)	(ft)
WR313 H002	26.66227	-91.67637	2072580	9676970.2	631714.663	2949744.675	6463	3010
WR313 G002	26.66299	-91.684172	2070030	9677205.6	630937.2946	2949816.434	6573	3085

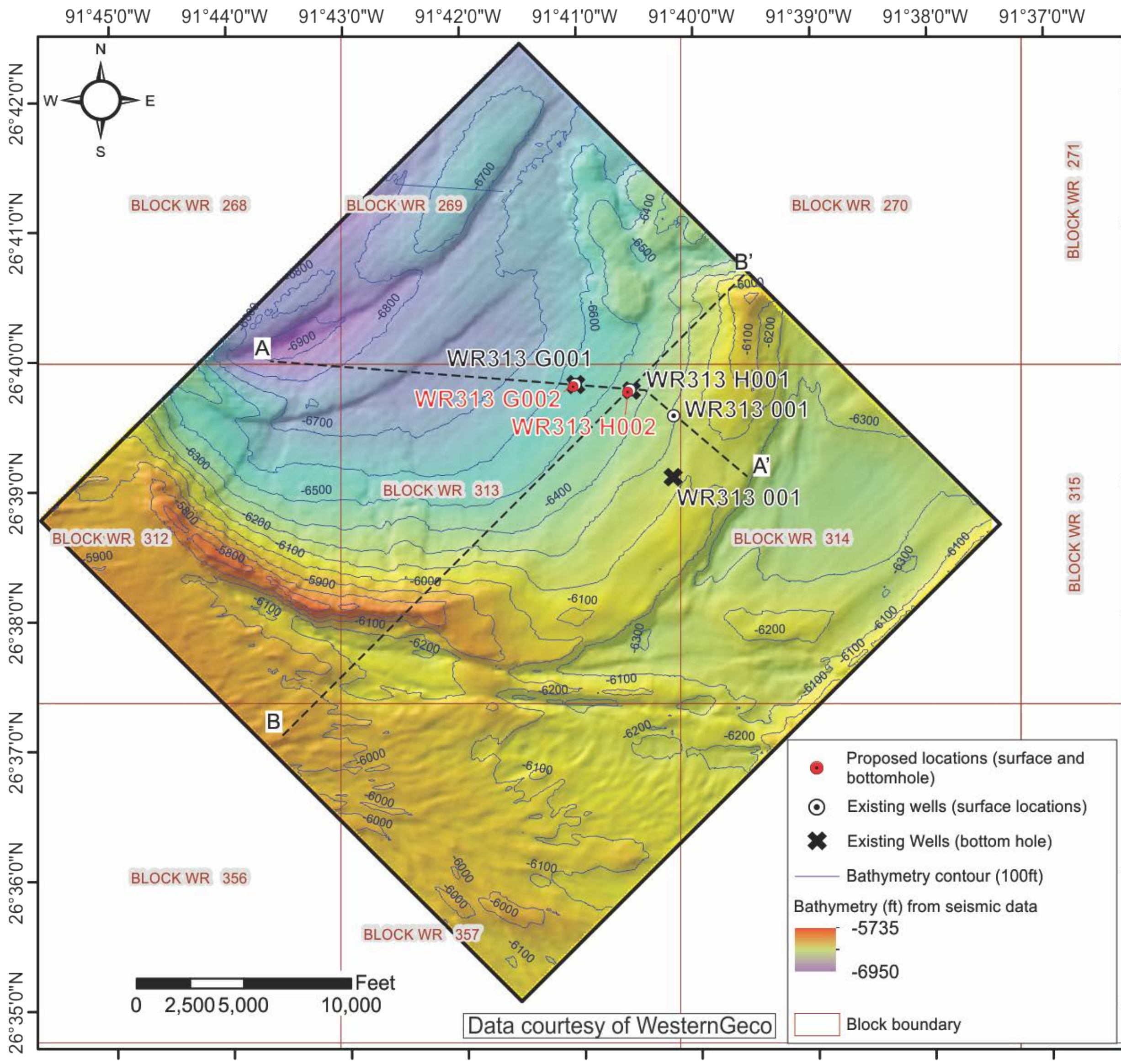

Figure 3-2. Bathymetry map of the area studied in southern Terrebonne Basin. Based on 3D seismic data, showing existing wells and proposed locations in Walker Ridge Block 313 (WR313). 3D seismic data were used with permission of WesternGeco.

3.3 Top Hole Stratigraphy

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

Intervals with low gamma ray values that are coarse-grained were found in both wells 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), we assume coarse-grained sediments are defined by low gamma-ray (API < 65), which distinguish them from higher gamma ray mud-rich sediments (Table 3-3). 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 3-3). Similarly, some thin mud intervals also have corresponding moderate increases in resistivity and velocity which we also interpret as pore-filling (Table 3-3). Water bearing sands have low resistivity (often lower than background), enlarged borehole size and low gamma ray (API < 65) (Table 3-3). 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 3-3. 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	incease 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, fracutres 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 reflections called the Blue Horizon and the Orange Horizon (Boswell et al., 2012a; Boswell et al., 2012b; Frye et al., 2012) (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 3-5).

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).

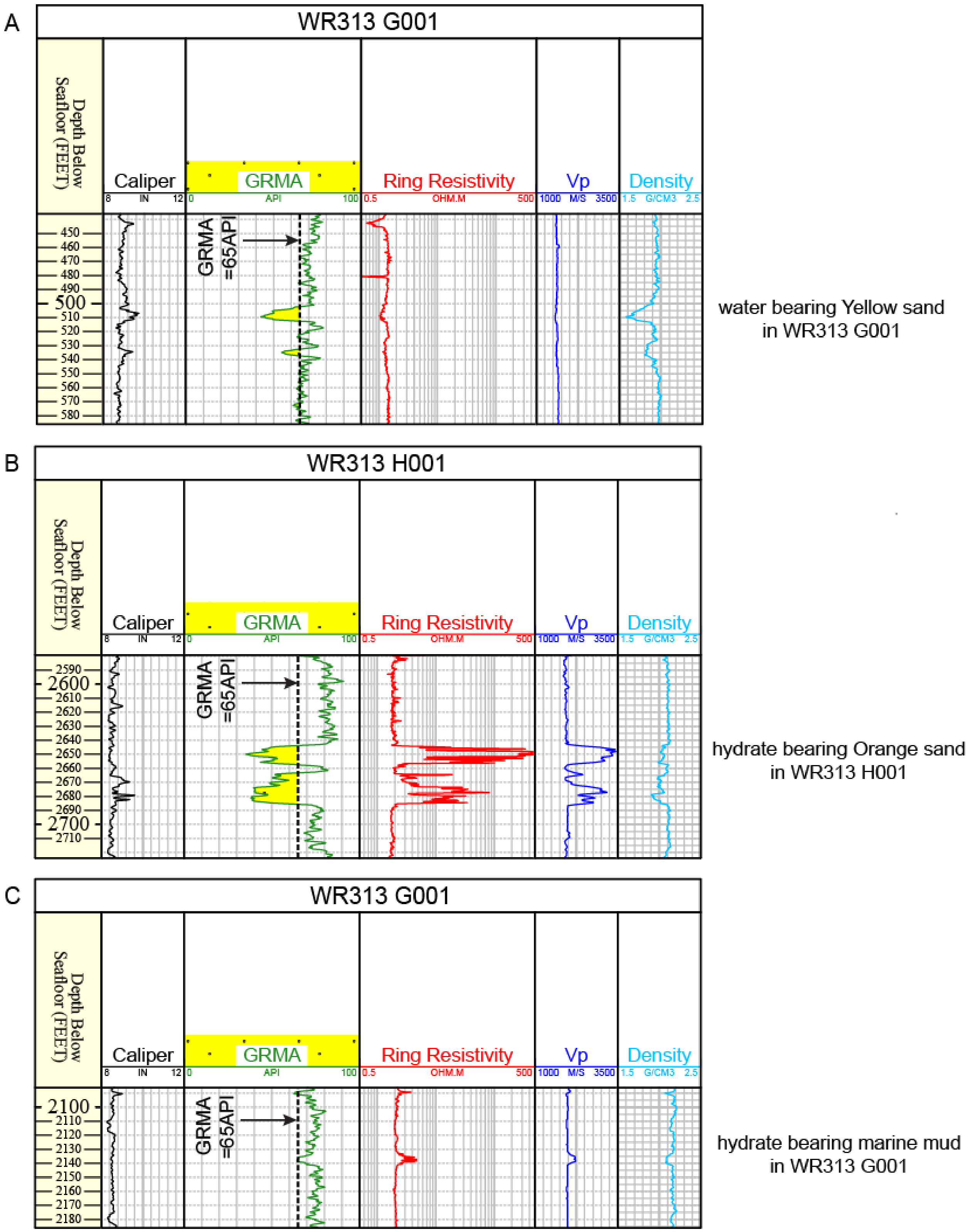

Figure 3-3. Identification of coarse-grained intervals (hydrate bearing or water bearing) and interpreted hydrate bearing marine mud from LWD data. A) Example of interpreted coarse-grained intervals with water showing low gamma ray (GRMA <65) values and low resistivity (lower than background); B) example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

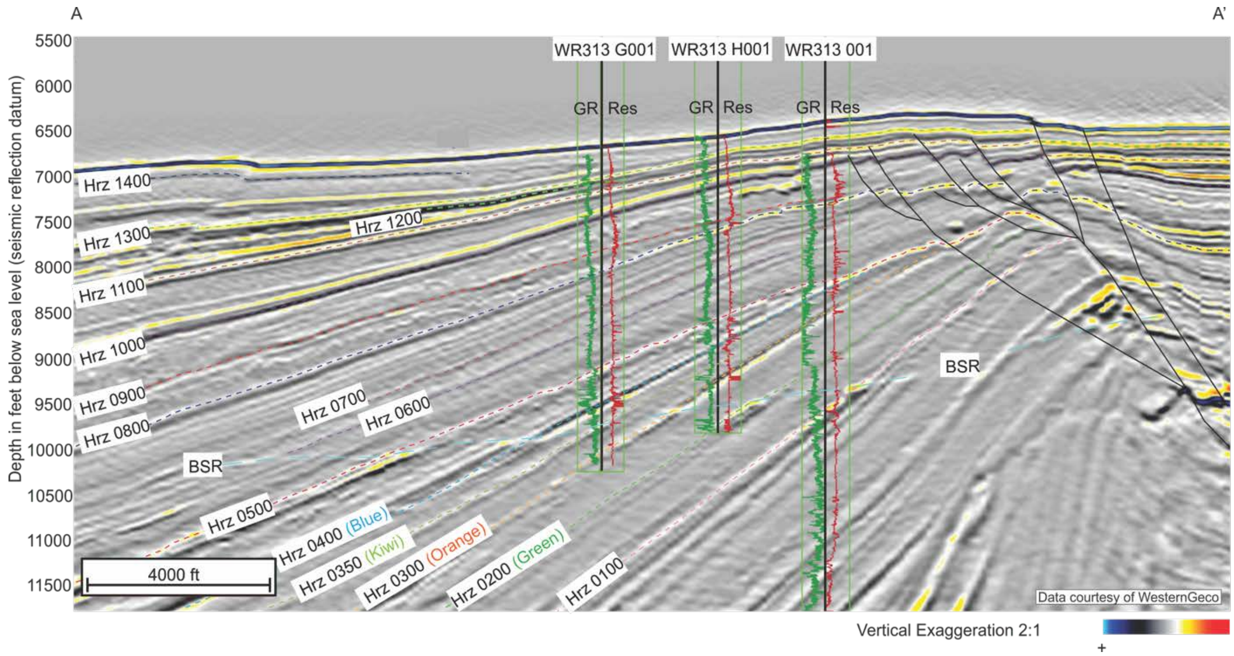

Figure 3-4. Seismic section AA' through existing wells in block WR313 (location in Figure 3-2), showing all interpreted stratigraphic horizons, BSR, and gamma ray (GR) and resistivity (Res) logs at wells. Stratigraphic nomenclature used for some previous studies in the area for relevant reservoir intervals (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.

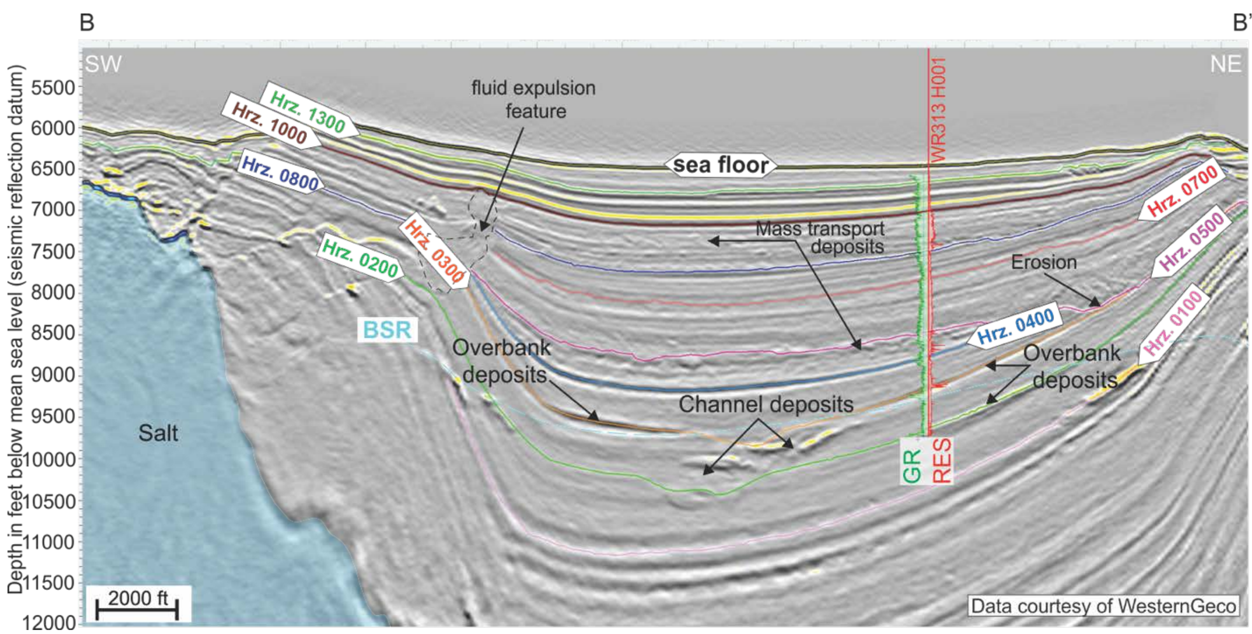

Figure 3-5. SW-NE oriented seismic section BB' (location in Figure 3-2) through well WR313 H001 showing major stratigraphic features in study area. Resistivity (RES) and gamma ray (GR) logs are shown at WR313 H001 well. High resistivity indicates presence of gas hydrate. Seismic data courtesy of WesternGeco.

Five major lithostratigraphic units are identified based on seismic reflection character and log response.

Unit 1 extends from seafloor to the depth of 789 fbsf in WR313 G001 and to 543 fbsf in WR313 H001. In the seismic data Unit 1 is imaged as sub-parallel reflections (Figure 3-5 & Figure 3-6). 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 3-4 & Table 3-5). 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 2718 fbsf at WR313 G001 and 2149 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 3-5 & Figure 3-6), 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 the shallowest reservoir interval (the top at 2718 fbsf at WR313 G001 and 2149 fbsf at WR313 H001). In seismic data, Unit 3 is characterized by continuous parallel reflections of moderate amplitude (Figure 3-5 & Figure 3-6), 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 Horizon 500 down to the shallowest major reservoir interval (top at 2718 fbsf at WR313 G001 and 2149 fbsf at WR313 H001). Horizon 500 is a strong seismic reflector, which has the characteristics of an erosion surface (Figure 3-5 & Figure 3-6), 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 (2189-2256 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 the horizons 0400 (Blue) and 0300 (Orange), and 0200 (Green) respectively, as indicated by low gamma ray 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 3-3).

In both WR313 G001 and WR313 H001, the top of Unit 5 is at the prominent reflector marked as Horizon 0400 (2650ft below sea floor in WR313 G001, 2296ft below sea floor in WR313 H001). The Lower Blue sand (just below Horizon 0400) interval 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 3-7). 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 2611 fbsf in WR313 G001 and WR313 H001 respectively).

In WR313 G001 a thin low gamma-ray interval has can be identified at 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 3-8).

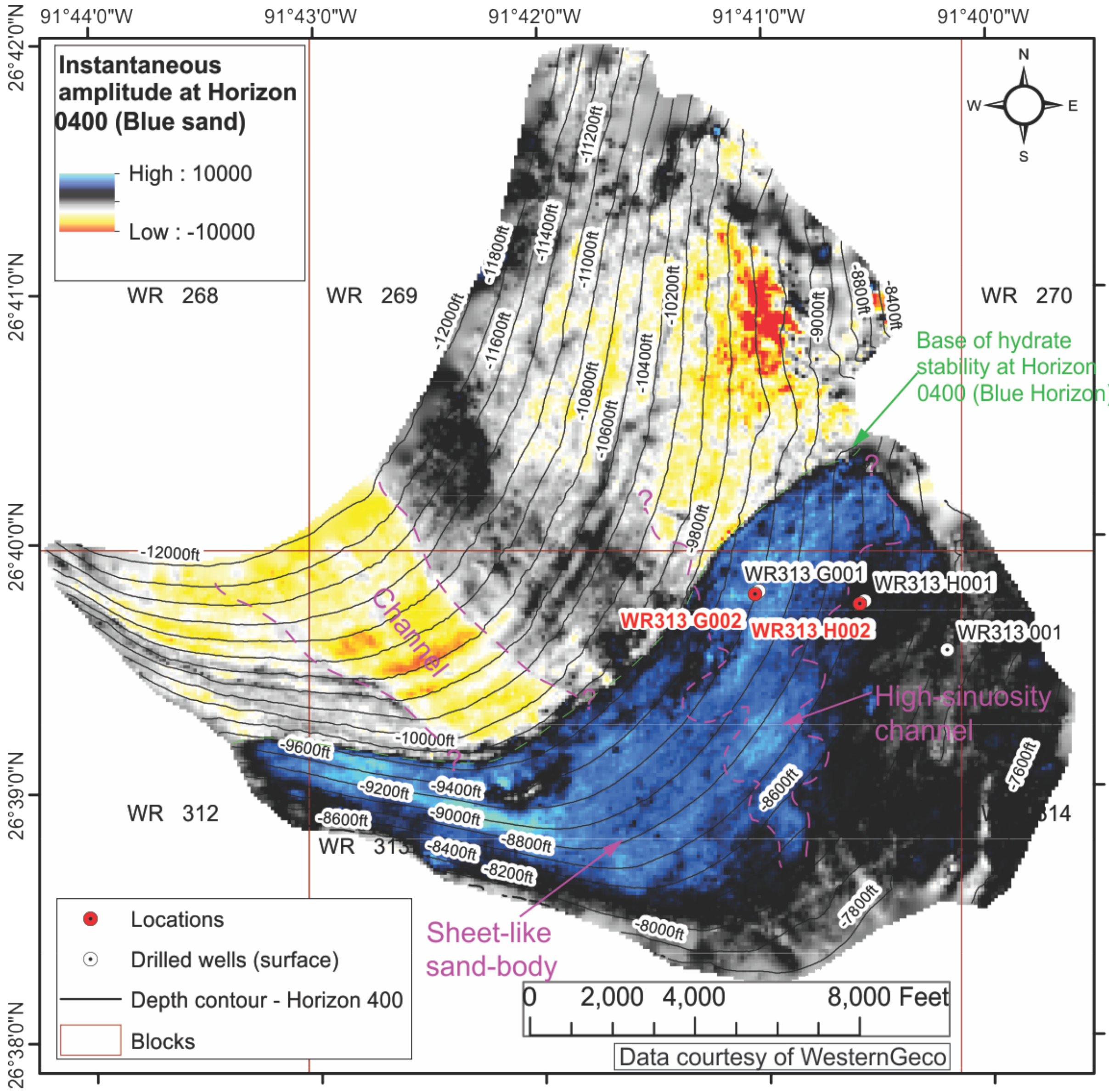

Figure 3-6. Instantaneous amplitude map extracted at Horizon 0400 (Blue Horizon) showing geological interpretation for the Blue sand – the upper of the two hydrate bearing target intervals. Maps generated from 3D seismic data used with permission of WesternGeco.

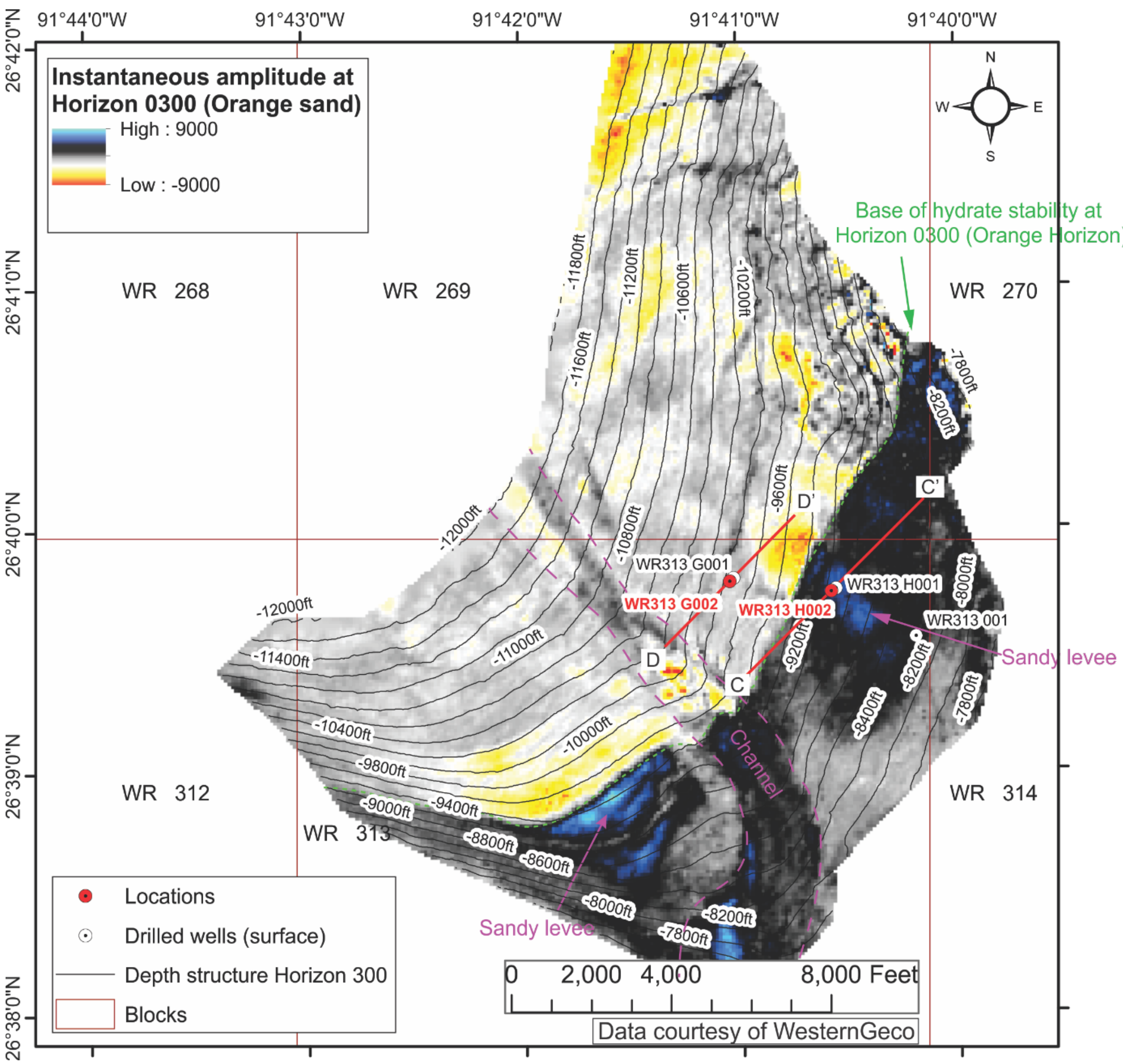

Figure 3-7. Instantaneous amplitude map extracted at Horizon 0300 (Orange Horizon) showing geological interpretation for the Orange sand – the lower of the two hydrate bearing target intervals. The well WR313 H001 and the proposed location WR313 H002 target gas hydrate-bearing sandy levee deposits showing strong positive amplitude response. 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, including tops and bases of coarse-grained and marine mud units, identified in WR313 H001 and WR313 G001 were tied with time domain and depth-domain seismic data to identify corresponding seismic reflections. The boundaries were projected to the proposed locations using the dips of the corresponding reflectors. Proximity of the drilled wells to the proposed locations ensures relatively low uncertainty in depth estimation of the predicted tops (Table 3-4 and Table 3-5).

3.4.2 WR313 H002

WR313 H002 is located ~100 ft to the SW, approximately along strike from the JIP II well WR313 H001 (Table 3-2 and Figure 3-2). WR313 H001 was drilled previously without incident (Collett et al., 2009). A top-hole prognosis for WR313 H002 is shown in Figure 3-8 and Table 3-4. The seafloor at WR313 H002 is projected to be at 6463 feet below sea level (fbsl). We infer we will encounter similar lithology and horizon depths as the JIP II WR313 H001 well.

Unit 1 (0-533 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 (206.1-268.6 fbsf, with a total of 12 ft of sand) and the Yellow sand (344.6-354.1 fbsf, with a total of 9.5 ft of sand) (Table 3-4). 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 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 (533.1-1047.7 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 957.4-965.4 fbsf (Table 3-4) 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 (1047.7 -2000 fbsf) is predominantly mud with one interval containing water-bearing thin coarse-grained layers (1050.9-1109.9 fbsf) and two thin marine muds containing pore-filling hydrate (1720.8-1726.8 fbsf and 1850-1864 fbsf) (Table 3-4).

Unit 4 (2000-2306.4 fbsf) is a muddy mass transport deposit, with two coarser intervals. The upper interval is a thinly-bedded hydrate-bearing coarse-grained interval (2012-2038 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 (2215-2282 fbsf, total thickness of coarse-grained layers is 13 feet).

Unit 5 (beginning at 2306.4) is predominantly mud but contains one hydrate bearing thin pore-filling mud interval (2602.8-2604.8 fbsf) and the Orange sand (2665.6-2709.6, 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 at approximately 2900 fbsf, however, there is no indication of this event on the well logs or seismic at the H002 location. The planned total depth is 3010 fbsf.

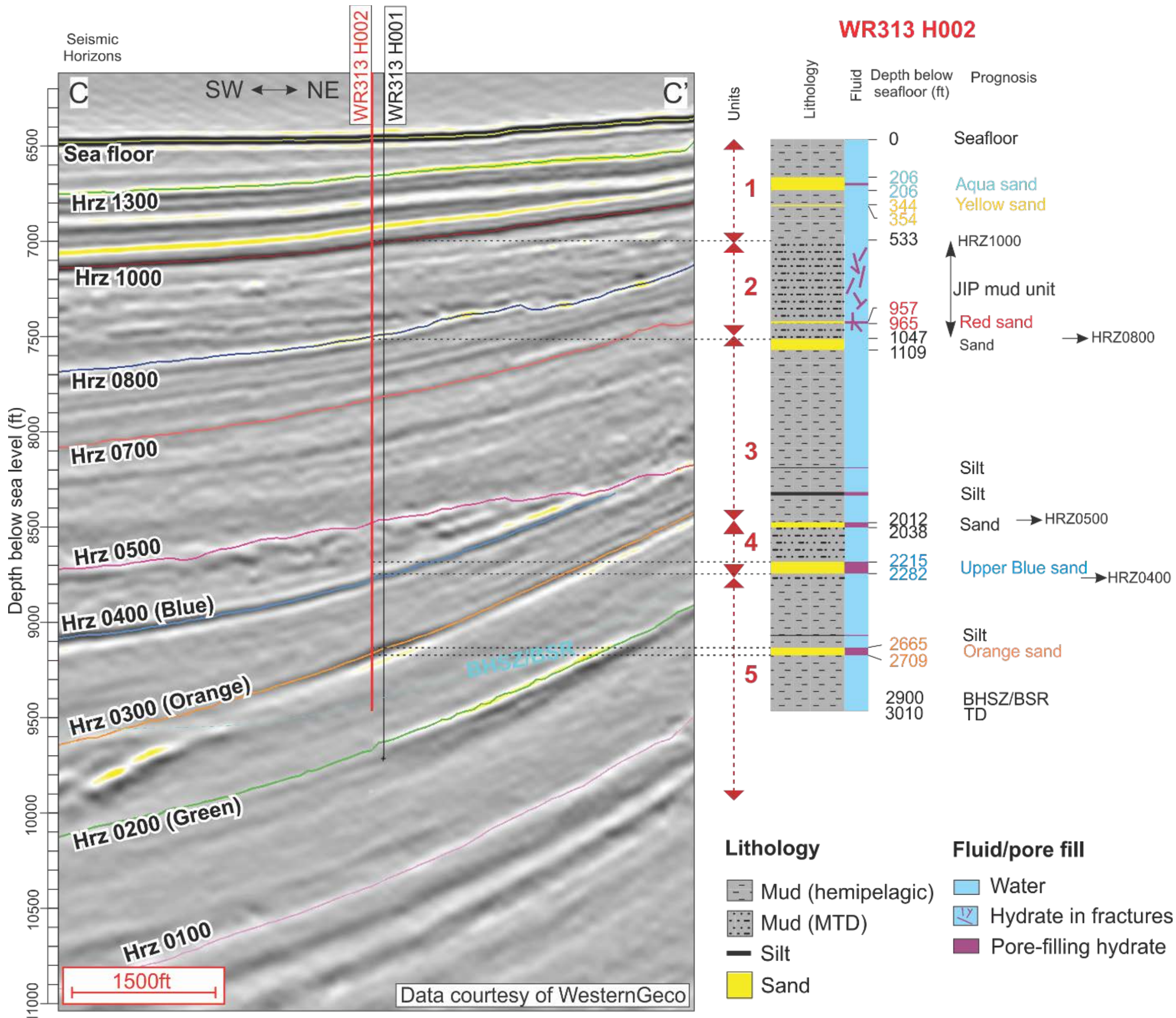

Figure 3-8. Seismic cross section CC' through Location WR313 H002 with interpreted lithology , hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked next to lithology column in red; The line of section is located in Figure 3-7.

Table 3-4. Projected tops for the proposed location WR313 H002 (Table 3.2).

			Water depth (ft)	Total depth (fbsf)	Total depth (fbsl)
WR313 H002			6463	3010	9473
Events, Sands & Units			**WR313 H001**	**WR313 H002**	
			depth (fbsf)	projected depth (fbsf)	projected depth (fbsl)
Seafloor			0.0	0	6463
water bearing **Aqua sand**	Top	**Unit 1**	201.5	206.1	6669.1
	Base		264.0	268.6	6731.6
water bearing **Yellow sand**	Top		334.5	344.6	6807.6
	Base		344.0	354.1	6817.1
Horizon 1000			520.0	533.1	6996.1
JIP mud unit with low concentration hydrate	Top	**Unit 2**	520.0	533.1	6996.1
hydrate bearing **Red sand**	Top		958.0	957.4	7420.4
	Base		966.0	965.4	7428.4
JIP mud unit with low concentration hydrate	Base		1038.0	1047.7	7510.7
Horizon 0800			1038.0	1047.7	7510.7
water bearing coarse-grained interval	Top	**Unit 3**	1096.0	1103.9	7566.9
	Base		1102.0	1109.9	7572.9
hydrate bearing marine mud	Top		1716.0	1720.8	8183.8
	Base		1722.0	1726.8	8189.8
hydrate bearing marine mud	Top		1832.0	1850	8313
	Base		1846.0	1864	8327
Horizon 0500			2000.0	2000	8463
hydrate bearing coarse-grained interval	Top	**Unit 4**	2017.0	2012	8475
	Base		2043.0	2038	8501
hydrate bearing **Upper Blue sand**	Top		2189.0	2215	8678
	Base		2256.0	2282	8745
Horizon 400			2285.0	2306.4	8769.4
hydrate bearing marine mud	Top	**Unit 5**	2578.0	2602.8	9065.8
	Base		2580.0	2604.8	9067.8
hydrate bearing **Orange sand**	Top		2642.0	2665.6	9128.6
	Base		2686.0	2709.6	9172.6
WR313 H002 TD				3010	9473

3.4.3 WR313 G002

The surface location for WR313 G002 is approximately 100 feet southwest (roughly along strike) of the JIP II well WR313 G001 (Table 3-2 and Figure 3-2). A top-hole prognosis for WR313 G002 is shown in

Figure 3-9 and Table 3-5. The seafloor at WR313 G002 is estimated to be 6573 fbsl. We expect to encounter similar lithology and stratigraphy as the JIP II WR313 G001 well.

Unit 1 (0-774.5 fbsf) is composed of mud interlayered with thin coarse-grained sediments. Within the mud interval, there is a unit containing low concentrations of gas hydrate in near-vertical fractures, which is called the Mendenhall unit (Hillman et al., 2017) from ~111.1 to 351.5 fbsf (Figure 3-9 and Table 3-5). Below the Mendenhall, there are two intervals containing thin coarse-grained sediments, identified as the Aqua sand (351.4-434.5 fbsf, with a total of 40 ft of sand) and the Yellow sand (501.3-540.3 fbsf, with a total of 19 ft of sand) (Table 3-5). Both are water-saturated however, the Aqua sand has a 5 ft thick layer where gas hydrate appears in the sand in G001. The Aqua and Yellow sand intervals are associated with seismic reflections that are continuous between wells. In the G001 well, this unit was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore occurred.

Unit 2 (774.5-1317.5 fbsf) is composed of mud with hydrate in near-vertical fractures, and is called the JIP mud unit (Figure 3-9 and Table 3-5). The interval is interpreted as a mass transport deposit and is more compacted or de-watered than the overlying mud. In the G001 well, this unit was drilled with only water and occasional gel sweeps (Collett et al., 2009). No flows into the well bore occurred.

Unit 3 (1317.5 -2426.2 fbsf) is predominantly mud with a number of coarser-grained layers. Near the top of the unit there is a water-bearing coarse-grained layer from 1658.5-1740.5 ft (with a total of 30 ft of coarse-grained sediments in this layer). The Purple sand occurs from 1986.6 to 1996.6 and contains high saturation, pore-filling gas hydrate. Farther down, there is a series of thin mud-rich layers between 2 and 8 ft thick that contain pore-filling gas hydrate (Figure 3-9 and Table 3-5).

Unit 4 (2426.2 – 2816.3 fbsf) hosts another hydrate-bearing, pore-filling mud (2706.4-2710.4 fbsf) and the Upper Blue sand (2722.8-2795.8). The Upper Blue sand is a reservoir targeted for coring, and contains high-saturation gas hydrate in a total of 27 ft of coarse-grained sediment.

Unit 5 (beginning at 2816.3) contains the Lower Blue sand interval, from 2821.2-2881.2 fbsf, and has a total of 30 ft of high saturation gas hydrate in coarse-grained sediments, which is one of our key reservoir intervals for coring. Below the Lower Blue at the BHSZ, there is a thin coarse-grained layer (total of 7 ft of coarse-grained sediments) called the Kiwi Sand (from 3060.7 – 3081.7 fbsf). The Kiwi sand has a mix of gas hydrate at high saturation, water bearing intervals, and a very low gas saturation.

The planned total depth of WR313 G002 is 3085 fbsf.

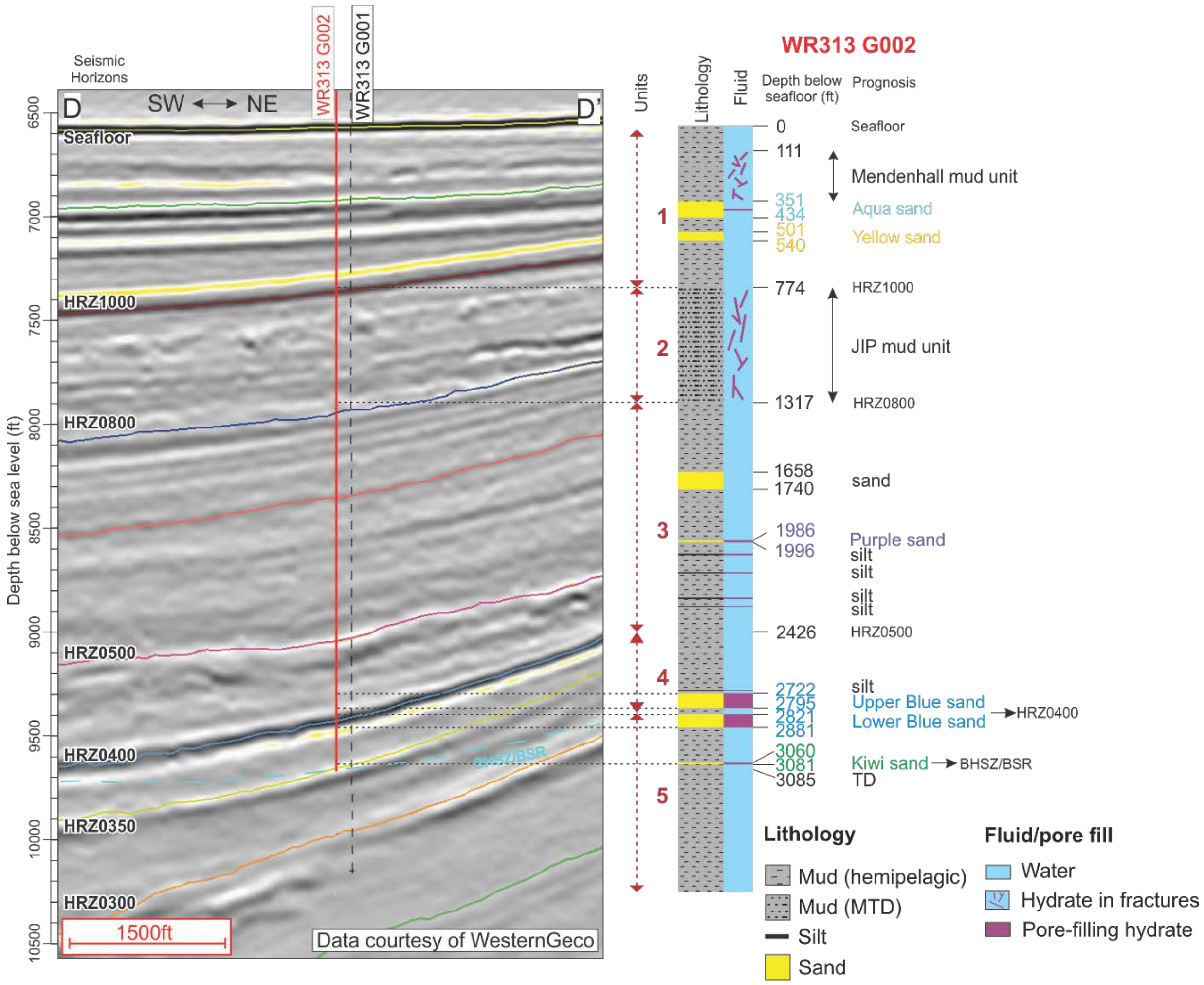

Figure 3-9. Seismic cross section DD' through Location WR313 G002 with interpreted lithology , hydrocarbon presence and major stratigraphic tops. Lithologic units (Units 1, 2, 3, 4, and 5) are marked on lithology column in red; The line of section is located in Figure 3-7.

Table 3-5. Projected tops for the proposed location WR313 G002 (Table 3.2).

			Water depth (ft)	Total depth (fbsf)	Total depth (fbsl)
WR313 G002			6573	3085	9658
Events, coarse-grained interval & Units			**WR313 G001**	**WR313 G002**	
			depth (fbsf)	projected depth (fbsf)	projected depth (fbsl)
Seafloor			0.0	0	6573
Mendenhall mud unit with low concentration hydrate	Top	**Unit 1**	102.0	111.1	6684.1
	Base		347.0	351.5	6924.5
water bearing **Aqua sand**	Top		347.0	351.5	6924.5
	Base		430.0	434.5	7007.5
water bearing **Yellow sand**	Top		499.0	501.3	7074.3
	Base		538.0	540.3	7113.3
Horizon 1000			773.0	774.5	7347.5
JIP mud unit with low concentration hydrate	Top	**Unit 2**	773.0	774.5	7347.5
	Base		1316.0	1317.5	7890.5
Horizon 0800			1316.0	1317.5	7890.5
water bearing coarse-grained interval	Top	**Unit 3**	1644.0	1658.5	8231.5
	Base		1726.0	1740.5	8313.5
hydrate bearing **Purple sand**	Top		1972.0	1986.6	8559.6
	Base		1982.0	1996.6	8569.6
hydrate bearing marine mud	Top		2040.0	2051.8	8624.8
	Base		2047.0	2058.8	8631.8
hydrate bearing marine mud	Top		2132.0	2138.8	8711.8
	Base		2140.0	2146.8	8719.8
hydrate bearing marine mud	Top		2240.0	2263.8	8836.8
	Base		2250.0	2273.8	8846.8
hydrate bearing marine mud	Top		2278.0	2301.4	8874.4
	Base		2282.0	2305.4	8878.4
Horizon 0500			2412.0	2426.2	8999.2
water bearing coarse-grained interval	Top	**Unit 4**	2680.0	2706.4	9279.4
	Base		2684.0	2710.4	9283.4
hydrate bearing **Upper Blue sand**	Top		2706.0	2722.8	9295.8
	Base		2779.0	2795.8	9368.8
Horizon 0400			2796.0	2816.3	9389.3
hydrate bearing **Lower Blue sand**	Top	**Unit 5**	2806.0	2821.2	9394.2
	Base		2866.0	2881.2	9454.2
hydrate bearing **Kiwi sand**	Top		3042.0	3060.7	9633.7
BSR			3058.0	3064	9637
hydrate bearing **Kiwi sand**	Base		3063.0	3081.7	9654.7
WR 313 G002 TD				3085	9658

3.5 Borehole Temperature and Hydrate Stability Field

To estimate the in-situ temperature prior to drilling, we assume the base of the hydrate stability zone is at three-phase stability, the pore water has nominal seawater salinity (35 ppt), the pore pressure is hydrostatic (0.4475 psi/ft), the seafloor temperature is 4.0 °C (Boyer et al., 2018), and the temperature increases 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 the depth of the Kiwi sand in Hole WR313 G001 (Table 3-5).

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 21.9°C and the gradient to be 5.8°C/1000 ft. At the WR313 H001 well, we estimate the temperature at the base of the hydrate stability zone to be 21.7 °C and the gradient to be 6°C/1000 ft. The recorded temperature at WR313 G001 and WR313 H001 wells (blue and green lines respectively) 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.

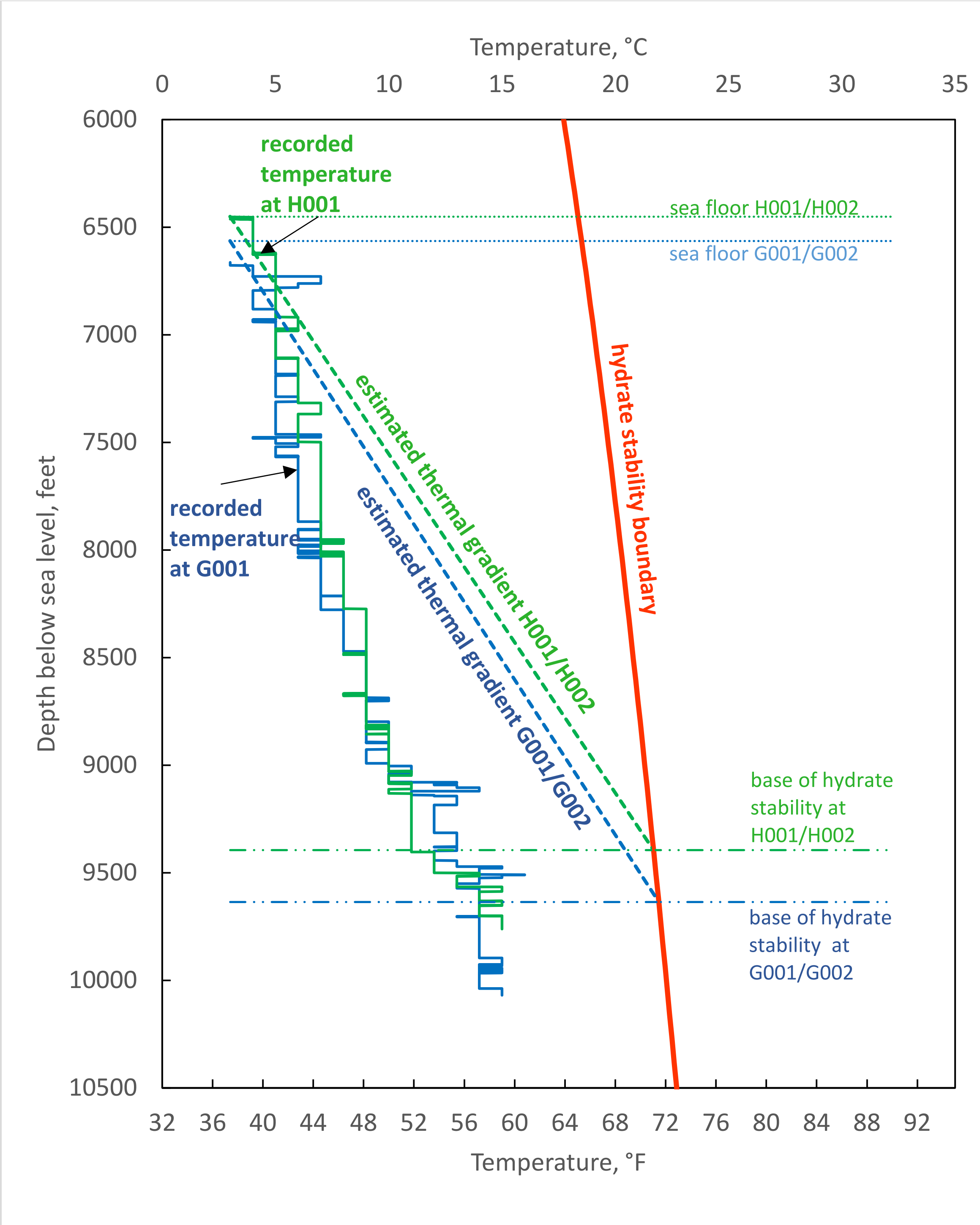

Figure 3-10. Estimated thermal gradient for WR313 G001 (blue dashed line) and WR313 H001 (green dashed line), in comparison with recorded borehole temperature (solid blue and green lines). Methane hydrate is stable on the left side of the hydrate stability phase boundary plotted in red. Horizontal lines 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 and WR313 G001, the formations penetrated at the proposed locations are expected to be normally pressured. Figure 3-11 illustrates the well paths for the planned G002 well and the planned H002 well. 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 H001 and G001 locations (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 where the gas leg. We will penetrate the Kiwi sand at its gas-water contact (Figure 3-11). However, the sand is very thin and a significant gas leg is not interpreted to be present.

We generated pore pressure and fracture gradient plots for WR313 H002 (Figure 3-12) and WR313 G002 (Figure 3-13). The plots are based on the following assumptions. 1) The overburden curve was generated by integrating the density log from the LWD data acquired in WR313 H001 and WR313 G001. 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 because there was no evidence of any elevated pore pressures during previous drilling of these wells. Hydrostatic pore pressures are expressed with a pore pressure gradient of 8.3 ppg, or seawater gradient of 0.46 psi/ft. 3) The least principle stress (σ_{hmin}) was estimated using Equation 3-1.

Equation 3-1

$$\sigma_{hmin} = K_0 * (\sigma_v - u_h) + u_h$$

u_h is the hydrostatic pressure. It is commonly observed in deepwater wells that in the shallow section (e.g. 1,000 feet below mud line), K_0 values can approach 1.0. An upper bound of $K_0 = 0.9$ and a lower bound of $K_0 = 0.7$ is assumed.

The H002 well penetrates both the Orange and Blue sands in the hydrate-bearing interval (Figure 3-11). The H001 well at this location was drilled without incident with 10.5 PPG mud. The solid orange line and blue line show the gas pressure within the gas leg of the interpreted in the Blue and Orange sand, respectively (Figure 3-12). Direct experience 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 G002 well penetrates only the Blue sands in the hydrate-bearing interval (Figure 3-11). We illustrate a pore pressure plot of this well in Figure 3-13. The G001 well at this location was drilled without incident with 10.0 PPG mud. The solid blue line shows the gas pressure within the gas leg of the interpreted in the Blue sand. Direct experience and observations of very low permeability in hydrate bearing intervals support that we will never observe these gas pressures where the well penetrates the hydrate-bearing interval.

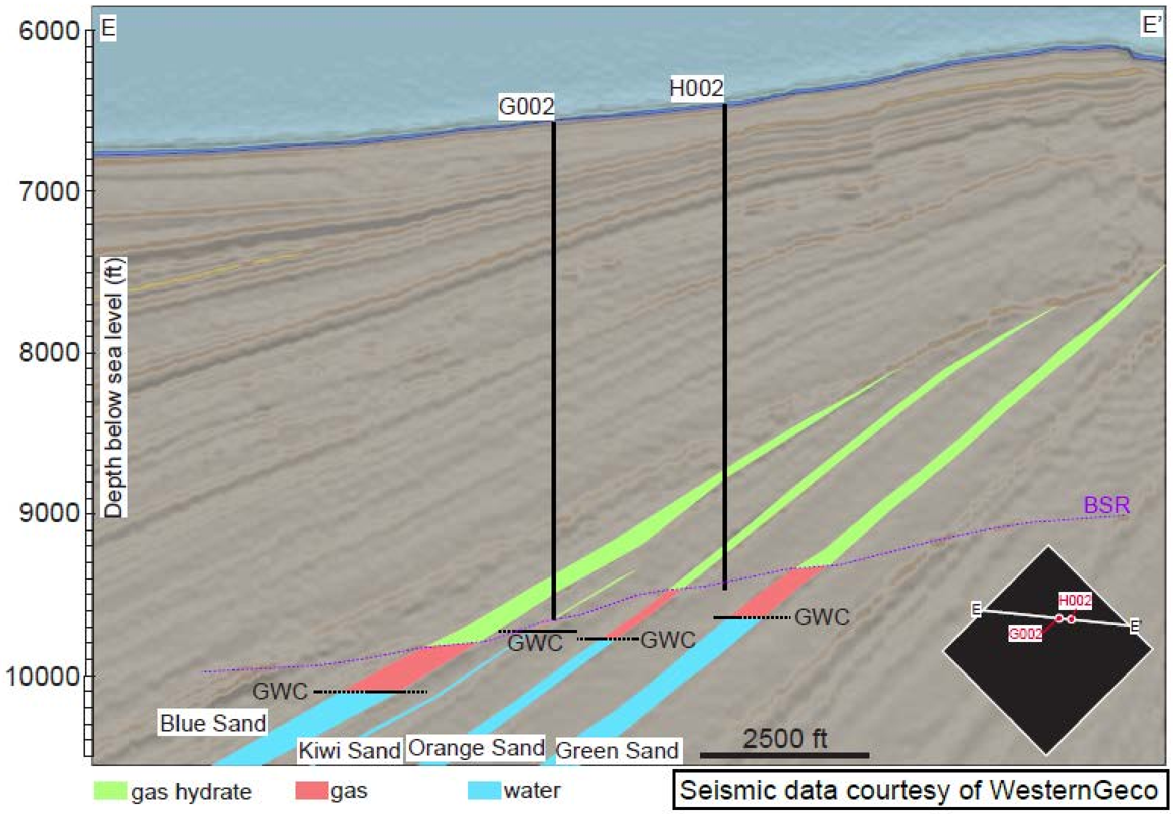

Figure 3-11. Seismic section EE' through proposed wells, showing hydrate-bearing sands, hydrate-gas contacts, and gas-water contacts.

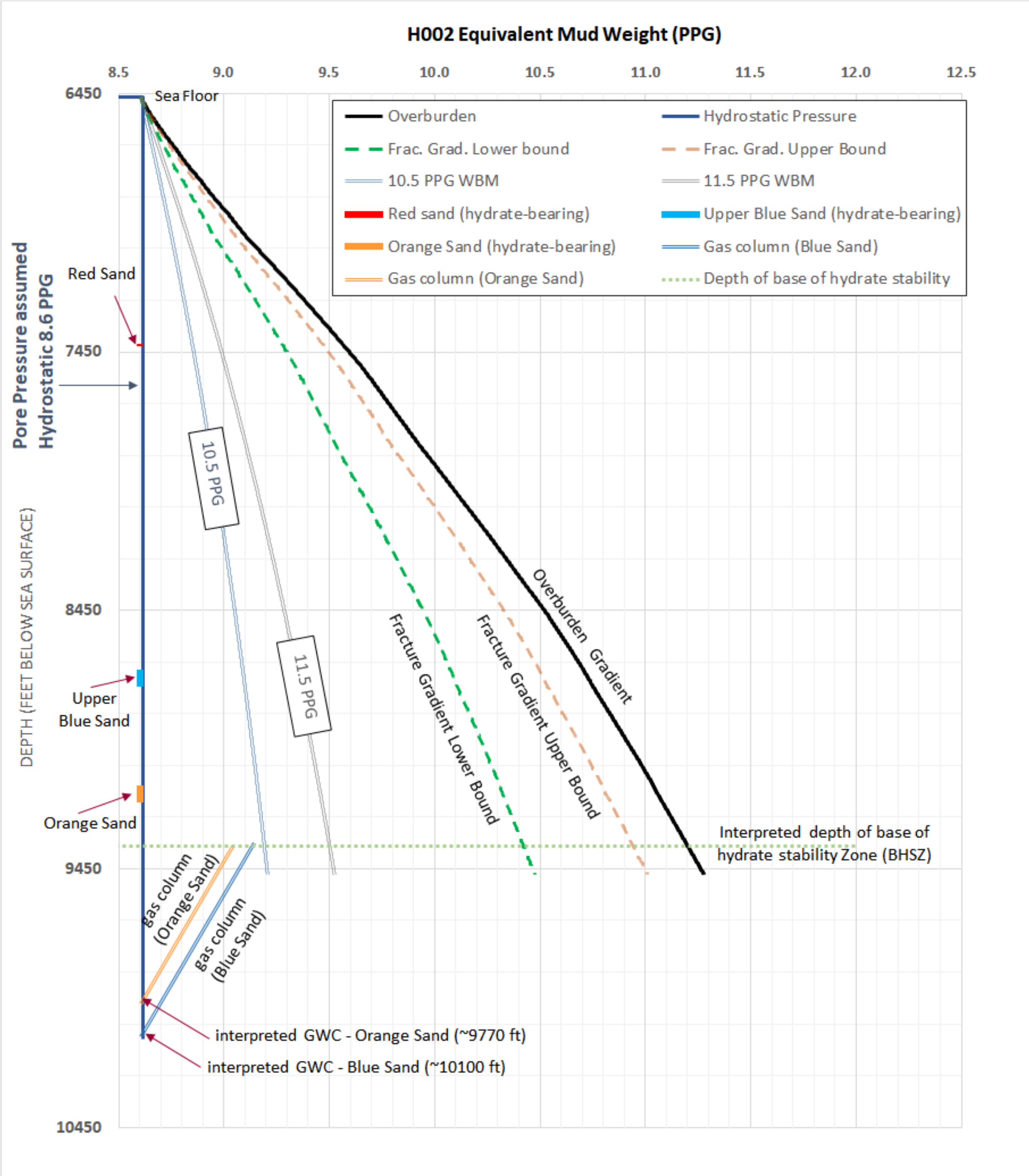

Figure 3-12. Equivalent mud weight plot for the planned WR313 H002.

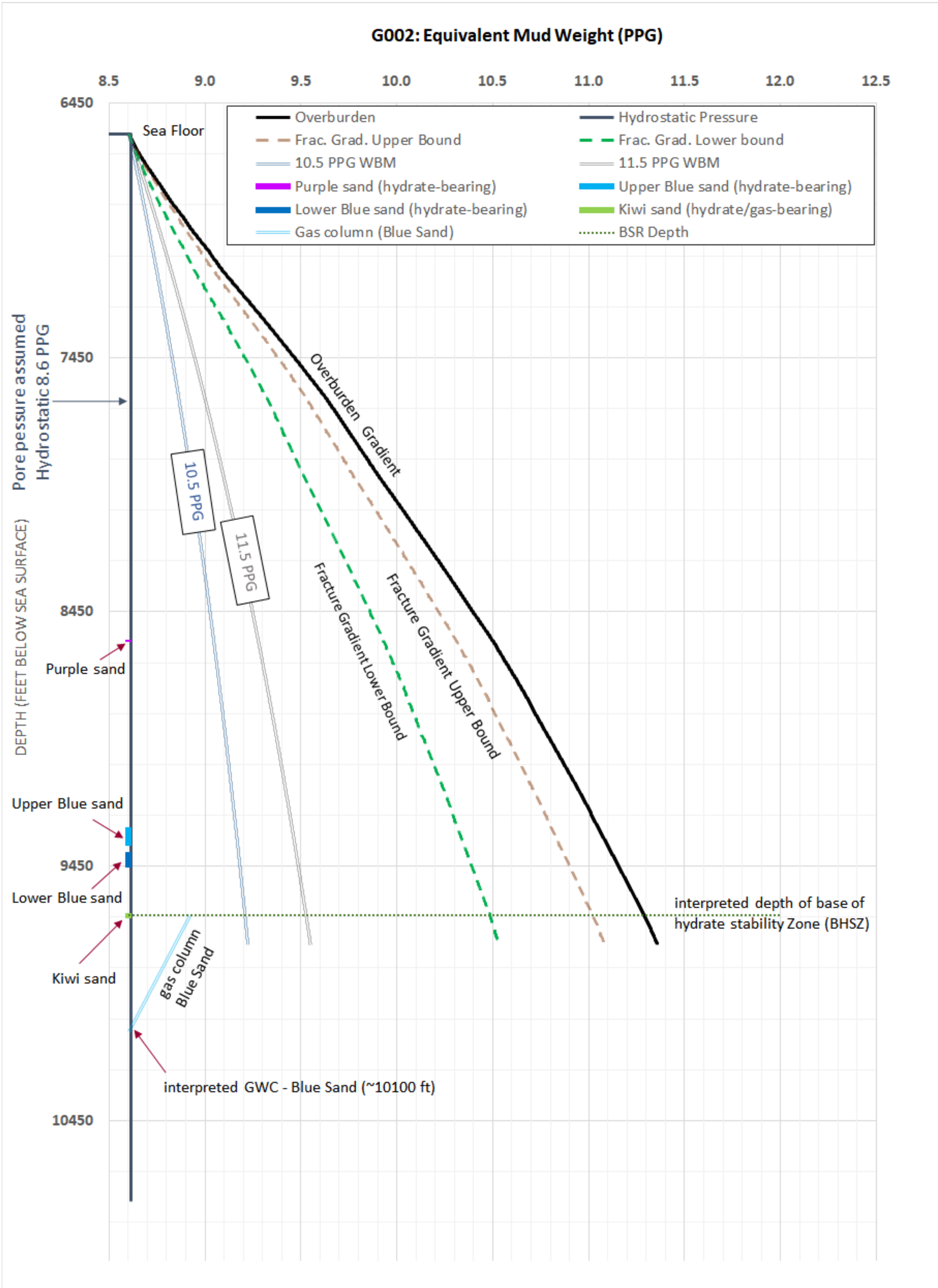

Figure 3-13. Equivalent mud weight plot for planned WR313 G002.

3.6.2 Previous drilling

Hole WR313 G001 was drilled without incident during Gulf of Mexico JIP Leg II (April 17-April 21, 2009). The seafloor was tagged and confirmed by ROV at 6614 ft MD (including 52 ft RKB). Within the upper 6614-9244 ft MD (0-2630 fbsf) interval, drilling was performed with seawater pumped at 380-410 gpm with sweeps of 10.5 ppg drilling fluid as needed. This interval included a thick unit with elevated resistivity (4-10 ohm m) with gas hydrate in near-vertical fractures in marine mud at 7458 to 7850 ft MD (844-1236 fbsf). The ROP within this interval ranged between 70 and 200 ft/h with the average of ~150 ft/h. Due to a major packoff at 9244 ft MD (2630 fbsf) stalling the rotary and requiring 140,000 lbs of overpull, drilling continued with 10 ppg drilling fluid. The main target (~70-ft thick high-saturation gas hydrate) was encountered at 9412 ft MD (2798 fbsf). The average ROP increased to ~270 ft/h. Drilling continued at 10 ppg drilling fluid down to 9599 ft MD (2985 fbsf) where it was switched to 10.5 ppg. After the total depth of 10200 ft MD (3586 fbsf) was reached, the hole was displaced with 12 ppg drilling fluid.

Hole WR313 H001 was drilled during Gulf of Mexico JIP Leg II from Q4000 (April 29-May 1, 2009). The seafloor was tagged at 6501 ft RKB (including 52 ft air gap). Within the upper 6501-8501 ft MD (0-2000 fbsf) interval, the hole was drilled with seawater pumped at 385 gpm and 10.5 ppg sweeps as needed. Within this interval, the ROP was on average 350 ft/h and rate of rotation gradually increased from ~70 to 110 rpm. Fracture filling gas hydrate was encountered at 7050-7400 ft MD (549-899 fbsf). At 8501 ft MD (2000 fbsf) with the decrease of the ROP to ~160 ft/h in the target gas hydrate interval, drilling fluid was changed to 10.5 ppg. The primary targets, two ~15 ft thick and ~21 ft-thick hydrate-bearing sand lobes, were encountered at ~9096 ft MD (2595 fbsf). After reaching the total depth of 9886 ft MD (3385), the hole was displaced with 10.5 ppg drilling fluid, followed by a 320-barrel "pill" of 12.0 ppg drilling fluid. 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 upper most hydrate bearing zone with the potential to flow, or a maximum depth of 8063 fbsl (1600 fbsf) in Hole WR313-H002 and a maximum depth of 8172 fbsl (1600 fbsf) in Hole WR313-G002, while circulating sea water and pumping 10.5 ppg high viscosity mud sweeps as required for hole cleaning.

2. Prior to penetrating the upper most hydrate zone with the potential to flow, or a maximum depth of 8063 fbsl (1600 fbsf) in Hole WR313-H002 and a maximum depth of 8172 fbsl (1600 fbsf) in Hole WR313-G002, 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 100 feet above the upper most hydrate bearing zone with the potential to flow.

4. Emplace a cement plug beginning approximately 100 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.

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.

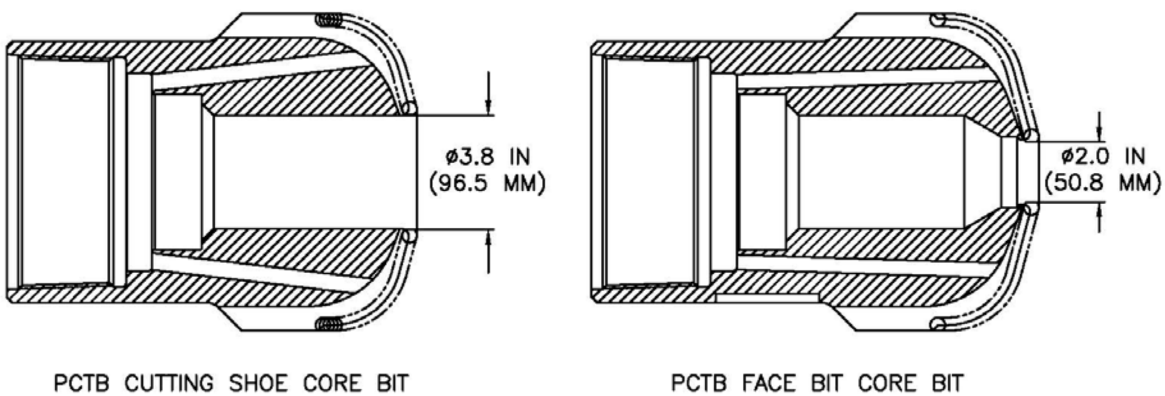

Figure 4-1. PCTB Coring Bit Configurations (Flemings et al., 2018)

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.

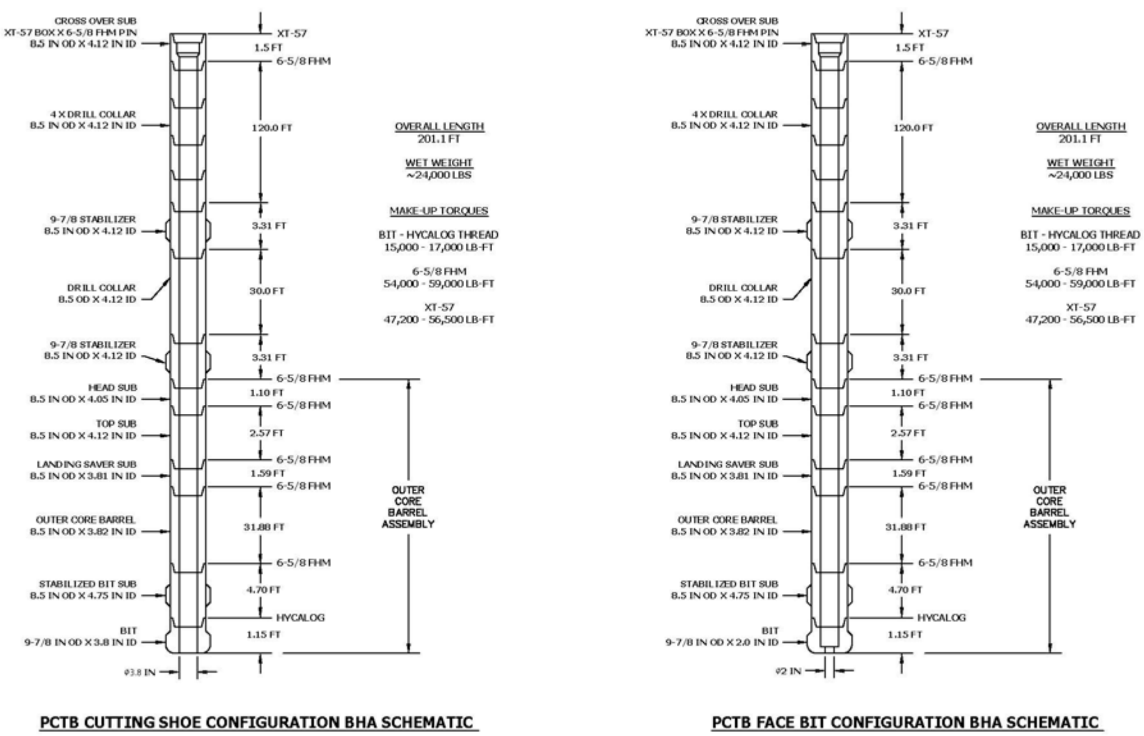

Figure 4-2. Drilling/Coring Bottom Hole Assemblies Configurations (Flemings et al., 2018).

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).

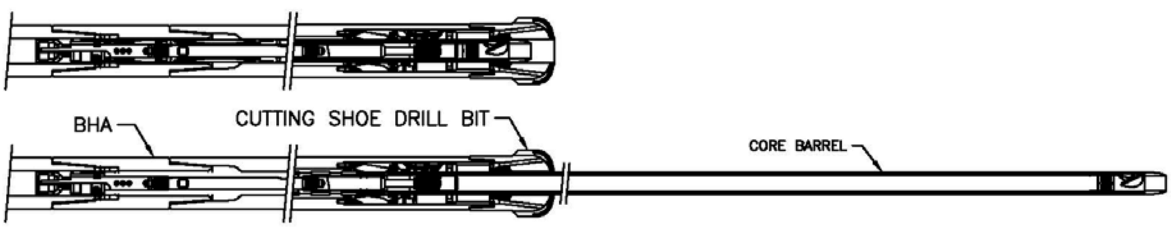

Figure 4-3. Geotek Advanced Piston Corer.

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).

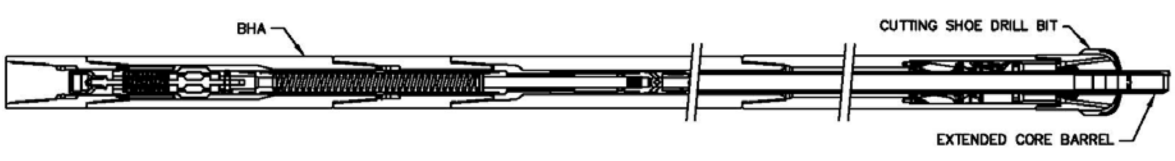

Figure 4-4. Geotek eXtended Core Barrel. -

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)

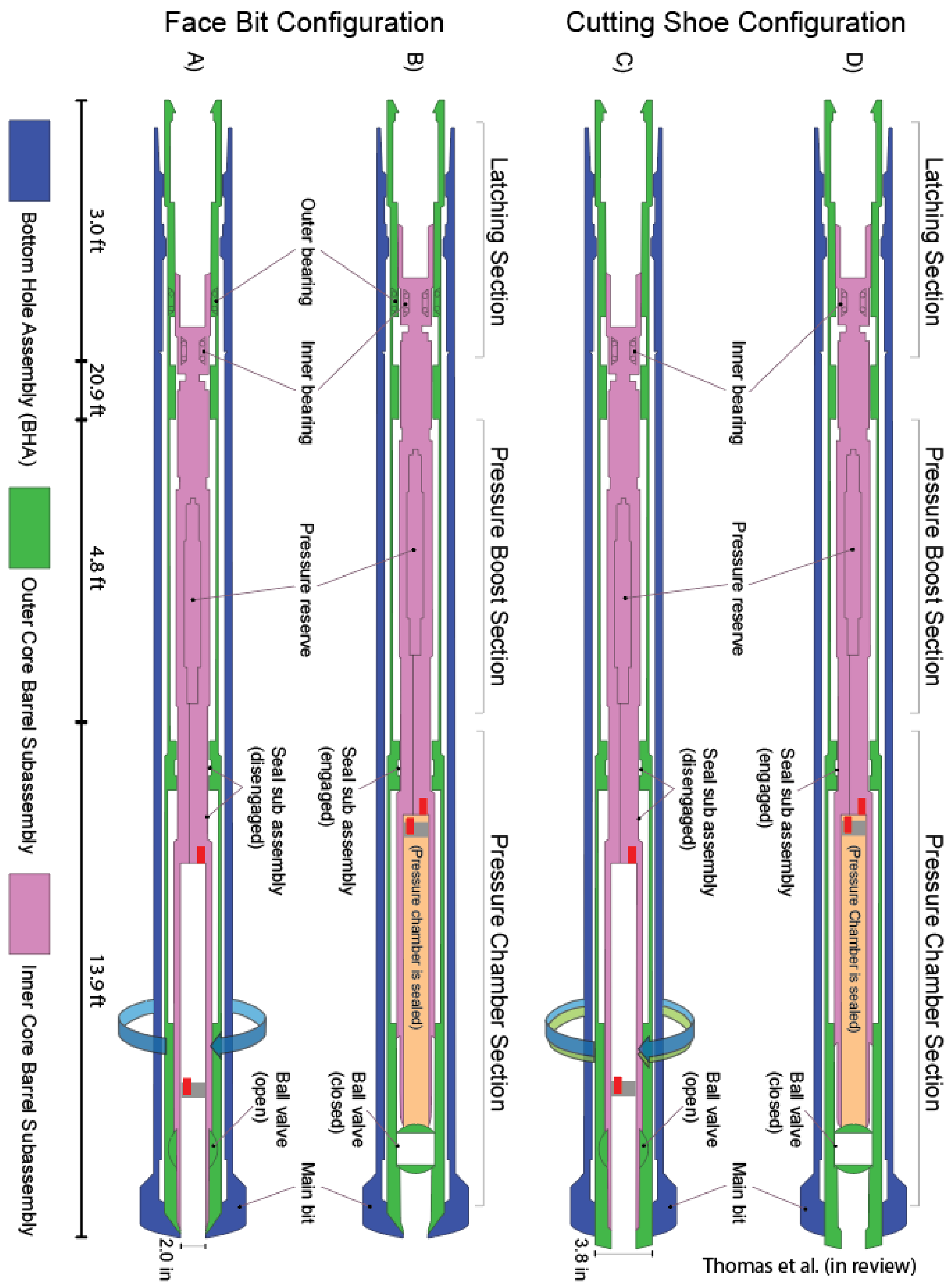

Figure 4-5. Pressure Coring Tool (PCTB) schematic Configurations. (A) PCTB-FB configuration during coring. In this configuration, the Outer (green) and Inner (pink) Core Barrel Subassembly move independently from each other and from the BHA. The blue arrow indicates direction of BHA rotation. (B) PCTB-FB 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., in review).

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

6.1 Coring Plan Overview

At WR313, we will acquire pressure cores at WR313 H002 using the PCTB-FB and PCTB bottom hole assembly (BHA) in the Orange sand, Blue sand, Red sand and select spot core pairs. At WR313 G002, we will combine conventional coring, pressure coring, and pressure/temperature measurements (Table 6-1). In this second hole we will use the PCTB-CS and PCTB-CS BHA to refusal to collect conventional cores, pressure cores and T2P measurements. Below this depth, we will use the PCTB-FB and PCTB-FB BHA to collect pressure cores in the Blue sand and Kiwi sand, as well as spot pairs of pressure cores.

6.1.1 WR313 H002

We will first drill WR313 H002 twinning the WR313 H001 location. It will be drilled with the PCTB-FB BHA from seafloor to total depth (3010 fbsf). Pressure cores will be acquired with the PCTB-FB tool. A center bit will be used to advance the borehole where pressure cores are not taken.

Continuous pressure-cores will be acquired in the Red sand (2 cores, complete interval), the Blue sand (3 cores, partial interval), and the Orange sand (7 cores, complete interval). Intermittent spot pressure-core pairs will be acquired throughout the borehole to develop a dissolved methane profile and above and below the bottom-simulating reflector (BSR) (Table 6-1, Figure 6-1).

6.1.2 WR313 G002

We will then drill WR313 G002 twinning the WR313 G001 location. It will be drilled using the PCTB-CS BHA from the seafloor until refusal and the PCTB-FB BHA to total depth (3085 fbsf).

Using the Geotek Advanced Piston Corer (G-APC), we will continuously conventional-core from the seafloor to approximately 250 fbsf, to maximize recovery over 1) the sulfate-methane transition (SMT), 2) the depth at which methane reaches saturation, and 3) at least one glacial-interglacial cycle (Table 6-1, Figure 6-1). Within this interval, a PCTB-CS spot core will be acquired just below the SMT, followed immediately by a temperature and pressure penetrometer deployment (T2P) (Table 6-1, Figure 6-1).

We will continue drilling with the PCTB-CS and a center bit to approximately 1640 fbsf. In this interval, we will take five intermittent spot core sequences consisting of one each of G-XCB conventional-core

(Geotek Extended Core Barrel), PCTB-CS pressure-core, and a T2P deployment (Table 6-1, Figure 6-1). One of these five deployments will be in the thin Aqua sand, with the four additional spot-deployments evenly distributed to develop the dissolved gas and geochemical profile (Table 6-1, Figure 6-1).

After encountering refusal with the PCTB-CS BHA; we will trip pipe, perform a BHA change, and reenter to continue drilling with the PCTB-FB with center bit. Between ~1640 fbsf and the top of the Blue sand we will complete three intermittent spot core sequences consisting of two PCTB-FB spot pressure-cores to develop the dissolved gas and geochemical profile (Table 6-1 & Figure 6-1).

Continuous pressure-cores will also be acquired in the Blue sand (10 cores) and Kiwi sand (3 cores, at the BSR) (Table 6-1 & Figure 6-1). These cores will not cover the full thickness of these sands, but will aim to collect representative intervals.

Table 6-1. WR313 G002 and WR313 H002 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.

LOCATION	CORE TYPE	CORING INTERVAL (fbsf)	BHA	CORING TOOL	NOTES
WR313 H002	Pressure Core	150-3010	PCTB-FB	PCTB-FB	8 spot pressure-core pairs (16): 6 – Dissolved gas profile (12) 2 – BSR (4)
					2 pressure-cores in Red sand
					3 pressure-cores in Blue sand
					7 pressure-cores in Orange sand
WR313 G002	Con-ventional Core	0-250	PCTB-CS	G-APC	Continuously conventional core from 0-175 with PCTB-CS and G-APC
		250-1650	PCTB-CS	G-XCB	Spot conventional core immediately above spot pressure cores
	Pressure Core	165-1650	PCTB-CS	PCTB-CS	6 spot pressure cores: 1 – Immediately below SMT 5– Dissolved gas profile / thin sands
		1650-3085	PCTB-FB	PCTB-FB	3 spot pressure-core pairs (6)
					10 pressure-cores in Blue sand
					3 pressure-cores in Kiwi sand

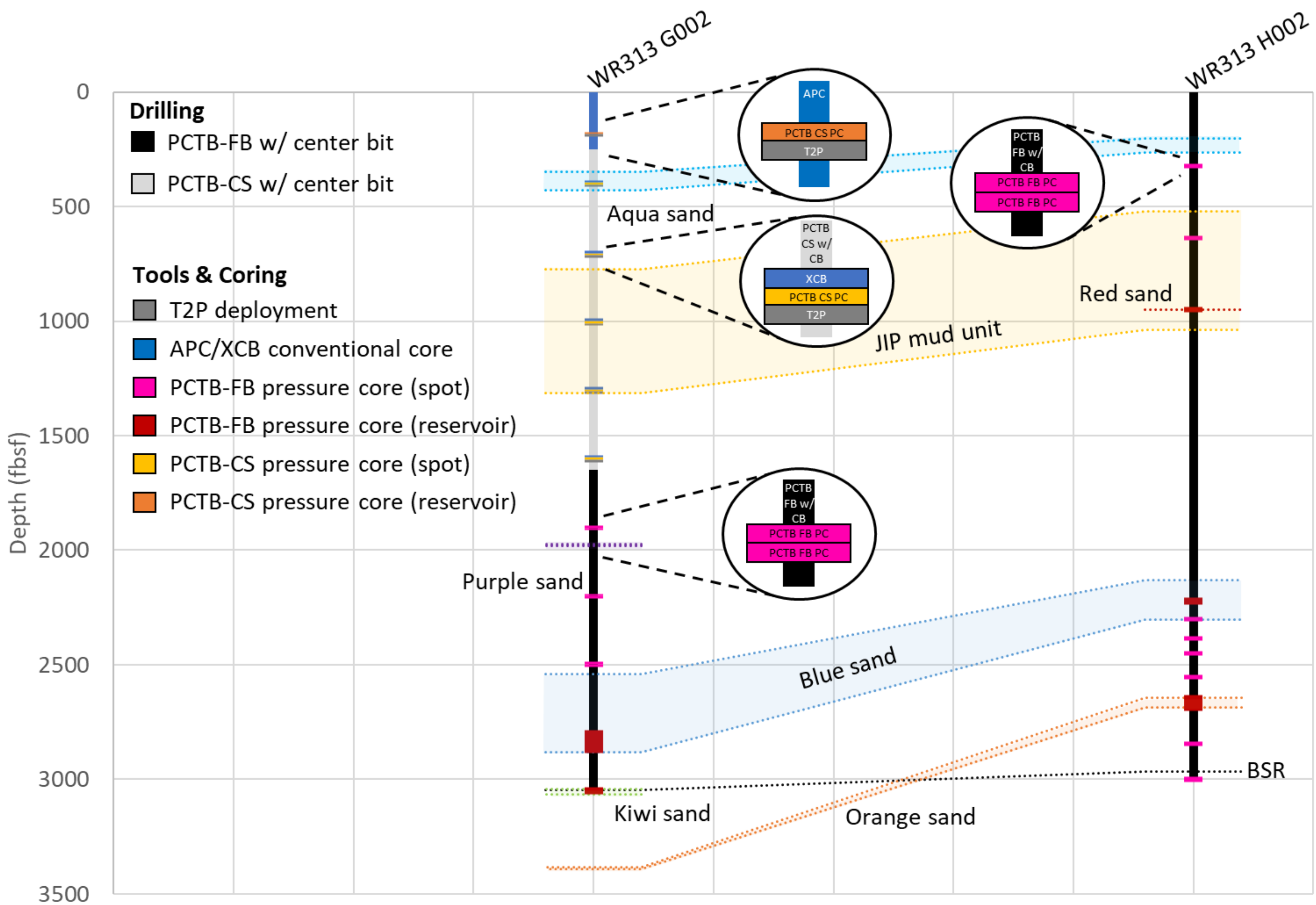

Figure 6-1. UT-GOM2-2 drilling and coring plan at WR313 G002 and WR313 H002 . Dashed lines represent approximate sand locations as described in Hillman et al. (2017) and Boswell et al. (2012a). Not to scale.

The total length of pressure core recovered for WR313 H002 and WR313 G002, including expected fall-in material, assuming 100% successful coring runs and 100% recovery, is 530 ft (152.4 m). This is the expected amount of core that will need to be logged using the PCTAS Quick Scan method (see below). If 100% of the first pressure core in a spot or series is fail-in material, then we expect 370 ft (112.8 m) of pressure core that will receive PCATS full-scan.

The total length of conventional core recovered for WR313 G002 and WR313 H002, including expected fall-in material, assuming 100% successful coring runs and 100% recovery is 386 ft (151.2 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		Total Pressure Core, not incl fall-in		Total Conventional Core not incl fall-in	
	ft	m	ft	m	ft	m	ft	m
TOTAL 2 HOLES (100% PC success, 100% recovery)	530	162	386	118	370	113	336	102
TOTAL 2 HOLES (70% PC success, 100% recovery)	371	113	545	166	259	79	447	136
TOTAL 2 HOLES (70% PC success, 80% recovery)	297	90	436	133	207	63	358	109

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 analysis types and core types, with required laboratory space equipment, and staffing.

Core Samples Type	Analysis	Where: Container or Lab	Required Equipment	Staff per shift
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8 + Data Processing Laboratory	PCATS, PCATS water tank, supplies	2
Pressure core	Quantitative degassing w/ gas sampling	R17	4 degassing stations, SC130 storage racks, copper tubes, stainless steal tubes, other supplies	2
Gas samples	Hydrocarbons, CO2 and Fixed Gases (N2, O2)	Geotek Gas Chromatography (GC)/Data Processing Laboratory (20-foot)	GC, computers, supplies	1
Whole round conventional core	Thermal imaging	Geotek 40 ft Whole Core Processing Laboratory	MSCL-IR	TBD
Whole round core cutting	Cut whole round core into sections, headspace gas sampling	Geotek 40 ft Whole Core Processing Laboratory and Mud lab	Cutting tools and supplies	
Whole core sections	Microbiology samples for DNA, 16S-rRNA	Mud Lab	Cutting tools and supplies, N2 bag, -80 C Freezer, Whirl paks, etc.	1
Whole core sections	Moisture and Density	Mud Lab	Packing supplies, refrigerator	
Whole core	Vane Penetrometer, Shear /Compressive Strength	Mud Lab	Vane penetrometer	
Whole core sections	Pore Water Squeezing and time-sensitive analysis	Pore Water Laboratory	4 squeezers and glove bags, alkalinity titrator, refractometer, sampling bottles and preservation agents	2

6.2.1 Pressure Core Processing Flow

If the pressure coring program were 100% successful, we would acquire 50 10' (3.1 m) cores.

As pressure cores arrive on deck, they will be transferred to PCATS where they will get a "Quick-Scan" and then they will be transferred to temporary storage. Geotek will provide a recommendation 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 the PCATS for 'Full-Scan' analysis, cutting, and transfer. There is very little 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 2 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. Ten temporary storage chambers are 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 returned to 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 1 cm resolution) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, small 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 hydrate concentration and sample the resultant gasses. Third, optimal 3.3’ (1.0 m) subsections can be chosen from the storage chambers and transferred to the transfer pressure chambers for shipment to UT.

6.2.1.3 Quantitative degassing

Sections cut for degassing will be quantitatively degassed on board. Gases will be analyzed, 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. Whole round sections will be cut for pore water squeezing, and ephemeral properties measured (alkalinity, pH, and salinity). Whole round sections will also be sampled and preserved for microbiological and physical property measurements.

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, location, required equipment, and required staff.

Core Samples Type	Analysis	Where: Container or Lab	Required Equipment	Staff per shift
Pressure core	Whole Core logging, CT scanning	PCATS11 + PCATS8 + Data Processing Laboratory	PCATS, PCATS water tank, supplies	2
Pressure core	Quantitative degassing w/ gas sampling	R17	4 degassing stations, SC130 storage racks, copper tubes, stainless steal tubes, other supplies	2
Gas samples	Hydrocarbons, CO2 and Fixed Gases (N2, O2)	Geotek Gas Chromatography (GC)/Data Processing Laboratory (20-foot)	GC, computers, supplies	1
Whole core sections	Microbiology samples for DNA, 16S-rRNA	Mud Lab	Cutting tools and supplies, N2 bag, -80 C Freezer, Whirl paks, etc.	1
Whole core sections	Moisture and Density	Mud Lab	Packing supplies, refridgerator	
Whole core	Vane penetrometer, Shear /compressive strength	Mud Lab	Vane penetrometer	
Whole core sections	Pore Water Squeezing and time-sensitive analysis	Pore Water Laboratory	4 squeezers and glove bags, alkalinity titrator, refractometer, sampling bottles and preservation agents	2
Whole core sections	XCT, 3D CT	Send to Stratum Reservoir	Chilled shipping container with racks	TBD
Whole core	Whole Core Logging Gamma density, P-wave, Mag susceptibility, Resistivity; natural gamma	MSCL Container	MSCL scanner	TBD
Whole Core	Thermal Conductivity probe	TBD	Probe	TBD
Split core	Core splitting	TBD	core cutters and supplies	TBD
Split core -plug	Visual description, and smear slide description	TBD	Core splitter	2
Split core scanning	Linescan images, color reflectance scans, X-ray fluorescence (core scanning), near IR scan	MSCL Container	Split Core scanner	TBD
Split Core -plug	Sampling for XRD, CHNS elemental/isotopic analysis, nannofossil biostratigraphy, grain size, rock mag, biomarkers, carbonate/sulfide nodules.	TBD	Area/tables to lay out split core working halves	1

6.3.1 Dockside Pressure Core Processing Flow

Any cores that were not "Quick-Scanned" will be scanned dockside, followed by 'Full-Scan' analysis, cutting, and transfer. Geotek will provide a recommendation 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 2 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 1 cm resolution) and acquire 3D X-ray computed tomography. We will use this data to make additional specific cuts. Secondly, small 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 hydrate concentration and sample the resultant gasses. Third, optimal 3.3' (1.0 m) subsections can be chosen from the storage chambers and transferred to the transfer pressure chambers for shipment to UT.

6.3.1.3 Quantitative degassing

Sections cut for degassing will be quantitatively degassed on board. Gases will be analyzed, 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, and split into archival and working halves. Split core will be scanned (photo-scan, X-ray fluorescence, and possible near-IR) and photographed. Smear slides will be prepared and assessed. Samples will be extracted for lithostratigraphy and biostratigraphy on-shore.

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 100 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, and the borehole displaced with an 11.5 ppg high viscosity (~100 lb/100 ft^2) mud from total depth to approximately 100 feet above the upper most hydrate bearing zone with the potential to flow. The drill bit will then be raised to approximately 100 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.

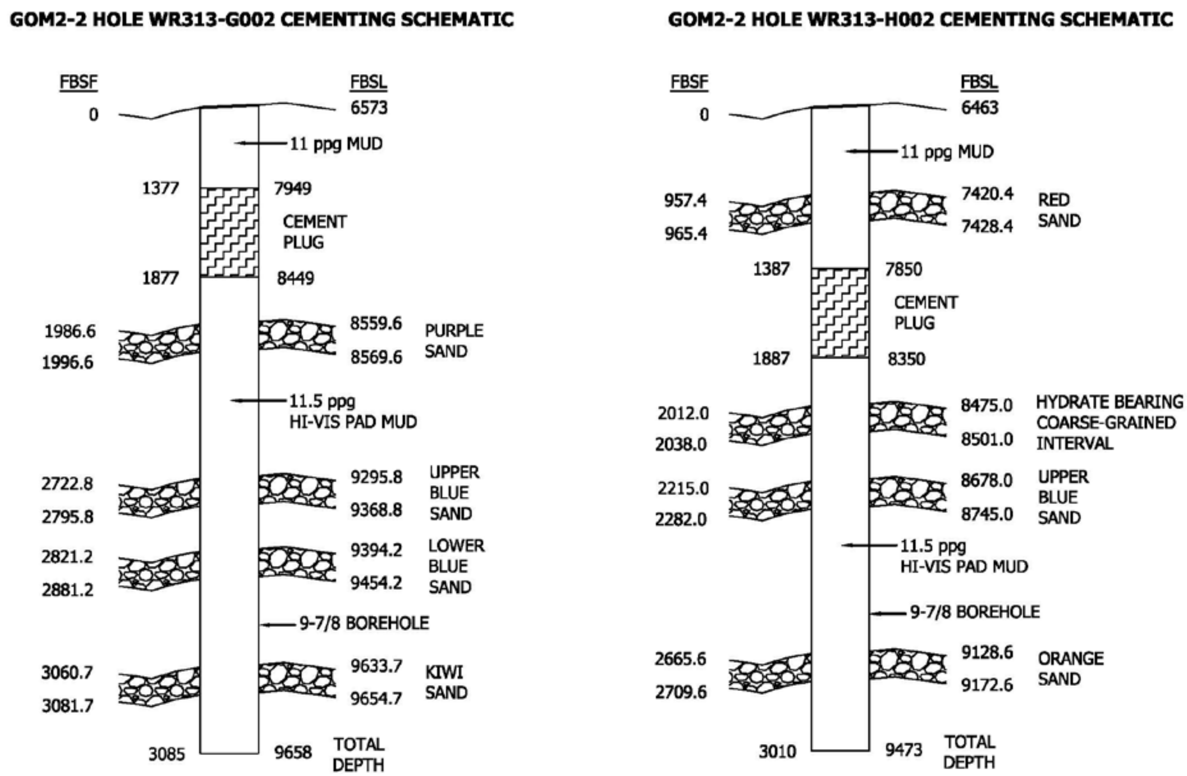

Figure 7-1. Plug and abandon cement plug emplacement hole schematics.

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 2022. The schedule begins with a one-week period for staging all expedition bound equipment in the port of embarkation. Mobilization, requiring 3.7 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 ~32.3 days to complete (Table 8-1 & Table 8-2). The time from start of mobilization to the first PCTB core on deck is ~4.2 days.

Demobilization, requiring 2.9 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 up to thirty 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 11 weeks.

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

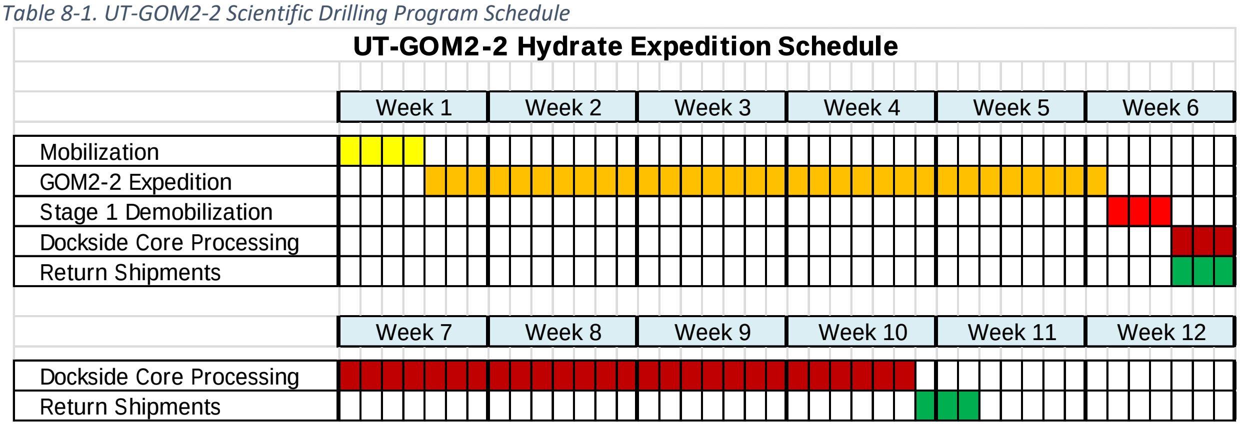

Table 8-2. UT-GOM2-2 Scientific Drilling Program Overview

UT-GOM2-2 Expedition Time Estimate Overview

Task	On Site Operations Time (days)	Transit Time (days)	Mob-Demob Time (days)	16 ppg mud usage (bbl)	Cement Usage (sks)	Notes
Transit from 1 NM off vessel last site		???				Last site unknown.
Mobilization on location Site WR313-H002			3.7			
Site WR313-H002 coring operations	15.2			13,165	475	
Transit Site WR313-H002 to Site WR313-G002		0.0				0.429 NM (2558 ft), transit in DP mode
Site WR313-G002 coring operations	17.1			11,540	475	
Demobilization on location Site WR313-G002			2.9			
Transit to 1 NM off Site WR313-G002		0.0				Transit in lump sum demob
Subtotals:	**32.3**	**0.0**	**6.6**	**24,705**	**1425**	Cement total = 1.5 x actual usage
Total Expedition Time:	**38.9**					

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. There are four PCTB pressure chambers and each pressure chamber must be emptied and cleaned before it is needed again at the rig floor. There are 10 SC_{350} chambers each of which must be emptied and cleaned below it is needed again at PCATS.

Full-scanning can take up to 24 hours to for each 10' pressure core in PCATS. Full scans will have to be completed dockside. Some detail is given below and a detailed breakdown of the amount of PCATS time required for the various PCATS operations will be described in the UT-GOM2-2 Science and Sample Distribution Plan.

8.2.3 PCATS schedule

8.2.3.1 WR313 H002

In the first hole, there will not be enough time to fully process two pressure spot cores before the next pair arrives. Processing of the two spot cores will be limited (Table 8-3). In the time available, we will run a quick-scan (3-5 hours) or each core, make cuts for one to three cuts for quantitative degassing samples, and run full-scanning as possible. All spot pressure cores and the 3 Blue sand pressure cores will be processed by the time the first continuous core from the Orange sand arrives at PCATS making all Geotek SC_{350} chambers available for pressure coring of the Orange sand and the spot cores below. PCATS data for these cores will include quick-scans and a limited amount of full-scans data only.

During pressure coring of the Orange sand, PCATS will run quick-scans on each core. After pressure coring the Orange sand there is extra time for full-scanning while collecting additional spot core pairs, after coring operations have ended, and before the first pressure core from G002 arrives. All 10 SC_{350} chambers do not need to be empty before the first pressure core from G002 arrives, but they will be emptied as required to not hold up spot pressure coring in G002. PCATS data for the Orange sand cores will include quick-scans and full-scans data that can be collected before and possibly beyond when pressure coring of the Blue sand in the second hole begins.

8.2.3.2 WR313 G002

Spot coring in G002 consists of a conventional core followed by a pressure core. There is extra time during this period to process these pressure cores and cores remaining from the first hole. Processing of all pressure cores will be completed before the first of ten pressure cores arrive from pressure coring of the G002 Blue sand, making all Geotek SC_{350} chambers available for pressure coring of the Blue and Kiwi sands. PCATS data for these cores will include quick-scans and a limited amount of full-scans data prioritizing PCATS time for the Orange sand pressure cores from the first hole, H002.

During pressure coring of the Blue sand, PCATS will run quick-scans on each core, although quick-scanning could be delayed and run dockside. After pressure coring the Blue sand there is extra time for full-scanning while collecting additional spot core pairs, and during G002 completion. Pressure cores can remain in the 10 SC_{350} chambers during demobilization. PCATS data for the Blue and Kiwi sand cores will include quick-scans and extensive full-scans data that can be collected before demobilization and dockside.

8.2.3.3 Dockside

The current plan is to transfer 10 pressure cores still in Geotek SC_{350} chambers to the dock for PCATS processing.

*Table 8-3. PCATS Onboard Overview. PCATS Tasks shown with corresponding number of pressure cores arriving, estimated time, estimated time per core. Mobilization is the time between the start of PCATS mobilization until the first pressure core arrives at PCATS. H002 spot core and Blue sand processing is the time between when the first pressure core arrives at PCATs and the first Orange sand pressure core arrives at PCATS. Orange sand and lower spot core processing is the time between when the first Orange sand pressure core arrives and PCATS and the last H002 core arrives at PCATS. Time between holes is an estimate of the time between when the last pressure core from H002 arrives at PCATS and the first pressure core from G002 arrives at PCATS. G002 spot core processing is the time between when the first pressure core from G002 arrives at PCATS and the first Blue sand pressure core arrives at PCATS. Blue sand processing is the time between when the first Blue sand pressure core and the first Kiwi sand pressure core arrives at PCATS. Kiwi sand processing is the time between when the first Kiwi sand pressure core arrives at PCATS and the start of demobilization. Demobilization is the time between the end of G002 operations and the end of PCATS demobilization from the vessel. *Time estimates do not include contingency; hence the total does not match the total vessel time shown above in Table 8-2.*

<table>
<tr><th>PCATS Task</th><th>Number of Pressure Cores</th><th>Time (hours)</th><th>~ Time per core (hours)</th><th>Time (days)</th></tr>
<tr><td>Mobilization</td><td></td><td>101.3</td><td></td><td>4.2</td></tr>
<tr><td>H002 spot Core and Blue sand processing</td><td>17</td><td>156.3</td><td>9.2</td><td>6.5</td></tr>
<tr><td>Orange sand and lower spot core processing</td><td>11</td><td>68.8</td><td rowspan="2">14.6</td><td>2.9</td></tr>
<tr><td>Time between holes</td><td></td><td>91.8</td><td>3.8</td></tr>
<tr><td>G002 spot core processing</td><td>9</td><td>178</td><td>19.8</td><td>7.4</td></tr>
<tr><td>Blue sand processing</td><td>10</td><td>61</td><td rowspan="3">9.8</td><td>2.5</td></tr>
<tr><td>Kiwi sand processing</td><td>3</td><td>10</td><td>0.4</td></tr>
<tr><td>Time after G002</td><td></td><td>56.8</td><td>2.4</td></tr>
<tr><td>Demobilization</td><td></td><td>70</td><td></td><td>2.9</td></tr>
<tr><td>Total</td><td>50</td><td></td><td></td><td>33.1*</td></tr>
</table>

9 Risk Management

Risks are broken into 7 categories: Environmental, Personnel and Equipment, Meeting Science Objectives, Weather, Vessel Selection, and Cost Inflation.

1) Environmental
    a) Release of fluids at the seafloor
        i) 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.
        ii) Uncontrolled shallow flows can result in drilling delays or loss of well site.
        iii) The risk of these events is minimized in the following manner:
            (1) 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.
            (2) 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.
            (3) Maintain visual observation of the wellbore returns at the seafloor via ROV camera for early detection of flow.
            (4) Review of offset well data.
    b) Release of pollutants from the rig
        i) Examples include spills of diesel fuel or other chemicals from the rig or supply vessel while on location. Spills can also occur during transit (collision) or during transfer between rig & supply vessel.
        ii) 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.
        iii) Releases of diesel will evaporate and biodegrade within a few days.
    c) Operational discharges
        i) Will be regulated as per the NPDES General Permit GMG290000.
        ii) Operational discharges are expected to only have short-term localized degradation of marine water quality.
    d) Emissions impact on air quality
        i) 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.
        ii) There are no plans for burning or flaring during this project.
    e) Impact on marine life
        i) Minimal to none expected.
    f) Dissociation of gas hydrates
        i) Hydrate dissociation can be either gradual or instantaneous when hydrates are heated or depressurized.
        ii) While drilling the boreholes, fluids cooler than the formation temperature will be introduced, which will act to further stabilize the hydrate zone.
        iii) Drilling-fluid weight will be controlled to maintain a positive pressure on the formation.

iv) 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.

2) <u>Personnel and Equipment</u>
   a) During Drilling
      i) 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.
      ii) Project-specific risk
         (1) 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.
      iii) 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.
   b) While Handling High Pressured Samples
      i) We will be recovering, transferring, and storing samples that are at significant pore pressures (up to 35 MPa).
      ii) The risk is mitigated in the following manner:
         (1) All pressure vessels are equipped with pressure release safety valves.
         (2) Pressure cores will be transported by vehicle in 'over-pack' containers, a US DOT approved approach to transport of pressurized material.
         (3) Strict adherence to proper procedure in the presence of pressurized containers.
         (4) Hold pre-job safety discussions.
         (5) Assure that personnel involved have been trained in the safe handling of pressurized samples.

3) <u>Meeting Science Objectives</u>
   a) 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

4) <u>Adverse Weather Conditions</u>
   a. 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.
   b. The maximum sea state for backloading and transporting pressured cores is 4 feet w/ wave heights up to 8.2 feet.
   c. The risk is mitigated in the following manner:
      i. Use active heave systems on the drilling vessel while coring
      ii. 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.
5) <u>Vessel Selection / Availability</u>
   a. General vessel availability in the Gulf of Mexico is expected to continue to tighten either due to increased stacking, vessels leaving the area, and/or increased activity.
   b. There are a limited number of vessels which can meet project requirements within the project budget.
   c. Vessel must be able to meet the regulations for conducting a deep stratigraphic test in the Gulf of Mexico. Current MODU Certificate of Inspection or Certificate of Compliance is required.
   d. The risk is mitigated in the following manner:
      i. Early development of detailed minimum drilling vessel specifications.
      ii. Pre-screening of potential vessels; i.e. knowing the market
      iii. Selecting and contracting vessel as soon as possible, well in advance of project execution date to secure time slot during preferred window.
6) <u>Cost Inflation</u>
   a. The use of 2018 quotes and 2017 historical cost information may not be adequate for building a cost estimate for project execution in 2022

b. The risk is mitigated in the following manner:
   i. Apply an inflation factor to items not covered by a firm quote for execution in 2022.

10 Drilling Vessel

A fit-for-purpose oil-industry deepwater drilling or intervention vessel will be contracted. Specific vessel requirements can be found in Table A1 in the 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 five 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), 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 Ltd., and a to-be-determined Vessel Contractor.

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

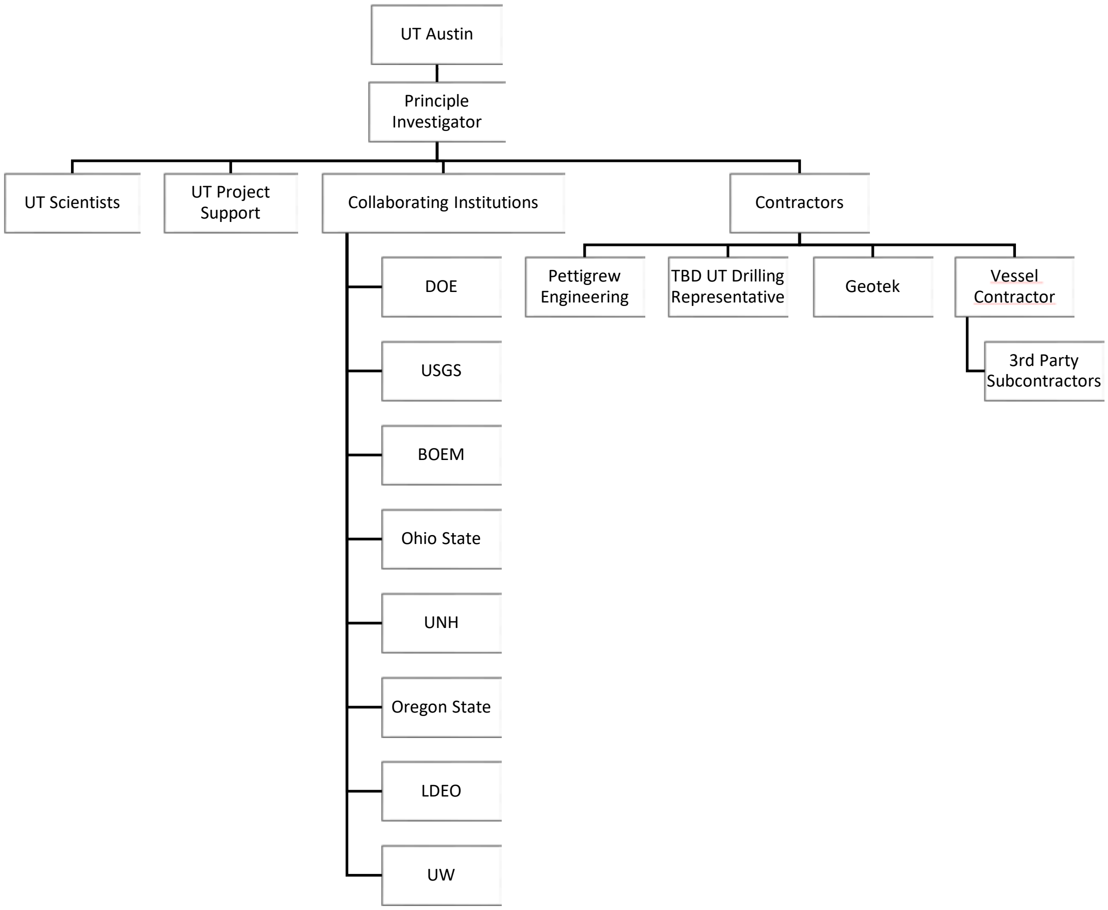

Figure 11-1. Personnel organization chart.

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

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

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

UT-GOM2-2 ONBOARD PERSONNEL		
ROLE / TASK	***PERSONS***	***INSTITUTION***
Chief Scientist	1	UT
Staff Scientist	1	UT
Technical Advisor	1	USGS
Observer	1	TBD
Drilling Data and Core Log Integration	2	Ohio State
Pore Water Geochemistry	4	UW, others
Gas Geochemistry	2	Geotek, others
Quantitative Degassing	4	UT, Geotek
Microbiology	2	Oregon State
Coring/PCATS	12	Geotek, others
UT Drilling Representatives	2	Pettigrew Eng., TBD
TOTAL	**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
Gas Geochem/De-Gassing	1	Ohio State
De-Gassing	3	UTIG, others
Microbiology	2	Oregon
Core Description	2	UNH
Biostratigraphy	1	UT
Physical Properties	1	UT, others
Splitting/Scanning/Photos/Curation	4	Geotek
PCATS & De-Gassing	4	Geotek
PCATS Mobilization/De-mobilization	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 Mobilization

13.1.1 Supplies and Equipment

13.1.1.1 Customs

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

13.1.1.2 Designated Mobilization Port

<u>Location:</u> TBD depending on which dockside service provider is chosen. Based on the area of the project operations, the dock chosen will most likely be in Port Fourchon, Louisiana.

<u>Port of call plan:</u> UT will work with the Vessel Operator, Geotek, and Port Management to create a Mobilization Management/Logistics Plan including: Personnel (numbers and departure plan): Cranage; Supply boats: vessel, sea-fastening requirements, supply list, electrical hook up, order for loading and unloading; and deck layout of containers on the supply boat; and deck layout of the containers on the drilling vessel. Figure 13-1 shows a portion of an example Port of Call plan.

The UT Drilling Representative and Vessel Operator will coordinate port logistics to ensure equipment arrives at the proper time and in the proper manner.

13.1.1.3 Trucking/Transport/Shipping

Arrangement for trucking of containers and equipment to the port (shore-based facility) will be the responsibility of the equipment owner/user. Prior to trucking, containers & contents will be properly secured for shipment and for offshore lifting. 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 Vessel Operator will coordinate trucking delivery with the Vessel Operator, 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 certification for offshore lifting (DNV) for the duration of the expedition.

13.1.1.4 Equipment

All Geotek container/van logistics will be handled by Geotek, this includes but is not limited to shipping from UK, customs, storage, inspection, 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. If these two containers/vans are stored at UT prior to the deployment, UT will be responsible. Timing for mobilization will be developed in conjunction with Vessel Operator, UT Drilling Representative, UT, and Geotek.

UT will be responsible for vans and equipment related to biochemistry sampling (mud lab), which may be outsourced to a 3rd party vendor or Geotek.

UT will also be responsible for the 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.).

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

UT will be responsible for supplies and equipment related to Pore Water sampling. UT will be responsible for providing a safe container lab with fridge, freezer (tbd, power, water, and drainage) for the pore water sampling work.

All equipment removed from a container while onboard will be stamped/stenciled/painted with "Property of UT."

13.1.1.5 Containers

Five 20 ft baskets will be required for pipe, collars, Geotek chillers, and Geotek cold shuck. See Table 13-1 below.

Pressure core operations and analysis will require 5 containers. Geotek will require a 40 ft container for the PCTB. Geotek will require a 40+20 ft container for PCATS operations. Geotek will also have and 20 ft container for degassing and a 20 ft trailer for computer work and gas analysis.

Conventional core operations will require 5-6 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. Geotek will provide a 40 ft container for MSCL-IR, 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 1-2 containers (size TBD) for porewater squeezing and analysis. UT or Geotek will provide a 20 ft container for conventional 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.

Table 13-1 Onboard 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	Activities	Mobilization/ demobilization	Required Vessel Hook-up
Narrow Pipe	20' basket	Narrow pipe for PCTB-FB	Same as GOM2-1		Onboard, via supply boat	None
Wide Pipe	20' basket	Wide pipe for PCTB-CS	Same as GOM2-1		Onboard, via supply boat	None
Collars	20' basket	Collars	Same as GOM2-1		Onboard, via supply boat	None
Cold	20' basket	Cold Shuck, and cold bath transport	Same as GOM2-1		Only required for supply boat transfer	None
Chillers	20' basket	Geotek Chillers	Same as GOM2-1		Onboard, via supply boat	Power
PCTB Van	40' container	PCTB coring	Same as GOM2-1	Some PCTB assembly, autoclave extraction	Onboard, via supply boat	Power, Water
CC Tools	20' container	Conventional Coring	NEW	Geotek-APX/XCB parts and supplies	Onboard, via supply boat	Power?
PCATS11	40' container	PCATS Analysis	Same as GOM2-1	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside	Power, water, drain/sediment waste trap
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2-1	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside	
G9	20' container	Gas Chromatography, Data Processing	Same as GOM2-1	CT image processing, GC analysis, Geotek office	Onboard, via supply boat, remobilize dockside	Power, water?
R17	20' container	Pressure Core storage and degassing	Same as GOM2-1	Pressure Core Storage, quantitative degassing	Onboard, via supply boat, remobilize dockside	Power, water?
CC Storage	20' container	Conventional Core Storage	NEW	Conventional core storage racks, and core transport	Onboard, via supply boat, send to Stratum Reservoir, then dockside, then archival halves to storage facility	Power
Core Processing Lab	40'	Geotek Whole Core Processing Laboratory	NEW	On-Board: Whole core sectioning, MSCL-IR scanning Dockside: Split core description, curation	Onboard, via supply boat, remobilize dockside	Power, water?
PC Storage	20'	*Possible* additional storage space for additional SC350's	NEW	Cold PC storage	Onboard via supply boat, remobilize dockside	Power
Mud Lab	20' container	Microbiology, M&D	Same as GOM2-1	Whole Core cutting under N2, Microbiology and M&D sample handling	Onboard, via supply boat, remobilize dockside	Power, water, drain/sediment waste trap
PW Lab	TBD	Pore Water Laboratory	NEW	Pore water, sqeezing, analysis, and storage	Onboard, via supply boat, remobilize dockside	Power, water, drain/sediment waste trap
3rd Party Conex	20' container	UT Office Space	Same as Gom2-1	Writing, Data Analysis	Onboard, via supply boat, remobilization dockside is TBD	Power, network, internet, desk

13.1.2 Personnel

13.1.2.1 Training

All personnel, prior to arriving on the vessel, will have completed all training and certifications required by their company and the Vessel Operator (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 prior arriving at the heliport for travel to the rig.

13.1.2.2 Travel to Heliport

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

13.1.2.3 Travel to Rig

Transport of personnel between the heliport/shore-based facility and the rig will be coordinated between the UT Drilling Representative and the Vessel Operator. 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.

13.1.2.4 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.

13.1.2.5 Rig Pass Cards

Documentation denoting completion of the Rig Pass training program will be supplied by all personnel to the Vessel Operator, as required.

13.1.2.6 Luggage limits

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

13.2 Onboard during Execution

13.2.1 Supplies and Equipment

13.2.1.1 Dockside Support

Shipment of supplies and equipment will be coordinated between the Vessel Operator and the Dockside Dispatcher with input from the UT Drilling Representative.

13.2.1.2 Supply Vessels and Crew Boats

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

13.2.2 Personnel

13.2.2.1 Safety Management System

All personnel on-board the vessel will follow the Vessel Operator'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 Vessel Operator and UT. The highest standard will be followed.

13.2.2.2 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.

13.2.2.3 Shifts

All personnel will work a 12-hour shift. Shifts for the science team and Geotek will be coordinated prior to deployment. Vessel Operator 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.

13.3 Stage 1 Demobilization (from Vessel) and Remobilization Dockside

13.3.1 Designated Port

Location: TBD depending on which dockside service provider was chosen; most likely Port Fourchon, Louisiana.

Port of call plan: UT will work with Geotek, the Vessel Operator, and Port Management to create a Stage 1 Demobilization Management/Logistics Plan including: Personnel (numbers and departure plan); Cranage requirements; Supply Boats: vessel, sea fastening plan, supply list, electrical hook up, order of loading and unloading, and deck layout of containers on the supply boat; Dockside Container Layout including order of hook up at the dock and deck layout of the containers at the dock, power generators, fuel bowsers, etc. Figure 13-1 shows a portion of an example demobilization Port of call plan.

13.3.2 Containers

Pressure and conventional core processing will continue dockside.

Pressure core operations and analysis will require 4 containers to be remobilized dockside. Geotek will have a 40+20 ft container for PCATS operations and storage chamber storage. Geotek will also have and 20 ft container for degassing and a 20 ft trailer for computer work and gas analysis. The Geotek 40 ft trailer for the PCTB will be transferred to a TBD location for cleaning and preparation for long term storage. There is a possibility we will require Geotek to supply a 20’ cold storage container for additional SC_{350}’s.

Conventional core operations may require up to 6 containers, 5 remobilized and one new. Geotek will provide a new (not from the vessel) 20 ft trailer for MSCL scanning. The Geotek 40 ft container for the IR track will be remobilized and repurposed for core splitting and analysis. The conventional core storage will be sent to Stratum and returned dockside for remobilization and use. UT’s 20 ft container for whole round sampling and may need to be remobilized (TBD).

The UT 20 ft Office may need to be remobilized (TBD).

All containers require dunnage, which will be provided by the dockside operator (contracted through the vessel). PCATS and the mud lab require drainage to a stillage. The dockside operator will provide the stillage.

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

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	Activities	Mobilization/ demobilization	Required Supply boat hook up	Required Dockside Hook-up
PCATS11	40' container	PCATS Analysis	Same as GOM2-1	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside	None	Power, water, drain/sediment waste trap
PCATS8	20' container	PCATS Autoclave and storage vessel handling	Same as GOM2-1	Pressure core imaging, scanning, cutting, and transfer	Onboard, via supply boat, remobilize dockside	Power	
G9	20' container	Gas Chromatography, Data Processing	Same as GOM2-1	CT image processing, GC analysis, Geotek office	Onboard, via supply boat, remobilize dockside	None	Power, water?
R17	20' container	Pressure Core storage and degassing	Same as GOM2-1	Pressure Core Storage, quantitative degassing	Onboard, via supply boat, remobilize dockside	None	Power, water?
CC Storage	20' container	Conventional Core Storage	NEW	Conventional core storage racks, and core transport	Onboard, via supply boat, send to Stratum Reservoir, then dockside, then archival halves to storage facility	Power	Power
Core Processing Lab	40'	Geotek Whole Core Processing Laboratory	NEW	On-Board: Whole core sectioning, MSCL-IR scanning Dockside: Split core description, curation	Onboard, via supply boat, remobilize dockside	None, unless freezer/fridge is transported inside	Power, water?
PC Storage	20'	*Possible* additional storage space for additional SC350's	NEW	Cold PC storage	Onboard via supply boat, remobilize dockside	Power	Power
Mud Lab	20' container	Microbiology, M&D	Same as GOM2-1	Whole Core cutting under N2, Microbiology and M&D sample handling	Onboard, via supply boat, remobilize dockside	None, unless freezer/fridge is transported inside	Power, water, drain/sediment waste trap
PW Lab	TBD	Pore Water Laboratory	NEW	Pore Water Sqeezing, Analysis, and storage	Onboard, via supply boat, remobilize dockside	None, unless freezer/fridge is transported inside	Power, water, drain/sediment waste trap
3rd Party Conex	20' container	UT Office Space	Same as Gom2-1	Writing, Data Analysis	Onboard, via supply boat, remobilization dockside is TBD	None	Power, network, internet, desk
MSCL	20' container	Core Scanning	NEW	Conventional Whole and split core scanning	Dockside only	None	Power, water?
Overpack	20' Reefer	Overpack reefer truck	Same as GOM2-1	Pressure Core Transport	Dockside only	Power	None
Gen1		Power Generator #1	Same as GOM2-1		Dockside only		None
Gen2		Power Generator #2	Same as GOM2-1		Dockside only		None
Fuel		Fuel Bowser	Same as GOM2-1		Dockside only	None	None

13.3.3 Personnel

13.3.3.1 Helicopters

Transport of personnel via helicopter will be coordinated between the UT Drilling Representative and the Vessel Operator. Helicopter trips will be scheduled/coordinated at maximum efficiency to reduce costs.

13.3.3.2 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.

13.3.4 Materials and Equipment

13.3.4.1 Disembarking Materials and Equipment

The Vessel Operator 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 demobilization port (e.g. Port Fourchon). Prior to backloading any Geotek equipment, Geotek will lead and UT will support a complete inventory of all their 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.

13.3.4.2 Equipment left onboard

Should equipment be accidently left onboard the drilling vessel; UT will work with the Vessel Operator to ensure timely delivery to port of call.

13.3.4.3 New Equipment

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

13.3.4.4 Waste

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

13.4 Dockside Core Processing

13.4.1 Site Plan

Dockside container layout will be as per the Stage 1 Demobilization Management/Logistics 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.

13.4.2 Samples and Cores

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

13.4.3 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.

13.4.4 Personnel

13.4.4.1 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.

13.4.4.2 Shifts

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

13.4.4.3 Supplies and Equipment

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

13.4.4.4 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.

13.4.4.5 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.

13.5 Stage 2 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.

Activities & Time Line				
Date	**Time**	**Description**	**Location**	**Responsible / Comments**
SUMMARY				
		Main Objectives for this stage of the plan: • Shut down and pack equipment for offloading • Test and confirm services on supply boat • Prepare samples for transit to port • Offload all equipment onto supply boat • Return to port to complete Stage 2		
TIMELINE				
		Day 1 Demob		
Actions in RED will need the ship's crane				
Times are all relative to a hypothetical start time of 08:00 on Day 1 of Demob, with each day having 24 hours of ops.				
Numbers [in brackets] refer to the offload plan				
Day 1	08:00	Commence operations – briefing and toolbox meeting	On Q4000	Geotek/Helix
		Load empty 20' basket from supply boat to Q4000, place next to drill deck.		
		Remove cold shuck & place in supports then into 20' basket	On Q4000	Geotek/Helix
		Remove all air, water and ethernet services and pack in 20' basket	On Q4000	Geotek
		Commence packing of all containers	On Q4000	Geotek
		Move UT freezer into PCTB van	On Q4000	Geotek/Helix
		Move small chillers from drill deck to 20' basket	On Q4000	Geotek/Helix
		Secure PCATS manipulator	On Q4000	Geotek/Helix
		Load cold bath into 20' basket	On Q4000	Geotek/Helix
		Offload Narrow pipe basket [1]	On Q4000	Geotek/Helix
		Offload Wide pipe basket [2]	On Q4000	Geotek/Helix
		Offload UT Mud van [3]	On Q4000	Geotek/Helix
		Offload Wide pipe basket [4]	On Q4000	Geotek/Helix
		Offload PCATS11 [5]	On Q4000	Geotek/Helix
		Continue packing and preparing remaining vans	On Q4000	Geotek/Helix
		Day 2 Demob		
Actions in RED will need the ship's crane				
Times are all relative to a hypothetical start time of 08:00 on Day 1 of Demob				
		Transfer 2 x Geotek personnel to supply boat	On Q4000	Geotek/Helix

Figure 13-1. Portion of example Port of Call document.

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
IODP	Integrated Ocean Drilling Program
IR	Infrared
JIP	Joint Industry Project
JR	JOIDES Resolution
LA	Louisiana

ACRONYM	DEFINITION
lb	pounds
LDEO	Lamont-Doherty Earth Observatory
LWD	Logging While Drilling
m	meter
m/s	meter per second
MD	Measured Depth
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

ACRONYM	DEFINITION
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
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., Boswell, R., Mrozewski, S. A., Guerin, G., Cook, A., Frye, M., Shedd, W., and McConnell, D., 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.

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.

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 Methods, *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.

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., Pettigrew, T., Mimitz, M., Holland, M., and Schultheiss, P., in review, Pressure-coring operations during Expedition UT-GOM2-1 in Green Canyon Block 955, northern Gulf of Mexico: American Association of Petroleum Geologist Bulletin.

Appendix D

Internal Memo: PCTB vs. HPTC Pressure Coring Tool for UT-GOM2-2 (DE-FE0023919)

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

THE UNIVERSITY OF TEXAS AT AUSTIN
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To: PCT Development Team

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

1. Summary

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

2. Background

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

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

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

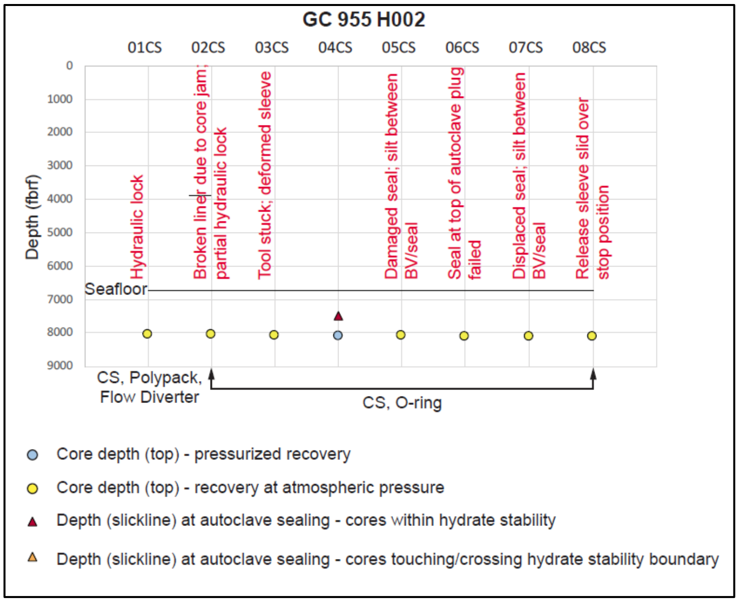

Figure 1: Tool configuration and failure mechanism for pressure cores at H002. 8 pressure cores were taken. Only one pressure core held pressure. Figure from (Flemings et al., 2018).

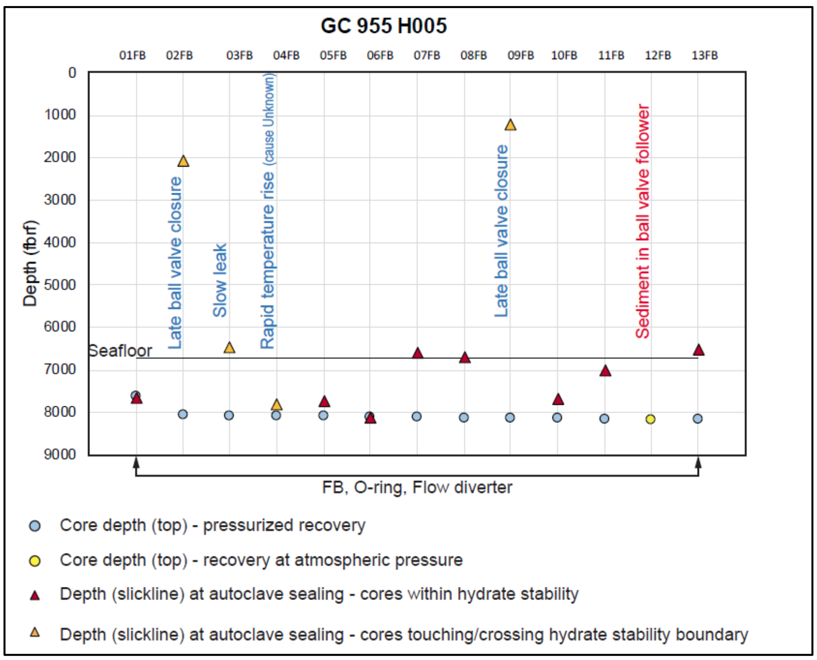

Figure 2 Tool configuration and failure mechanism for pressure cores at H005. 13 pressure cores were taken. Figure from (Flemings et al., 2018).

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

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

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

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

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

3. Review of PCTB and HPTC-III performance

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. Decision: Move forward with the PCTB_CS and PCTB_FB

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

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

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

5. References

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.

Appendix E

Final Report
Pressure Coring Tool with Ball (PCTB)
Computational Fluid Dynamics Analysis

Pettigrew Engineering, PLLC

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

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Final Report
Pressure Coring Tool with Ball (PCTB)
Computational Fluid Dynamics Analysis

Tom Pettigrew, PE
9 January 2020

Final Report
Pressure Coring Tool with Ball (PCTB) Computational Fluid Dynamics Analysis

Overview

Collapse of the Pressure Coring Tool with Ball (PCTB) inner tube and core liner have been experienced during both laboratory and field testing. A better understanding of the fluid dynamics within the PCTB while coring was needed to identify areas of high pressure drop that potentially lead to collapse of internal components. A better understanding of the fluid dynamics within the PCTB may also aid in determining the cause of boost pressure loss, autoclave sealing, and ball closure issues.

The complex internal structure of the PCTB does not lend itself to analyzing the fluid flow via hand calculations. Thus a computer based computational fluid dynamics (CFD) analysis was commissioned with Reaction Engineering International (REI) in Salt Lake City, Utah. Geotek Coring, Inc. (GCI), in Salt Lake City, Utah, provided the necessary three-dimensional mathematical models of the PCTB suitable for incorporation into the CFD software. Reference **Appendix A**, "Statement of Work, Pressure Coring Tool with Ball Computational Fluid Dynamics Analysis".

Modeling

A "kickoff" meeting was held at REI on March 13, 2018 with GCI and Pettigrew Engineering (PE) personnel in attendance. It was determined that the GCI PCTB 3-D drawings archive was incomplete. GCI was contracted to complete their PCTB 3-D drawing archive and deliver a complete 3-D math mathematical model of the PCTB, in its current configuration and in SolidWorks® format, to REI for use in their CFD analysis (**Appendix B**, "Geotek Coring Inc. Task 1 Summary"). The commercial SolidWorks Flow Simulation software package was used for the CFD analysis.

Phase I CFD Analysis

The Phase I CFD Analysis consisted of constructing a baseline CFD model and then vetting it. The baseline CFD model was created in SolidWorks Flow Simulation and then the following inputs were applied.

1. Sea water flowing at 20 gpm with a simulated hydrostatic pressure of 2,000 psi. The model was static, i.e., no rotation was imparted to the tool.

2. Sea water flowing at 20 gpm with a simulated hydrostatic pressure of 2,000 psi. The model was dynamic, i.e., a rotation of 80 rpm was imparted to the parts of the tool that move relative to one another during actual coring operations.

3. Sea water flowing at 120 gpm with a simulated hydrostatic pressure of 2,000 psi. The model was static, i.e., no rotation was imparted to the tool.

Hand calculations were preformed to analyze flow rates and pressure drops at specific points within the PCTB and then compared to the CFD model predictions to vet it. Reference **Appendix C,** "PCTB CFD Analysis Phase I - Methods and Results Summary Report".

Phase II CFD Analysis

The Phase II CFD Analysis was devised to establish the linear relationship of the PCTB internal pressure drops with changes in fluid viscosity. For comparison, the Phase I CFD analysis static simulation with a sea water flow rate of 120 gpm and a simulated hydrostatic pressure of 2,000 psi was used. However, the fluid was changed from sea water to 10.5 ppg drilling mud. The Phase II CFD analysis results indicted only a small increase in the maximum predicted pressure differential. Reference **Appendix D**, "PCTB CFD Analysis Phase II – Methods and Results Summary report.

PCTB CFD Analysis Discussion

The PCTB CFD model was configured with the diverter system introduced during the U.S. Department of Energy (DOE)/University of Texas (UT) UT-GOM2-1 Marine Field Test, conducted 4 – 25 May 2017. The diverter system was designed to eliminate the high pressure differential across the inner tube and core liner associated with moderate to high flow rates through the PCTB and thus eliminating collapse of those structures. Prior to the introduction of the diverter system calculated and empirical data were used to determine upper flow rate boundaries to eliminate collapse. No collapse issues have been observed after introducing the diverter system. The Phase I CFD analysis indicated that the diverter system is working as designed and should eliminate all future collapse issues.

Little change in the predicted pressure drops were observed with the dynamic simulation.

Detailed review of the Phase I CFD analysis results did not produce any further insight into boost pressure loss, autoclave sealing, or ball closure issues.

During Phase I the CFD model was fully vetted and the simulation results not only were much as expected but also confirmed the operation of the diverter system. The Phase I results indicated a liner relationship between flow rate and pressure drop thus eliminating the need for analysis of the full flow variable matrix originally proposed. After detailed review and discussion of the Phase I results the decision was made to produce a single simulation to establish the pressure drop relationship with a change in fluid viscosity.

The Phase II CFD analysis results indicated only a small increase in the pressure drop with the higher viscosity drilling mud. It was determined that the predicted pressure drops at typical coring parameters will be well within the capability of the inner tube and core liner to resist collapse. Thus no further CFD simulations were deemed necessary.

Appendix A

Statement of Work
Pressure Coring Tool with Ball Computational Fluid Dynamics Analysis

Revision: 1 2 August 2018

<u>Introduction</u>

The University of Texas at Austin is in need of a Computational Fluid Dynamics (CFD) analysis of a Pressure Coring Tool with Ball (PCTB). The PCTB is a proprietary coring tool of Geotek Coring Incorporated. The PCTB is undergoing upgrades, and subsequent land and sea testing, via a Department of Energy program with the University of Texas at Austin as the primary investigator. The PCTB will primarily be used to recover gas hydrate cores at near in situ pressures offshore in the Gulf of Mexico.

<u>PCTB Description</u>

The PCTB is a coring tool typically deployed offshore from a floating drilling vessel. The PCTB is deployed through the drill string via wireline and locks into a specially configured Bottom Hole Assembly (BHA). The BHA is the bottom end of the drill string and is made up of a special coring drill bit, heavy wall drill pipes called drill collars, and the required subs to incorporate a landing and latching point for the PCTB. The complete PCTB assembly is approximately 43 feet long and 3-1/2 inches in dimeter.

The PCTB has two coring configurations referred to as "Face Bit" and "Cutting Shoe". During coring operations with either PCTB configuration, the PCTB is rotated via the drill string by a top drive or rotary table on the drilling vessel while fluid is pumped down the drill sting into the BHA. The fluid flow passes through (inside the PCTB) and around (between the PCTB outside diameter and the BHA inside diameter) portions of the PCTB eventually exiting the BHA via the drill bit nozzles and PCTB ports. The fluid pumped varies in flow rate, density, viscosity, and pressure, depending on the formation conditions.

In the case of the PCTB face bit configuration, the main coring drill bit cuts the core as the borehole is advanced. As the core is being cut, it moves through the coring drill bit and up inside the PCTB. Although the PCTB is rotating with the BHA and drill bit, the PCTB inner core barrel is bearinged such that it does not rotate relative to the incoming core.

In the case of the PCTB cutting shoe configuration, the main coring drill bit advances the borehole while the cutting shoe cuts the core. As the core is being cut, it moves through the cutting shoe and up inside the PCTB. Although the PCTB is rotating with the BHA and cutting shoe, the PCTB inner core tube is bearinged such that it does not rotate relative to the incoming core.

<u>CFD Analysis Description</u>

The CFD analysis is required to determine the pressure changes throughout the PCTB, in the coring configuration inside the BHA, at various flow rates, flow pressures, fluid viscosities, and fluid densities. Plots of the pressure changes shall be developed for key areas of interest. Table 1: PCTB CFD Analysis Variables Matrix, shows the range of fluid characteristics to be analyzed.

Given that the PCTB Face Bit and PCTB Cutting Shoe configurations are identical except for the PCTB bottom end and coring drill bit, the CFD analysis will focus on only one of the configurations. However, some runs of the CFD analysis utilizing the other PCTB configuration are required to establish a comparison of the two configurations.

Changes to the CFD variables matrix may occur based on early results of the analysis. Minor changes to the three dimensional model, representing potential modifications to the PCTB, may occur based on results from the analysis and thus further analysis may be required.
A complete three dimensional model of the PCTB, in SolidWorks format, in the coring configuration with BHA, will be provided for integration into the CFD analysis model.

CFD Analysis Deliverables

1. Copies of all plots and data generated during the CFD analysis process.
2. Written report detailing how the analysis was conducted and archiving all data generated.

Technical Contact

For answers to any technical questions that may arise please contact,

Tom Pettigrew
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Table 1: PCTB CFD Analysis Variable Matrix

PCTB CFD Analysis Variable Matrix
Revision: 2 16 November 2018

Fluid	Viscosity (cP)	Density (lb/gal)	Temperature (F°)
Sea Water	1	8.6	50
Water Based Mud	9	9.5	50
Water Based Mud	12	10.5	50
Water Based Mud	(20)	(11.5)	(50)

Bottom Hole Pressure (psi)

Flow Rate (gpm)	1000	2000	3000	4000	5000	6000
10						
20		X		X		(X)
40						
100		X		X		(X)
200						
300						
400		X		X		(X)
500						
600						

Notes:
1. TBD = variables to be determined and supplied at a later date
2. Bottom Hole Pressure = the ambient pressure surrounding the BHA during coring operations
3. (X) = variables to be considered after initial runs

Appendix B

Geotek Coring, Inc. Task 1 Summary

TASK 1 SUMMARY

As requested by the University of Texas, Geotek Coring Inc. facilitated a computational fluid dynamics study (CFD) of the PCTB III by Reaction Engineering International (REI). This study was performed to assess the effect of flowing drilling fluid on the actuation function of the PCTB III, and to determine any corrective action which might be necessary.

Accurate CFD required precise three-dimensional renderings of each of the individual components of the PCTB III as well as the bottom hole assembly. Geotek mechanical engineering staff used the Solidworks CAD platform to produce fully-detailed 3D models of the 231 parts, which were then placed into functioning assemblies.

To ensure correct 3D rendering, Geotek engineering staff also provided advisement to REI over the course of the modeling project. In-person meetings were held on four occasions, at both the offices of REI and of Geotek Coring, to give background and shed further light on the operating conditions encountered in the downhole environment. Additionally, as the CFD study progressed, Geotek staff participated in multiple remote teleconferences with REI to clarify questions as they arose.

After REI produced a working flow rendering, Geotek staff reviewed draft and finished items for accuracy, tracing found flow paths to ensure congruity with the existing tool as well as to interpret findings from the completed CFD analysis.

Models of the PCTB III were provided in confidence as Geotek intellectual property.

Appendix C

PCTB CFD Analysis Phase I - Methods and Results Summary

Overview

A baseline computational fluid dynamics (CFD) model was created to simulate the flow of sea water through the PCTB coring tool developed by Geotek in this Phase I effort. While geometric specifics will not be given in this report to protect IP, the modeled geometry consists of a long pipe that is over 40 feet long and has an internal diameter of about 7 inches and hundreds of individual parts. The flow domain inside the pipe includes various complex obstructions, with the majority of the flow domain being annular in nature. The baseline simulations consider a 20 GPM and 120 GPM flow rate with a 2000 psi bottom-hole pressure. Both a completely stationary tool and a tool with the appropriate parts rotating at 80 RPM are considered for the 20 GPM flow rate, while only a stationary case was considered for the 120 GPM flow rate.

Methodology

The commercial SolidWorks Flow Simulation software package was used to perform steady-state CFD simulations. SolidWorks Flow was utilized for its unique CAD to mesh capabilities as Geotek provided the CAD files in the native SolidWorks format. This allowed for the extraction and meshing of the complex internal flow domain of the PCTB tool. SolidWorks Flow uses a cut cell type hexahedral mesher. A base grid of 8 x 8 x 65 cells was used, which resulted in elongated rectangular prism shaped cells with an aspect ratio of about 10:1:1, with the longest dimension being in the direction of the flow. A cross section of the inlet is shown in a front and a right view in Figure 1. This aspect ratio was applied in order to keep the mesh size manageable. Local refinement (up to 5 levels) was applied to achieve a reasonable number of cells across all the main gaps of the flow domain. The resultant mesh was approximately 2.5 million cells.

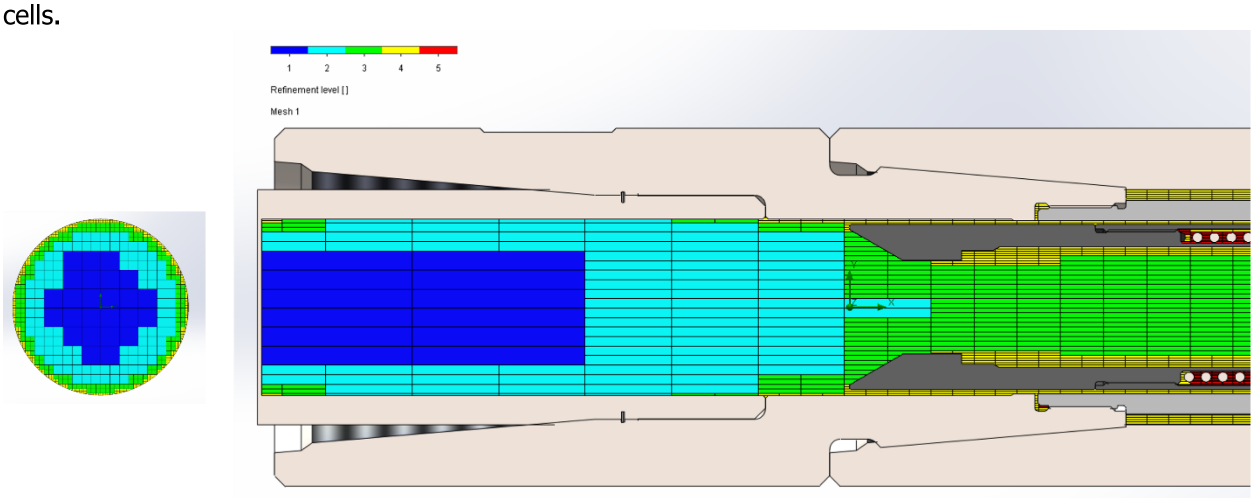


Figure 1: Cross section of the inlet depicting mesh resolution. Front view (left). Right view (right).

SolidWorks Flow uses an industry standard RANS (Reynolds Averaged Navier Stokes) realizable k-epsilon turbulence model with a control volume approach. For this Phase I effort the working fluid, sea water, was modeled as a Newtonian fluid with a density of 8.6 lb/gal and dynamic viscosity of 1.07 cP.

The inlet boundary condition was specified as a constant mass flowrate condition with a uniform velocity profile. For the 20 GPM and 120 GPM cases the prescribed mass flowrates were 2.8667 lb/s and 17.2 lb/s, respectively. An environmental pressure outlet was specified for each of the 5 nozzles at the end of the tool. The effects of gravity were included in the simulation with the tool oriented downward and gravity being 32.2 ft/s^2. The downhole pressure at the datum of the tool was specified to be 2000 psi; including the contribution of hydrostatic pressure, this resulted in the pressure specification at the nozzle outlets being approximately 2019 psi. The tool was modeled in coring mode and the central opening at the end of the tool was closed with a wall boundary condition, assuming that the incoming core would block the flow. For the 120 GPM case, the central opening was also modeled as an environmental pressure boundary condition to explore the effects of the opening being exposed the downhole pressure. All faces where the fluid domain is in contact with solid geometry were considered to be smooth walls with a no-slip boundary condition.

For the rotating case, a global reference frame was specified with a rotational rate of 80 RPM. All parts of the tool above the first set of bearings was modeled as rotating, while the inner assembly below the bearings was held stationary, as would be expected ideally in coring mode, and the outer portion of the tool was rotating. Additionally, for the rotating case, the inlet boundary condition had an 80 RPM rotational component added to it, so the velocity profile at the inlet would have no rotation relative to rotating reference frame (since the flow already had rotation imparted to it from the upstream piping which would also be rotating).

The simulations were run until several convergence criteria were satisfied. These included observing key quantities such as the pressure drop over the geometry, the average and maximum shear stresses, and the bulk average velocity in the domain. The mass flowrate at the inlet and outlet were also monitored to ensure that conservation of mass was satisfied. Convergence was determined once all these quantities reached an asymptote for several hundred iterations. Convergence required several thousand iterations, with substantially more for the rotating case.

A mesh refinement study was performed using SolidWorks Flow's built in adaptive mesh refinement tool to determine grid independence. Up to two levels of additional refinement were performed on the 2.5 million cell mesh in regions of high shear stress and large geometry curvature after convergence of the initial solution. The resultant mesh was about 4.8 million cells and the simulation was run to convergence again with the refined mesh. The results for pressure drop between the 2.5 million and 4.8 million cell meshes only differed by approximately 2% for the 120 GPM case. To keep solving times reasonable, the refinement level of the 2.5 million mesh was determined to be adequate for further simulations.

Results and Discussion

This discussion of the results that follows will be limited to mainly qualitative remarks as all contour and vector plots are contained in the accompanying PowerPoint presentation and include sensitive IP material and are not be reproduced here.

For the 20 GPM stationary case, the velocity field and flow trajectories all look reasonable and the flow traverses the geometry in the expected manner (e.g. speeding up through constrictions, following the engineered flow diverter paths, etc.). For this low flow rate case the pressure field is largely dominated by hydrostatic effects as the pressure drop required to drive the flow is only 3.6 psi while the hydrostatic pressure change over the length of the tool is 19.5 psi.

For the 20 GPM rotating case, the pressure field is very similar to the 20 GPM case, but the flow trajectories are different due to the rotation. In the reference frame relative to the rotating tool, there are local secondary rotating flows wherever there is a contraction or expansion due to the conservation of angular momentum. Also, flows with a relative tangential velocity component are observed in the lower section where one wall of the annular flow region is rotating, while the other is held fixed. While the effects of the rotation are interesting, they will become less influential as the flow rate increases since the axial component of the velocity will increase in relation to the tangential portion imparted by the rotating walls.

The 120 GPM stationary case has velocity fields that are very similar to those of the 20 GPM stationary case, albeit scaled up. The pressure drop required to drive the higher flow rate increases substantially, as expected, to 109.5 psi. Once the flow reaches the annular portion, the pressure in the annulus is greater than that in the inner core. A comparison of the three cases is summarized in Table 1.

Table 1: Summary of Simulation Results

Simulation Type	Mesh Size	Wall Time	Pressure Drop	Avg. Velocity	Predicted pressure drop annular flow (fully developed)
Stationary (20 GPM)	2.48 M	2.4 days	3.645 psi	0.841 ft/s	4.4 psi
Rotating (20 GPM)	2.68 M	7.6 days	3.285 psi	1.243 ft/s	
Stationary (120 GPM)	2.48 M	1.5 days	109.5 psi	5.066 ft/s	104.6 psi

A simplified major head loss analysis was performed to validate the flow solver assuming that the annular portion of the tool comprised the entire length of the tool, and that the flow was fully developed,

$$\Delta P = f\frac{L}{D_h}\frac{\rho V^2}{2} \#(1)$$

where f is the Darcy friction factor, L is the length of the domain, D_h is the hydraulic diameter, ρ is the fluid density and V is the average velocity. The Reynolds number used to obtain the friction factor from the Moody chart was based on the annular hydraulic diameter and prescribed flowrate. As seen in Table 1, the predicted pressured drop from the CFD simulations is quite close the head loss prediction, which is surprising considering the crude simplification of the geometry for the simplified head loss analysis. This analysis verifies that the pressure drop predicted from the CFD simulation is indeed in the correct range.

Fluid Structure Interaction Considerations

The pressure field from the CFD analysis was examined to identify any potential fluid structure interactions (FSI). For the 20 GPM flow rate, the pressures were small enough that no potential FSI were able to be observed. For the 120 GPM test there were a couple of areas where a large pressure differential could be identified. The first can be seen on the left of Figure 2, where the pressure differential across the lip seal is about 40 psi. The second can be seen on the right, where the pressure differential across the middle barrel is about 32 psi. However, a rough hoop stress analysis shows that the stress on middle barrel is due the pressure differential is orders of magnitude lower than its yield stress. These areas are not predicted to be problematic at the low flow rates, however Equation 1 shows that the pressure drop in the geometry scales roughly quadratically with the average velocity and therefore flowrate. Thus, these areas should be checked again in the higher flowrate simulations. For the case with the environmental pressure boundary condition applied to the central opening. The pressure throughout the core was essentially equal to the pressure specified at the outlet (approximately 2019 psi). This increases the pressure differential across the two identified areas to approximately 79 psi and 71 psi respectively. In reality, the pressure will be somewhere in between the two modeled conditions, as the boundary is not fully closed off, nor fully open. Thus, these two cases give a good estimate of the bounding region.

Specific subsets of the geometry can also be explored in more detail if the team identifies other potential areas of FSI in the Phase II effort.

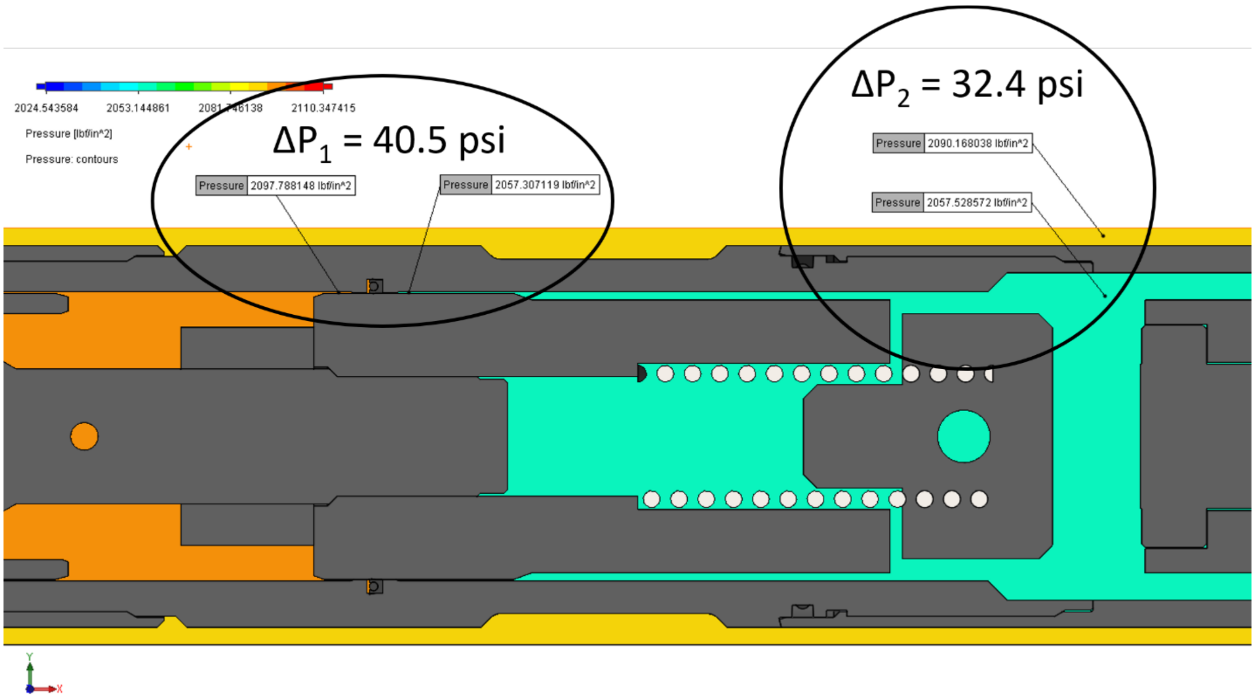


Figure 2: FSI potential locations.

Uncertainty Estimates

One source of uncertainty is due to the approximated roughness of the walls. The CFD model assumes smooth walls. In reality, all of the parts will have different finite roughness values throughout the tool, and/or buildup of debris may change the effective roughness during usage. The friction factor in Equation 1 is dependent on the roughness value, and from Eq. 1 it can be seen that the pressure drop scales linearly with the friction factor. While increasing wall roughness will increase the friction factor and therefore scale up the actual pressure drop and thus pressure field in the tool, the qualitative velocity profile is expected to remain the same.

Conclusions

Overall, the Phase I effort has produced a detailed CFD model of the complex PCTB geometry and demonstrated that reasonable results can be obtained for predicting flow and pressure fields throughout the tool. While the rotating results are more physically realistic, they come at an increased computational cost. Also, as flow rate increases, the influence of the rotating tool will become lessened. Modeling the tool as stationary drastically reduces the computational time and gives similar pressure results to the rotating case, which is useful in identifying potential FSI effects.

Appendix D

PCTB CFD Analysis Phase II - Methods and Results Summary

Overview

Additional simulations were performed in this Phase II effort in order to model the flow of drilling mud through the PCTB coring tool. The results were compared to the simulations carried out for sea water in the Phase I effort. The mud simulations consider the 120 GPM flow rate with a 2000 psi bottom-hole pressure. All simulations consider the stationary reference frame here.

Methodology

The same SolidWorks Flow model geometry and mesh that were set up for the Phase I simulations were used in the Phase II simulations as well (mesh size is approximately 2.5 million cells). See Phase I report for full details.

The inlet boundary condition was specified as a constant mass flowrate condition with a uniform velocity profile. For a 120 GPM volumetric flowrate, the prescribed mass flowrate was 21 lb/s for the given mud density of 10.5 lb/gal. An environmental pressure outlet was specified for each of the 5 nozzles at the end of the tool and at the central opening as well. The effects of gravity were included in the simulation with the tool oriented downward and gravity being 32.2 ft/s^2. The downhole pressure at the datum of the tool was specified to be 2000 psi; including the contribution of hydrostatic pressure, this resulted in the pressure specification at the nozzle outlets being approximately 2023 psi. All faces where the fluid domain is in contact with solid geometry were considered to be smooth walls with a no-slip boundary condition.

Several different viscosity models were exercised in order to best estimate the behavior of the drilling mud. Two different non-Newtonian models were used: the Bingham plastic (BP) and Herschel-Bulkley (HB) models. However, these models are limited to the laminar flow regime in SolidWorks Flow. The estimated Reynolds number in the annular portion of the tool is about 4000 if an effective viscosity of 16.1 cP is assumed. This indicated that the flow may be transitional, therefore, the Newtonian k-epsilon turbulent model was also used for comparison. The parameters for the different models used are shown in Table 2. These parameters were derived from the provided rheology data. Plots of the models against data are shown in Figure 3.

Table 2: Viscosity model parameters for drilling mud

Model	Parameters
Bingham Plastic (laminar)	PV: 15 cP, YP: 14 lbf/100ft^2
Herschel-Bulkley (laminar)	τ_0: 3.06 Pa, β: 0.724, K_{HB}: 0.128
Newtonian (turbulent k-ε)	μ: 16.07 Pa

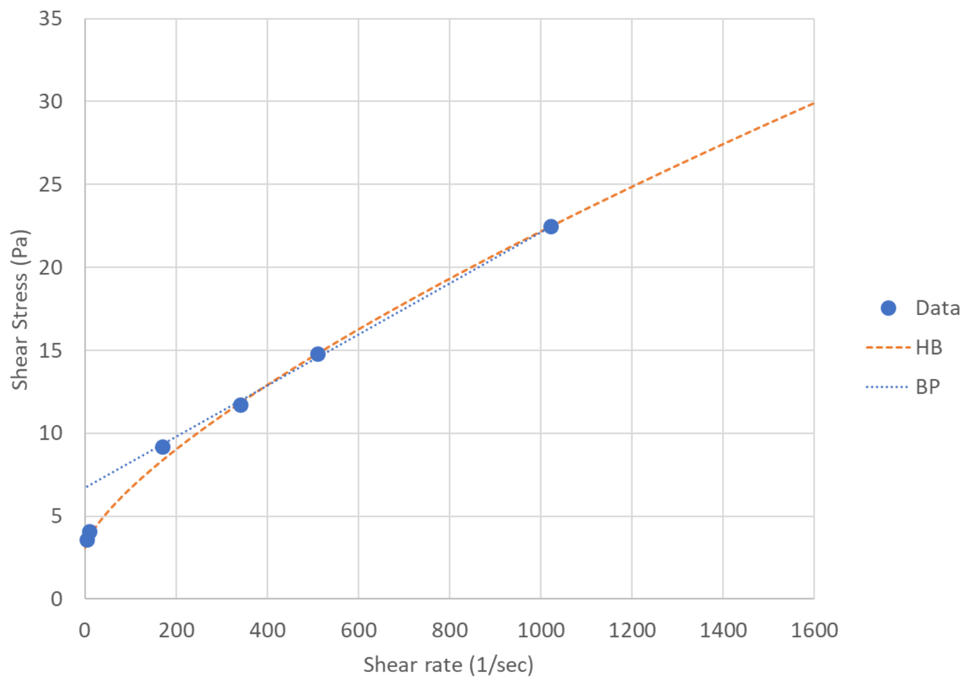


Figure 3: Viscosity models compared to rheology data for drilling mud

The simulations were run until several convergence criteria were satisfied. These included observing key quantities such as the pressure drop over the geometry, the average and maximum shear stresses, and the bulk average velocity in the domain. The mass flowrate at the inlet and outlet were also monitored to ensure that conservation of mass was satisfied. Convergence was determined once all these quantities reached an asymptote for several hundred iterations. Convergence required several thousand iterations.

Results and Discussion

Overall, the qualitative behavior of the velocity profiles and pressure field look similar to the sea water 120 GPM case. For contour plots of pressure and velocity, the accompanying presentation can be referenced. Here, the difference in the pressure drops required to drive flow through the tool will be discussed between the different models. Shown in Table 3 are the predicted pressure drops associated with the different models and their comparison to the sea water case. Of the two non-Newtonian laminar models, the Bingham Plastic model predicts a larger requisite pressure drop than the Herschel-Bulkley model. This is due to its larger predicted shear stress for lower shear rates and larger yield point (see Figure 3). The Newtonian turbulent model predicts the highest requisite pressure drop. All the models are within about 20% of each other and, as expected, all the models predict a higher pressure drop required for mud than for sea water.

Table 3: Comparison of the pressure drop to the sea water case for the various viscosity models.

Simulation Type	Fluid	Viscosity Model	ΔP	% Increase vs. water
Stationary (120 GPM)	Water	Newtonian (Turbulent)	105.5 psi	n/a
Stationary (120 GPM)	Mud	Bingham Plastic (Laminar)	142.0 psi	34.6%
Stationary (120 GPM)	Mud	Herschel-Bulkley (Laminar)	124.9 psi	18.4%
Stationary (120 GPM)	Mud	Newtonian (Turbulent)	153.5 psi	45.5%

Fluid Structure Interaction Considerations

The pressure field from the CFD analysis was examined to identify any potential fluid structure interactions (FSI). For the 120 GPM sea water test, there were a couple of areas where a large pressure differential could be identified. These same locations were examined for the Bingham Plastic mud case as well. The pressure differentials were only marginally higher for the mud in these locations (see Figure 2).

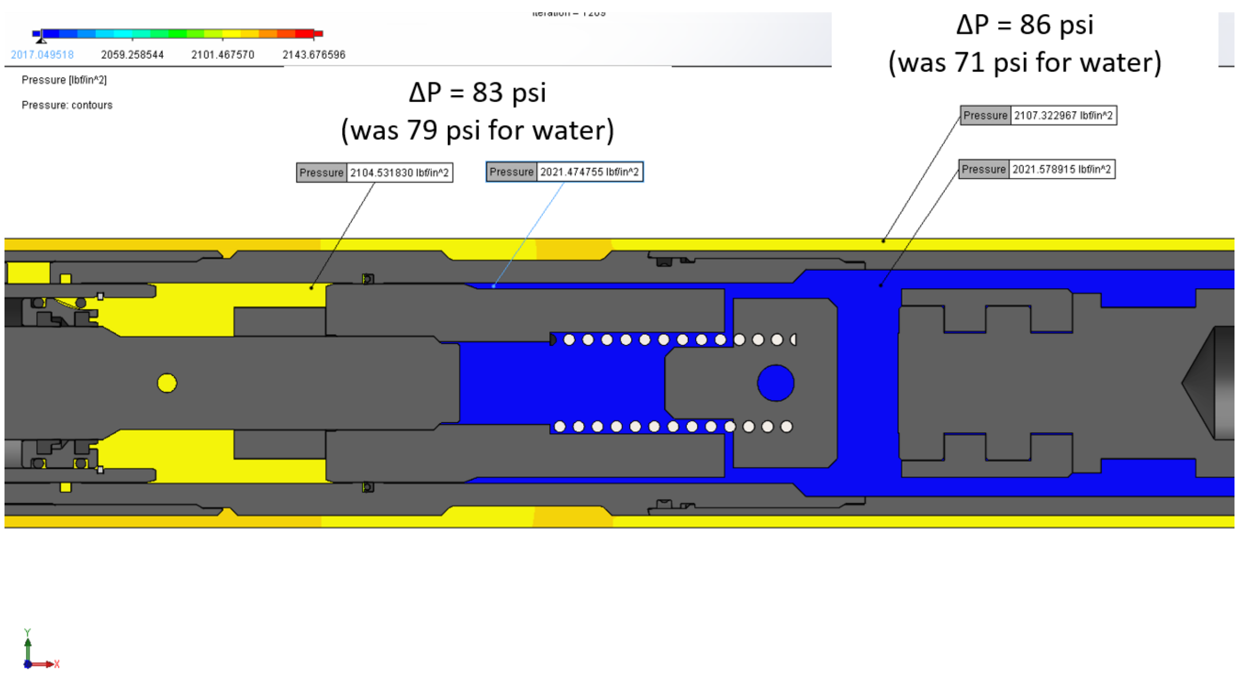


Figure 4: FSI potential locations.

Uncertainty Estimates

Some uncertainty arises from the flow being in the transitional regime as well as the fluid being non-Newtonian. Therefore, the different models were run so there could be some estimate of this uncertainty. For pressure drop, the difference between the models is roughly 20%.

Another source of uncertainty, as discussed in the Phase I report, is due to the approximated roughness of the walls. The CFD model assumes smooth walls. In reality, all of the parts will have different finite roughness values throughout the tool, and/or buildup of debris may change the effective roughness during usage.

Conclusions

Overall, the Phase II mud simulations have given an estimate of the pressure drop and flow fields if drilling mud was used instead of water for the working fluid. Compared to sea water, the qualitative mud profiles look similar. The required pressure drop to drive mud is predicted roughly to be 20-45% higher than that for sea water.

Appendix F

Pressure Coring Tool with Ball Laboratory Pressure Actuation Test II Report
Geotek Coring, Inc., Test Facility, Salt Lake City, Utah
13 May – 17 May 2019

Pettigrew Engineering, PLLC

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin

Pressure Coring Tool with Ball Laboratory Pressure Actuation Test II Report
Geotek Coring, Inc., Test Facility, Salt Lake City, Utah
13 May – 17 May 2019

Tom Pettigrew
Pettigrew Engineering, PLLC
10 June 2019

Introduction

This report covers laboratory pressure actuation testing (PAT) of the Pressure Core Tool with Ball (PCTB) as witnessed at Geotek Coring, Inc. (GCI) during the week of 13 May 2019. For convenience the PATs witnessed during the week are labeled as PAT #1, PAT #2 . . . PAT #8. Detail accounts of the PATs can be found in Appendix A: Daily PCTB PAT Test Reports. It is suggested that the daily reports be perused prior to perusing this report. Pressure plots comparing the simulated hydrostatic pressure to the PCTB autoclave internal pressure can be found in Appendix B: PCTB PAT Pressure Plots.

GCI Test Facility

This series of PATs was the first use of the new GCI test facility. The test facility provides the ability to test the fully assembled PCTB in a mock BHA with a simulated hydrostatic environment up to 5,000 psi. The test medium can also be circulated through the test chamber while under pressure. A lubricator allows for fulling stroking of the PCTB from closure of the ball valve through release from the mock BHA while maintaining the simulated hydrostatic pressure and circulation.

Some initial teething pains were experienced during the outset of testing. However, manipulating the test facility soon became routine and the PATs were carried out in an expeditious manner. Safety was paramount and the PATs were carried out with no incidents even while training was underway.

The test facility proved to be very valuable in providing a better understanding of the PCTB function in ways that had not been possible during previous laboratory testing or deployments. The tests were performed expeditiously and safely.

PCTB Configuration

The PCTB used during the tests was configured with the new "single trigger" boost mechanism and flow diverter. Also, a shear rod had been added to the PCTB that provided for a time dwell period immediately after the ball valve actuation spring is released closing the ball valve. The intent of the shear rod is to provide additional time for the ball valve to fully close and seal prior to introducing the boost pressure to the autoclave.

Ball Closure, Sealing

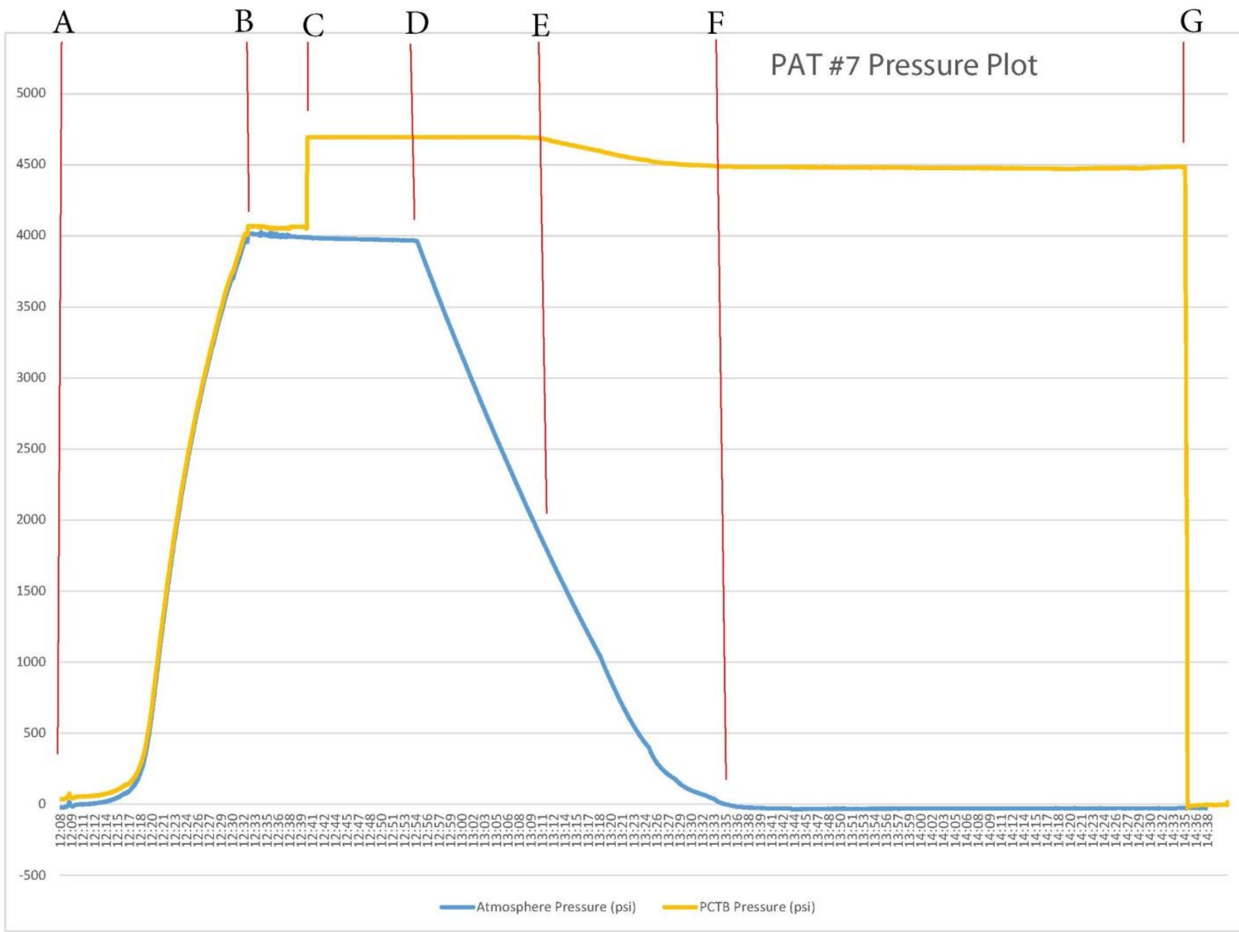
No issues with sealing, ball closure, or loss of boost pressure occurred during testing except for PAT #6. The boost pressure was trapped and retained during all testing except for PAT #6. PAT #6 was a failed test due to a mechanical malfunction.

Single Trigger Mechanism

The fact that the single trigger boost mechanism worked as designed during the testing is only an indication that it is working properly. It does not necessarily mean that it is a fix for lost or late boost since in all previous laboratory testing the original by-pass port, triggered by a separate mechanism, functioned flawlessly as well. Further field testing and/or deployments should clarify the viability of the single trigger boost mechanism aid in the capture and retainment of boost pressure over the original by-pass port mechanism. In any case, the single trigger mechanism is a more robust mechanism and simplifies the PCTB assembly process.

<u>Autoclave Compliance</u>

A retained boost pressure drop was observed and attributed to compliance of the autoclave. This is best seen in the annotated PAT #7 pressure plot below.



<u>Figure 1: PAT #7 Pressure Plot</u>

Section A-B of the pressure plot shows the simulated hydrostatic and autoclave pressures increasing together as the test fixture is brought up to a simulated hydrostatic test pressure of 4,000 psi. Note that the autoclave pressure data was gathered via a DST located inside the autoclave and the simulated hydrostatic pressure data was gathered via a DST installed in the test fixture fluid supply line. The pressure data sampling rate was 2 seconds.

Section B-C of the pressure plot shows the dwell that occurred once the test fixture was at the simulated hydrostatic test pressure during which the system was held steady for approximately 10 minutes to allow for the collection of pressure data.

Point C of the pressure plot shows the boost firing during actuation of the PCTB.

Section C-D of the pressure plot shows a second dwell period to collect pressure data where the system was held steady.

Section D-F of the pressure plot shows the simulated hydrostatic pressure being slowly bled off to simulate pulling the PCTB up hole via wireline during recovery.

Section E-F of the pressure plot shows the boost pressure drop thought to be due to autoclave compliance.

Section F-G of the pressure plot shows another dwell period to collect pressure data where the system was held steady.

Note that while the simulated hydrostatic pressure is dropping (section D-F) the retained boost pressure dropped (section E-F) until all of the simulated hydrostatic pressure was bled off. The drop in the retained boost pressure is thought to be due to autoclave compliance. As the simulated hydrostatic pressure drops, the "inside to outside" autoclave pressure differential increases causing the autoclave to expand. Autoclave calculations (Appendix C: PCTB Autoclave Volume Change Calculations) were made at a differential pressure of 4,500 psi resulting in an autoclave volume change of 2.288 in^3 (37.5 cc). This is the only substantial volume change that can occur once the autoclave is completely closed and sealed. Note that there is a volume change of ~3.402 in^3 (55.7 cc) that occurs while the upper seals are pulled into the seal sub until the pawls expand and engage the seal sub. However, this volume change is compensated for by flow into the autoclave via the by-pass port until the by-pass port is closed.

When the PCTB is deployed, the hydrostatic pressure will force the boost accumulator separator piston to the top of the boost accumulator compressing the air trapped above the separator piston between the sleeve valve and separator piston. Similarly, the air trapped below the separator piston and above the by-pass port is also compressed and driven into solution with the ambient seawater. When the boost fires the separator piston is forced down the accumulator compressing the fluid in the autoclave until the autoclave pressure is equal to the boost pressure. The boost accumulator, once the sleeve valve has opened, remains hydraulically linked to the autoclave until it is isolated on deck. As long as the separator piston can continue to move down the accumulator and the boost nitrogen reservoir pressure remains above the preset boost pressure the boost accumulator will continue to maintain the autoclave at the preset boost pressure.

Of interest is the lag between the time the simulated hydrostatic pressure begins to drop and the autoclave pressure begins to drop as shown by section D-E of the pressure plot. As the simulated hydrostatic pressure drops the autoclave volume begins to increase and the boost accumulator maintains the autoclave pressure at the preset boost pressure. The specifications for the back pressure regulator used in the boost accumulator state an accuracy of plus or minus 1% of the center pressure range or ~50 psi. This means that as the autoclave pressure drops 50 psi the boost accumulator will bump the autoclave pressure back up to the preset boost pressure. However, drops of 50 psi and then sudden bumps back to the preset boost pressure are not observed in the autoclave pressure plot. The autoclave pressure plot produced is what one expect if the boost accumulator were isolated from the autoclave after having fired the initial boost. It is theorized that the separator piston seal friction requires a much higher pressure loss to occur before the separator piston moves enough to cause the back pressure valve to open. Thus no stepwise pressure boosts are observed in the autoclave pressure record.

It is also theorized that the lag between the time the simulated hydrostatic pressure begins to drop and the autoclave pressure begins to drop as shown by section D-E of the pressure plot is due to the expansion of the trapped compressed air within the autoclave. As the autoclave begins to slowly expand the trapped compressed air also expands maintaining the trapped boost pressure until the autoclave volume change is too large for the trapped compressed air to compensate for at the boost pressure. As the autoclave slowly expands the autoclave pressure slowly drops bolstered by the remaining trapped compressed air until the expansion stops when the autoclave is back on deck. This is when the autoclave pressure drops and then stabilizes as shown in section E-F of the pressure plot. This relatively small pressure drop is thought to occur without triggering the boost accumulator due to the separator piston seal friction preventing the piston from moving and thus negating the boost accumulator.

The phenomenon described above was observed in all of the test data from all of the PATs. A review of past pressure plots revealed the same apparent loss of retained boost pressure. Given the coarse data sets (low sample rates) from some of the previous tests and deployments it is difficult to specifically identify the retained boost pressure losses. Note that the retained boost pressure loss is directly proportional to the ambient pressure at the time the autoclave is closed and sealed. This is due to the elasticity of the autoclave material which acts similar to a spring in that the higher the trapped pressure the higher the retained boost pressure loss will be due to the autoclave higher volume change. Thus, with coarse (high sampling rates) pressure data sets and low differential pressures the retained boost pressure loss is difficult to observe.

Conclusions

It would be worthwhile, and interesting, to determine the separator piston seal friction force. Especially the stiction force required to initiate movement.

The PCTB functioned quite well during the week long testing and a high degree of confidence in the tool was obtained.

The GCI test facility is extremely useful in obtaining a better understanding of the PCTB function.

The single trigger mechanism works well and should be incorporated into the standard PCTB configuration for all future deployments and testing.

The apparent autoclave compliance issue should be compensated for by adding 10% of the anticipated hydrostatic pressure to the planned boost pressure so as to maintain the planned boost when to PCTB is recovered to the rig floor.

Appendix A: Daily PCTB PAT Test Reports

13 May 2019, Day 1, PCTB Lab Testing II

<u>Activities</u>

Discussed boost single trigger system design in detail. The design looks good. Besides adding the single trigger, 6 parts of the old by-pass port were removed making the tool simpler and easer to assemble.

A plastic shear rod has also been added during the single trigger redesign. The shear rod is engaged during the actuation stroking process after the ball valve actuation spring has been released closing the ball valve. The shear rod requires 1,000 – 1,500 lbs force to shear. This is enough load to easily see on the wireline winch load indicator. The actuation stroke can be briefly interrupted while loading the shear rod providing additional time for the ball valve to close before the boost is fired. As the wireline load is increased the shear rod eventually shears releasing the inner subassembly to complete actuation and release from the BHA. The dwell provided by the shear rod does not appear to hinder any of the actuation sequence and may even help.

Also discussed the occasional high unlatch load issue. All of the latch dogs and mating components have been Xylan coated. Xylan is a Teflon based coating with a very low coefficient of friction. Geotek thinks this has made a positive difference in lowering the load required to release to tool from the BHA. A potential positive fallout from the addition of the shear rod is providing a jarring force, downhole at the latch, helping to knock the latch lose. This action, in conjunction with the Xylan coating may eliminate any further problems of high wireline loads required to release to tool from the BHA. Testing of the latch subassembly is still on the schedule.

<u>PFT #1</u>

Today was the first time Geotek has performed a full function test in their new test facility. There were some teething pains associated with rigging various components up and down. Thus only one full function test was completed today. The test was conducted at 1,000 psi simulated hydrostatic pressure with the boost set at 1,500 psi and the reservoir pressure set at 3,000 psi. With the tool inside the test chamber water circulation was established at ~40 gpm through the BHA for 10 minutes. Circulation was stopped and while maintaining the 1,000 psi simulated hydrostatic pressure the tool was actuated. The actuator rod used to stroke the tool while under pressure was observed during the actuation process. The rod was observed to move slightly and stop, presumably when engaging the shear rod, and then abruptly stroked out to its full extent. The simulated hydrostatic pressure was then slowly bled off simulating pulling the tool up hole. When the tool was recovered the ball valve was closed and 1,548 psi pressure was trapped in the autoclave. All indications of a good test. Note that the tool was configured with the boost single trigger mechanism and shear rod.

<u>Comments</u>

Although the first test was successful, it doesn't necessarily mean the boost single trigger is the cure all for lost boost. All it means is that the boost single trigger mechanism works as designed and show potential for eliminating lost boost. Note that during the pressure actuation testing, both the boost single trigger mechanism and the original by-pass port design worked all of the time. However, it is believed that the boost single trigger mechanism is a better design and should be fully tested from here on out.

The proposed use/design of a G-RCB that is compatible with the PCTB was discussed. There are some pros and cons that should be considered before a final decision is made to go with the G-RCB.

Plan for Tomorrow

The plan for tomorrow is to complete another full function test at 1,000 psi simulated hydrostatic pressure and then at least one full function test at 4,000 psi simulated hydrostatic pressure. The issue of measuring the torque required to spin the core liner within the PCTB-FB and PCTB-CS will be discussed.

14 May 2013, Day 2, PCTB Lab Test II

Activities

PFT #2

Boost pressure set at 1,500 psi. Reservoir pressure set at 3,000 psi. Simulated hydrostatic pressure at 1,000 psi. Circulated water for 10 minutes. Activated lubricator with accumulator set at 2,000 psi. The lubricator (long stroke hydraulic actuator used to unlatch the tool) rod stroked up and momentarily stopped then continued on to end of stroke. Stopping of the stroke was assumed to be loading and eventually shearing of the shear rod. When the tool was recovered the autoclave was found to have trapped ~1,448 psi, indicating a good run.

PFT #3

Boost pressure set at 1,500 psi. Reservoir pressure set at 3,000 psi. Simulated hydrostatic pressure at 1,000 psi. Circulated water for 10 minutes. Activated lubricator with accumulator set at ~2,000 psi. Lubricator rod stroked to its full extend will little or no indication of shearing the shear rod. While recovering the tool, the connection between the lubricator rod and QLS (quick latching system) on top of the pulling tool was found to have failed. The connection, equivalent to the rope socket, was made from and old female QLS that had been bored out and a hex nut, with the same thread as the lubricator rod, welded into it. The weld had failed allowing the nut to be pulled from the female QLS and remaining attached to the lubricator rod. When the tool was recovered the autoclave was found to have trapped ~1,450 psi, indicating a good run.

It appears the lubricator rod may be extending too rapidly due to the high set pressure of the accumulator used to drive the lubricator. Will discuss with Geotek the possibility of reducing the lubricator accumulator drive pressure.

Failure of the weld was evident upon inspection. The weld had little penetration. With the "hard" stroking events of the previous tests, a crack in the weld probably developed leading to ultimate failure. Since the boost was captured it is evident that the failure occurred while unlatching the tool from the BHA after firing the boost. Typically when activating the lubricator and the rod strokes to its fullest extent the tool would be unlatched from the BHA and raised up a short distance. Given the tool weighs ~1,000 lbs, the simple act of dynamically lifting the tool from rest would place an high impact load across the welded connection. This is thought to be the cause of the failure.

PFT #4

Boost pressure set at 4,500 psi. Reservoir pressure set at 8,000 psi. Simulated hydrostatic pressure at ~3,600 psi. With the "rope socket" rewelded the tool was placed in the test fixture for PFT #4. A delay of 3 hours and 45 minutes occurred while pressurizing the entire closed system, including 3 accumulators, to 4,000 psi. With time running short for the day, the decision was made to run the test at 3,600 psi. Water was circulated through the tool while pressurizing the system. The lubricator was activated with the accumulator set at 2,000 psi. The lubricator rod stroked to its fullest extent with only a slight delay to shear the shear rod. When the tool was recovered the autoclave was found to have trapped only ~3,450 psi. It was also noted that the boost reservoir contained only ~3,450 psi. The DST record indicated that a boost of ~4,200 psi was momentarily captured and then quickly bled off to ~3,600 psi.

The fact that the boost reservoir was found to be at ~3,600 psi upon recovery of the tool is a bit puzzling since it should not have dropped lower than the boost set pressure of 4,500 psi unless it was leaking. It is also interesting that the DST data indicated a boost pressure of only ~4,200 psi rather than that of the set boost pressure of 4,500 psi.

Comments

The need to measure the torque required to spin the core liner within both the PCTB-FB and PCTB-CS was discussed. Unfortunately to do so is not as simple as originally thought. Doing the actual measurement is simple. However, since the bearings that allow the core tube and core liner to spin in both PCTB configurations reside in the top portion of the tool, the fully assembled tool (~42 ft long) has to be suspended vertically to allow for the measurement to be made. Unfortunately, the winch truck that Geotek uses for its "derrick" can only lift ~30 ft. Thus, the entire tool assembly cannot be raised high enough to access the core liner. The measurement may have to wait until the land test or possibly during one of the upcoming coring expedition Geotek has be contracted to perform.

Plan for Tomorrow

The plan for tomorrow is to break down the tool looking for any damaged or missing seals. Note that the tool had not been completely broken down and redressed since the beginning of the PFT testing. The DST data will be looked at in detail once the PCTB internal DST data and the external simulated hydrostatic pressure data can be combined on a single printable graph. Assuming the cause of the failure cannot be determined by the time the tool is redressed and prepared for deployment, PFT #5 will be carried out with the boost pressure set at 4,500 psi, the boost reservoir pressure set at 8,000 psi, and with a simulated hydrostatic pressure of 4,000 psi. It may be possible that there was a leak in the boost reservoir. Calculations will be performed for the PCTB accumulator to see if the boost reservoir pressure can be lowered to ~6,000 psi to ease the strain on the seals.

15 May 2019, Day 3, PCTB Lab Test

Corrections to 14 May 2019 Report

Contrary to what was stated, the pressure section reservoir pressure CAN drop below the boost set pressure (back pressure valve) as long as the pressure downstream of the back pressure valve is below the boost set pressure. Also, the post deployment PAT #4 N2 reservoir pressure stated as 3,450 psi was incorrect. That number was taken from the DST data and reported as being from the N2 reservoir.

Activities

After what was interpreted as a possible leak as indicated by the initial pressure readings from PAT #4, the tool was completely disassembled for inspection and redressing. No indication of a leak source was discovered. The N2 reservoir was pressurized and monitored for 30 min with no signs of loss of pressure. Further review of the DST data revealed that the boost was captured. What was originally interpreted as a leak is now thought to be due to compliance of the tool. Note that the test DST data is taken at a high sample rate of 2 seconds. This is much faster than can be achieved in the field due to the long cycle time and limited data storage capability of the DST. The detailed DST data indicates that an initial boost of ~4,200 psi was captured and then slowly lowered while simulating pulling the tool up hole. Once all of the simulated hydrostatic pressure was relieved the autoclave pressure held steady at ~3,800 psi. Since the simulated hydrostatic pressure was at ~3,600 psi it was originally theorized that only simulated hydrostatic pressure was captured with no boost. However, the data appears to indicate a volume change is happening rather than a fluid loss. After further reflection it is theorized that there is some compliance to the tool that is affected by the differential pressure change as the simulated hydrostatic pressure is reduced. Note that reducing the simulated hydrostatic pressure increases the "inside to outside" pressure differential of the tool. PAT #5 was set up to test the compliance theory.

PAT #5

Boost pressure set at ~4,500 psi, N2 reservoir pressure set at 8,000 psi, simulated hydrostatic pressure at 4,000 psi. After achieving steady state within the closed system water was circulated for 10 min. The lubricator was actuated using the accumulator set at 2,000 psi. Upon recovery of the tool the autoclave pressure was found to be ~4,200 psi indicating a good test with boost captured.

A detailed review of the PAT #5 DST data showed the same lowering of the initial trapped boost pressure during simulated pulling of the tool up hole as was observed in the PAT #4 DST data. To confirm that this is a compliance issue after actuating the tool it was left in the test fixture under simulated hydrostatic pressure for 10 minutes to collect data points. The data indicates that the tool maintained the initial boost pressure during the 10 minute dwell period and only began to lower during simulated pulling the tool up hole. The trapped boost pressure then held steady once again when all simulated hydrostatic pressure was relieved. This seems to support the compliance theory.

To see if the compliance issue only occurs at high pressures the 1,000 psi hydrostatic test data from PAT #2 was reviewed in detail again and the same lowering of the boost pressure was observed. The lowering of the trapped boost pressure in the 1,000 psi PAT #2 was ~100 psi. The lowering of the trapped boost pressure in the 4,000 psi PAT tests #4 and #5 were ~400 psi in each case. Thus it appears there is a relationship between the hydrostatic pressure and lowering of the trapped boost pressure while pulling the tool up hole of ~10 percent of the hydrostatic pressure. **Unfortunately, the late discovery of this phenomenon may result in some of the previous boost pressure loss interpretations, especially in the field, of "no boost captured" as being incorrect.** Previous lab tests were carried out at relatively low pressure where the 10 percent of hydrostatic pressure drop is relatively low and thus lost in the noise. However, at the higher hydrostatic pressures, such as deployments in the field, a 10 percent of hydrostatic pressure drop becomes a significant event that can overshadow the intended boost pressure.

To further ground truth this theory the remaining PATs will have the boost pressure set to the desired final boost pressure plus 10 percent of the test simulated hydrostatic pressure.

PAT #6

Boost pressure set at ~4,500 psi, N2 reservoir pressure set at 8,000 psi, simulated hydrostatic pressure at 4,000 psi. After achieving steady state within the closed system water was circulated for 10 min. The lubricator was actuated using only the Sprague pump (high pressure/low volume). By doing so the lubricator stroke occurred very slowly. A slow lubricator stroke was used to determine if lowering of the trapped boost pressure had anything to do with the rapid fire lubricator actuation when using the lubricator accumulator as the driver. Upon recovery of the tool no pressure was trapped in the autoclave even though the ball valve was closed and the plug seals (at the top of the autoclave) were engaged in the seal sleeve. However, the shear rod was not sheared and the single trigger sleeve had not been actuated. Since the single trigger sleeve was not actuated the by-pass port remained open allowing whatever pressure that was captured in the autoclave at the time it closed to leaked out.

A review of the actuation stroke sequence revealed that if the shear rod is not sheared the internal rod subassembly can still continue to stroke upward while compressing the over travel spring enough to allow the tool to be released from the BHA without shifting the single trigger sleeve. It is theorized that even if the shear rod had sheared the single trigger sleeve seal friction may be high enough to prevent shifting of the sleeve when actuating the tool very slowly. The function of the over travel spring is to do just what it did, allow for release of the tool from the BHA should the internal stroking mechanism fail to complete its full stroke. The solution to this problem is to increase the over travel spring force to above what is required to shear the shear rod and shift the single trigger sleeve while keeping it within the typical limits of wireline overpull at the tool.

This problem is not seen when the lubricator is driven by the accumulator due to the rapid stroke. The rapid stoke is able to shear the rod and shift the single trigger sleeve without fully compressing the over travel spring by essentially impacting the components rather than slowly loading them.

Plan for Tomorrow

The tool will be redressed with a spacer in the over travel spring housing to increase the over travel spring load to above the shear rod shear load. A repeat of PAT #6 will then be carried out to confirm the solution is correct. Also the boost pressure will be set at 4,500 psi plus 10 percent of the simulated hydrostatic pressure of 4,000 psi, or 4,900 psi, to test the trapped boost pressure drop compliance theory.

Comments

The test facility teething pains are going away and manipulation of the test facility is getting better with each test. Test cycle time is coming down to a reasonable time. Being able to carry out tests at various simulated hydrostatic pressures up to 5,000 psi is a big plus. It is possible the tool compliance issue would never have been discovered had we not be able to use this test facility or a similar one. It has been worth the effort to set the test facility up.

16 May 2019, Day 4, PCTB Lab Test II

Activities
The tool was redressed, including the over travel spring spacer, in preparation for PAT #7.

PAT #7
Boost pressure set at ~4,500 psi, N2 reservoir pressure set at 8,000 psi, simulated hydrostatic pressure at 4,000 psi. Note that the 10 percent hydrostatic pressure was not added to the boost set pressure for this test. After achieving steady state within the closed system water was circulated for 10 min. The lubricator was then actuated using only the Sprague pump (high pressure/low volume). By doing so the lubricator stroke occurred very slowly. A slow lubricator stroke was used to determine if lowering of the trapped boost pressure had anything to do with the rapid fire lubricator actuation when using the lubricator accumulator as the driver. Upon recovery of the tool ~4,100 psi was captured by the autoclave indicating a good test. A review of the DST data showed the same drop in the initial boost pressure as in previous tests. The issue of collapsing the over travel spring to the point of releasing the tool from the BHA without completing the stroking process did not occur. Apparently increasing the over travel spring load solved the problem.

When recovering the tool, the pulling tool could not be extracted from the PCTB. The pulling tool was disconnected from the lubricator and the PCTB upper section was laid out with the pulling tool still attached. While breaking down the pulling tool one of the collet fingers was found to have failed binding up the pulling tool release mechanism. It is not clear how just one of the collet finger was overloaded to the point of failure.

Given the tool redress and fabrication of the over travel spring took longer than thought only one PAT was carried out today.

Plan for Tomorrow
Repeat PAT #7 with a set boost pressure of 5,000 psi anticipating a final captured boost pressure of 4,500 psi.

Comments
Although it may seem that a lot of problems have occurred during this testing phase, a more complete understanding of the tool has been acquired. All of the problems that have occurred were understood and solved. No sealing or ball valve problems have occurred. The reliability of the tool is now believed to be very high.

17 May 2019, Day 5, PCTB Lab Test II

Activities
Redress tool in preparation for PAT #8.

PAT #8
Boost pressure set at ~5,000 psi, N2 reservoir pressure set at 8,000 psi, simulated hydrostatic pressure at 4,000 psi. Note that the 10 percent hydrostatic pressure was added to the boost set pressure for this test anticipating a captured boost pressure of ~4,500 psi. After achieving steady state within the closed system water was circulated for 10 min. The lubricator was then actuated using the accumulator set at 2,000 psi. A rapid stroke occurred with no indication of shear rod shearing. After activating the lubricator a 10 min dwell was held to collect pressure data. After the dwell period the simulated hydrostatic was slowly bled off simulating pulling the tool up hole. Once the simulated hydrostatic pressure was bled off a 10 minute dwell was held to collect pressure data. After the dwell period, the system was opened and an attempt was made to recover the tool during which only the pulling tool was recovered. Inspection of the pulling tool revealed one slightly damaged collet finger. It was theorized that the lubricator was so rapid it pulled the pulling tool collet out of the tool without actuating the internal closure procedure.

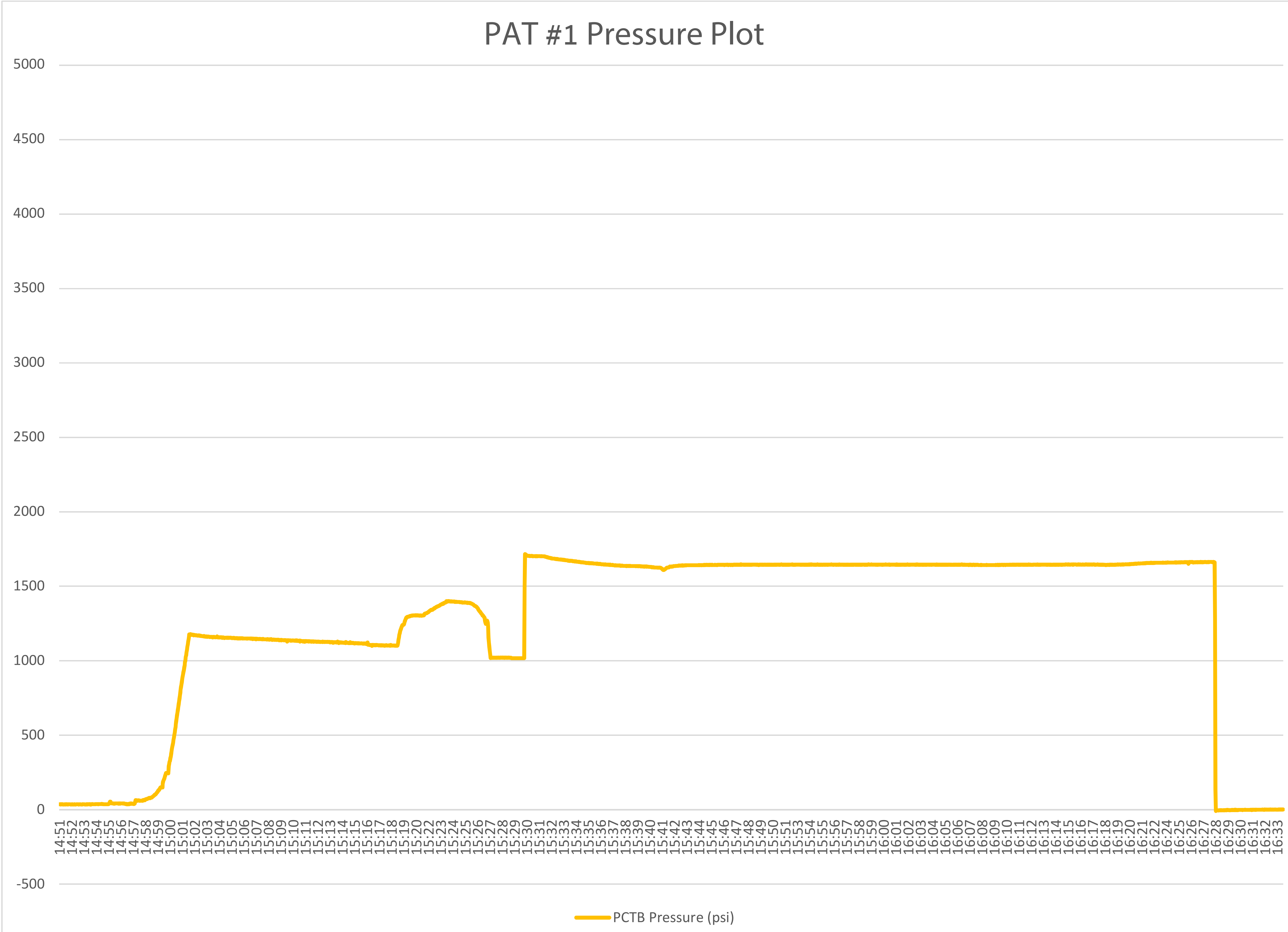
The pulling tool was repaired and lowered into the test chamber snapping into the tool. The system was closed and repressured to 4,000 psi. The lubricator pressure was reduced to 1,700 psi. The downstream lubricator ball valve was opened ~1/4 turn and then the upstream ball valve was opened to activate the lubricator. The lubricator stroked at a speed approximately twice as fast as when using the Sprague pump only. Two distinct hesitations were observed during the lubricator stroke assumed to be from shearing the shear rod and stroking the single trigger sleeve closed. After completing a 10 minute dwell period to collect pressure data the simulated hydrostatic pressure was bled off to simulate pulling the tool up hole.

Upon recovery of the tool the DST data indicated an initial boost pressure of ~5,000 psi which was held during the 10 min dwell period. The DST data also indicated that as the simulated hydrostatic pressure was bled off simulating pulling the tool up hole that a final boost pressure of ~4,500 psi was captured by the autoclave indicating a good test and further supporting the 10 percent hydrostatic pressure compliance theory. The DST data showed the same drop, equal to ~10 percent of the hydrostatic pressure, in the initial boost pressure as in previous tests. The issue of collapsing the over travel spring to the point of releasing the tool from the BHA without completing the stroking process did not occur.

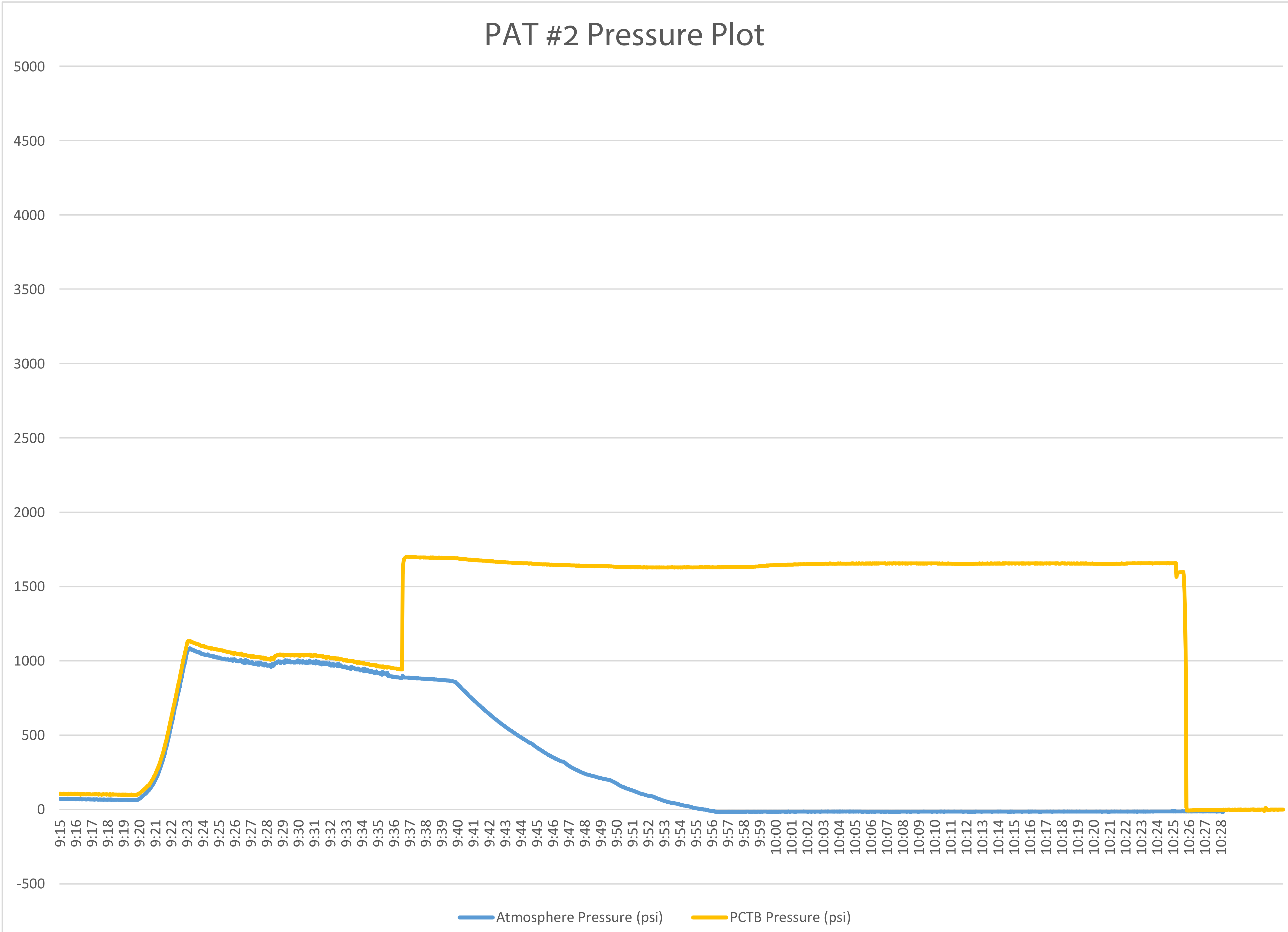
Note that the DST data also indicated that the tool internal actuation stroke did not occur during the first attempt to recover the tool.

Future Testing Plans
Additional PATs are scheduled to occur early the following week, Monday, Tuesday, and possibly Wednesday.

Appendix B: PCTB PAT Pressure Plots



PAT #1 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
PCTB Pressure (psi)



PAT #2 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
9:15
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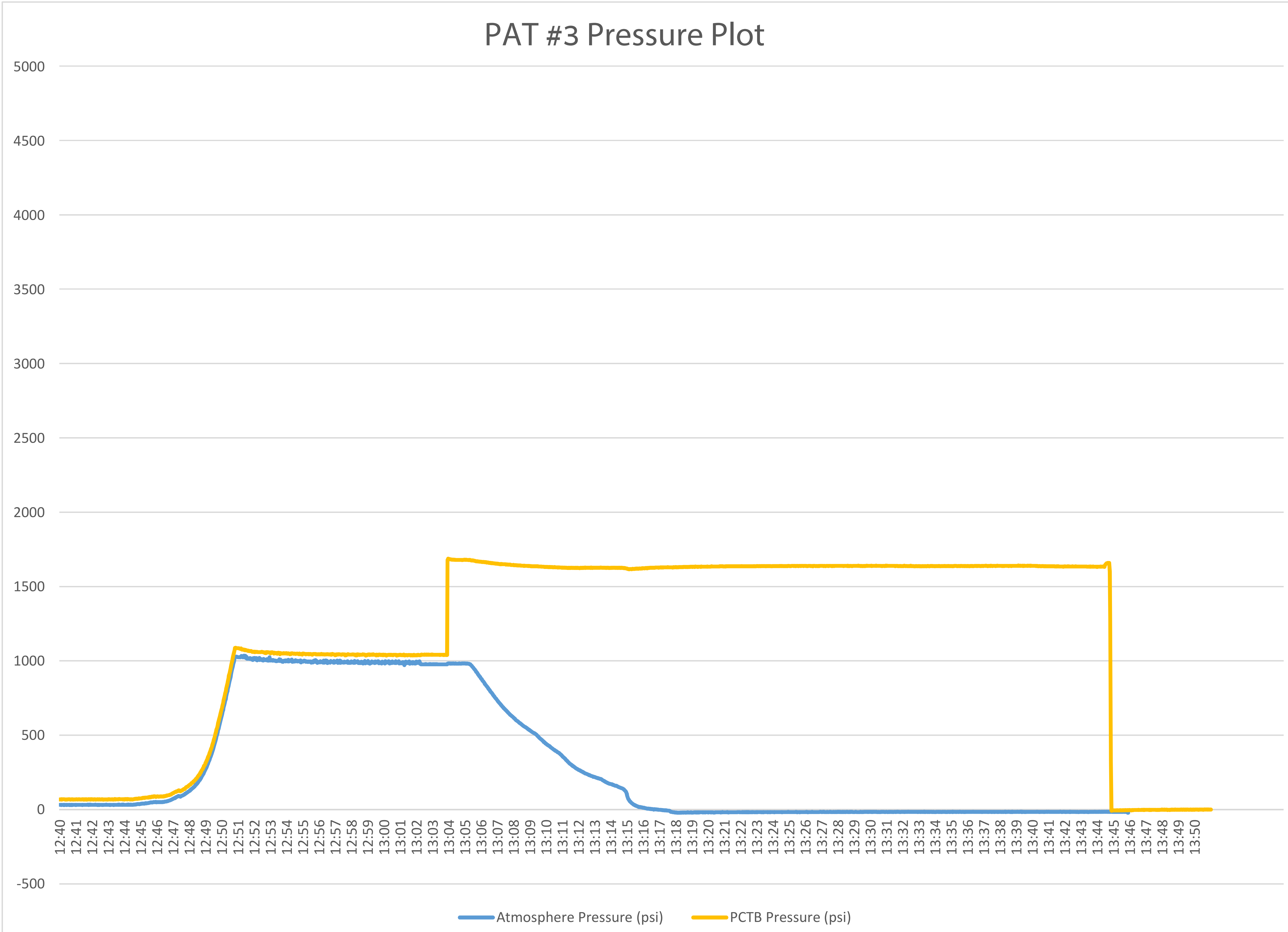
10:28
Atmosphere Pressure (psi)
PCTB Pressure (psi)


PAT #3 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
12:40
12:41
12:42
12:43
12:44
12:45
12:46
12:47
12:48
12:49
12:50
12:51
12:52
12:53
12:54
12:55
12:56
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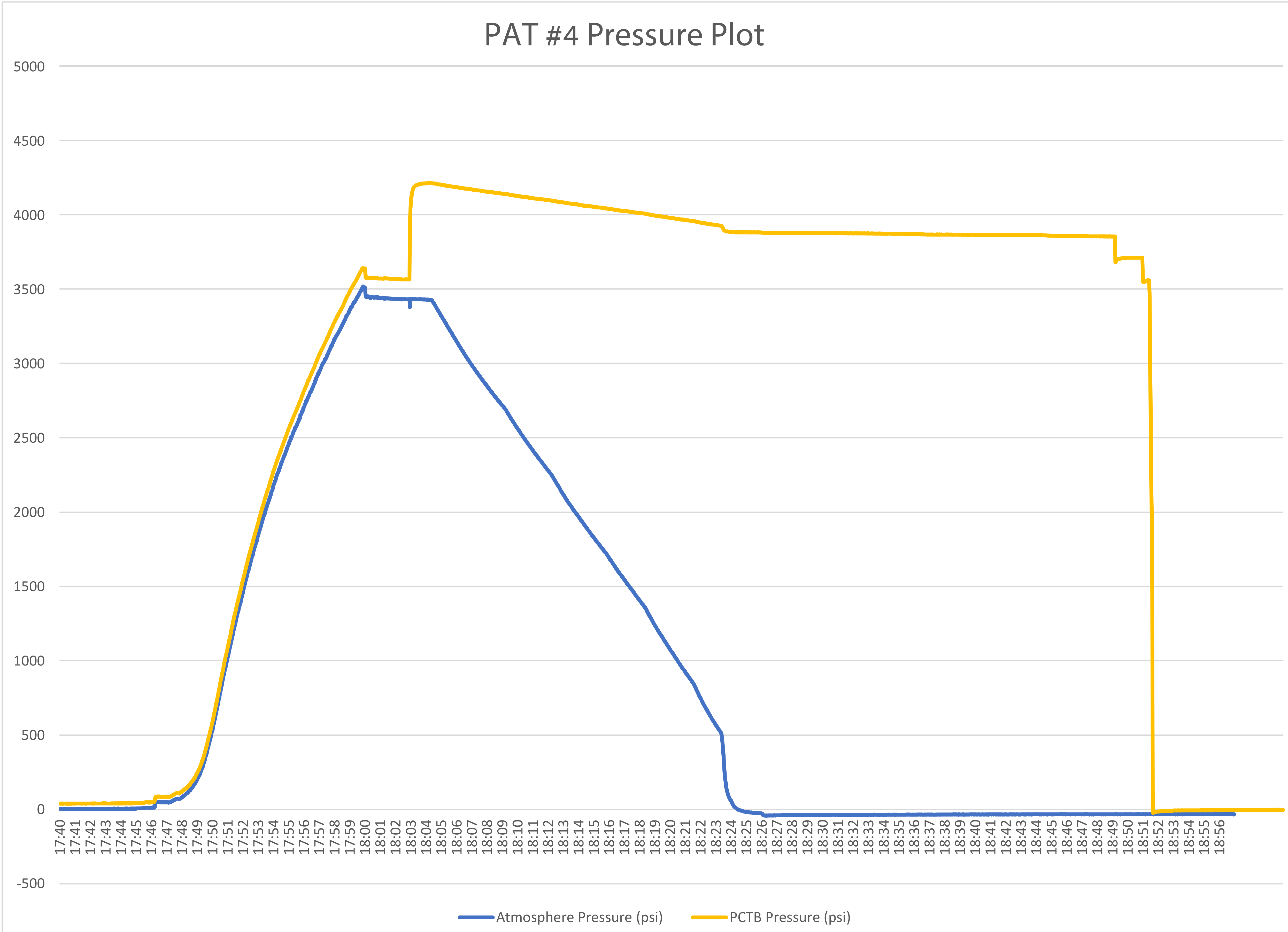
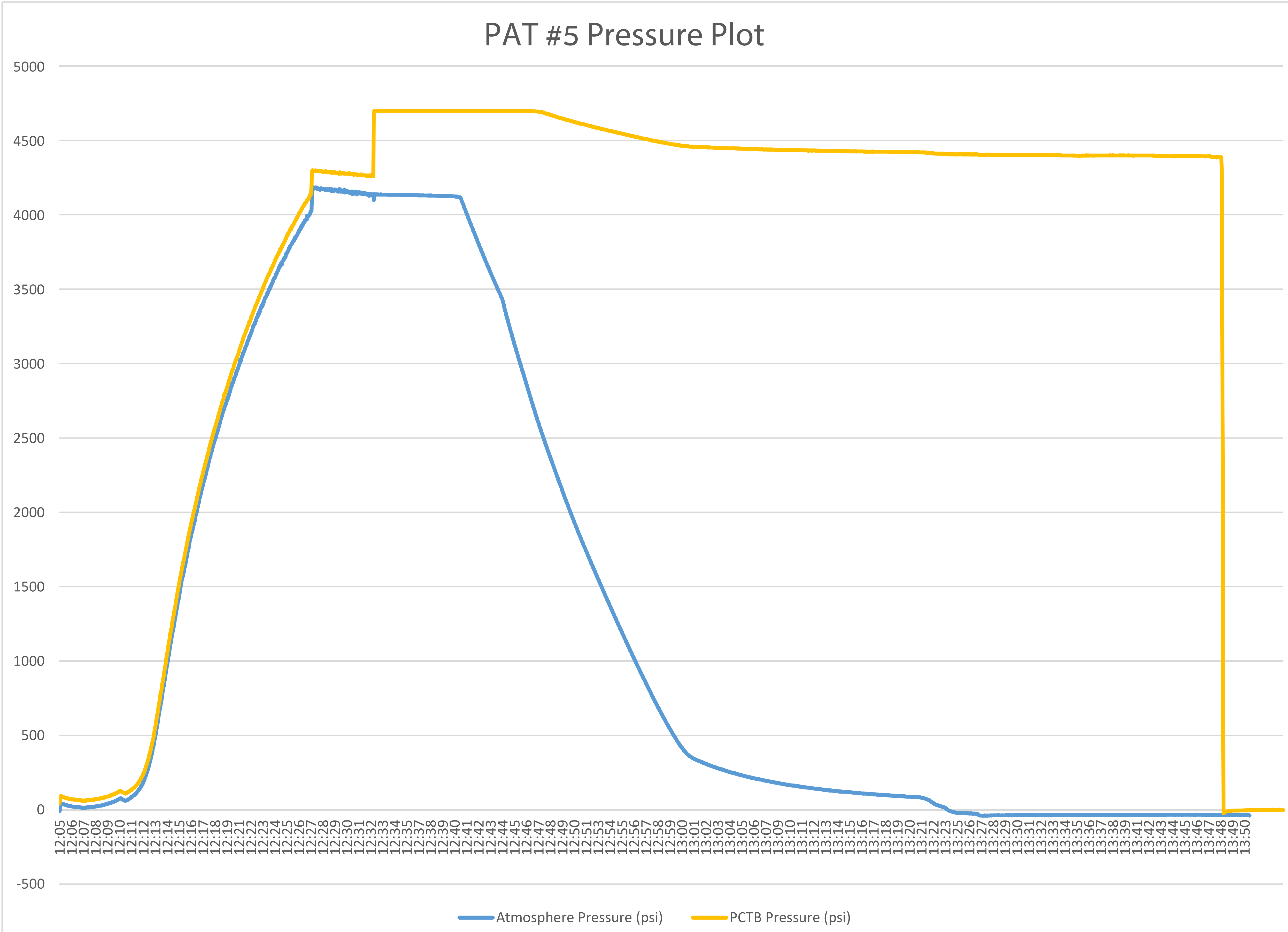
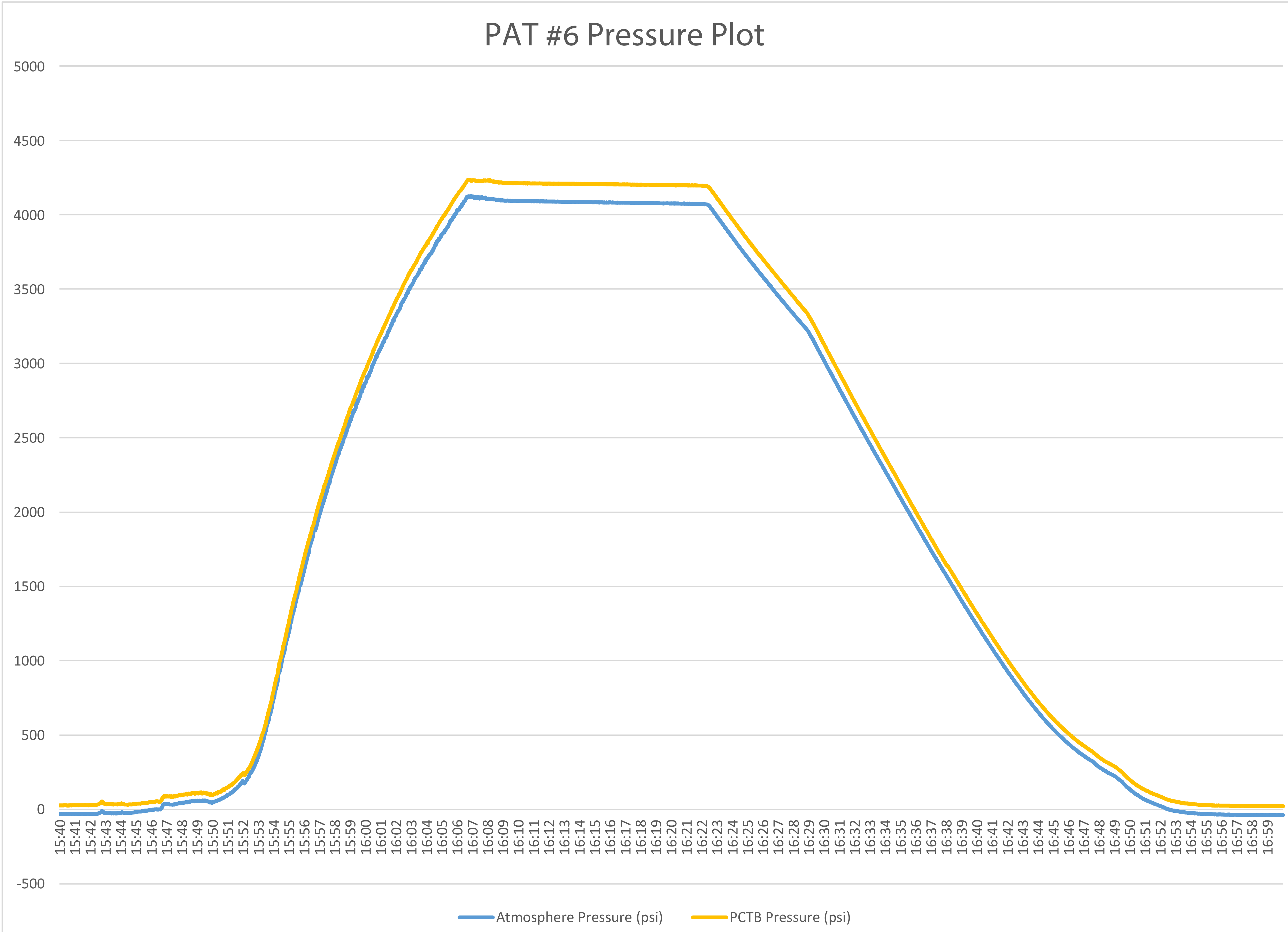
13:48
13:49
13:50
Atmosphere Pressure (psi)
PCTB Pressure (psi)


PAT #4 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
Atmosphere Pressure (psi)
PCTB Pressure (psi)


PAT #5 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
Atmosphere Pressure (psi)
PCTB Pressure (psi)



PAT #6 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
15:40
15:41
15:42
15:43
15:44
15:45
15:46
15:47
15:48
15:49
15:50
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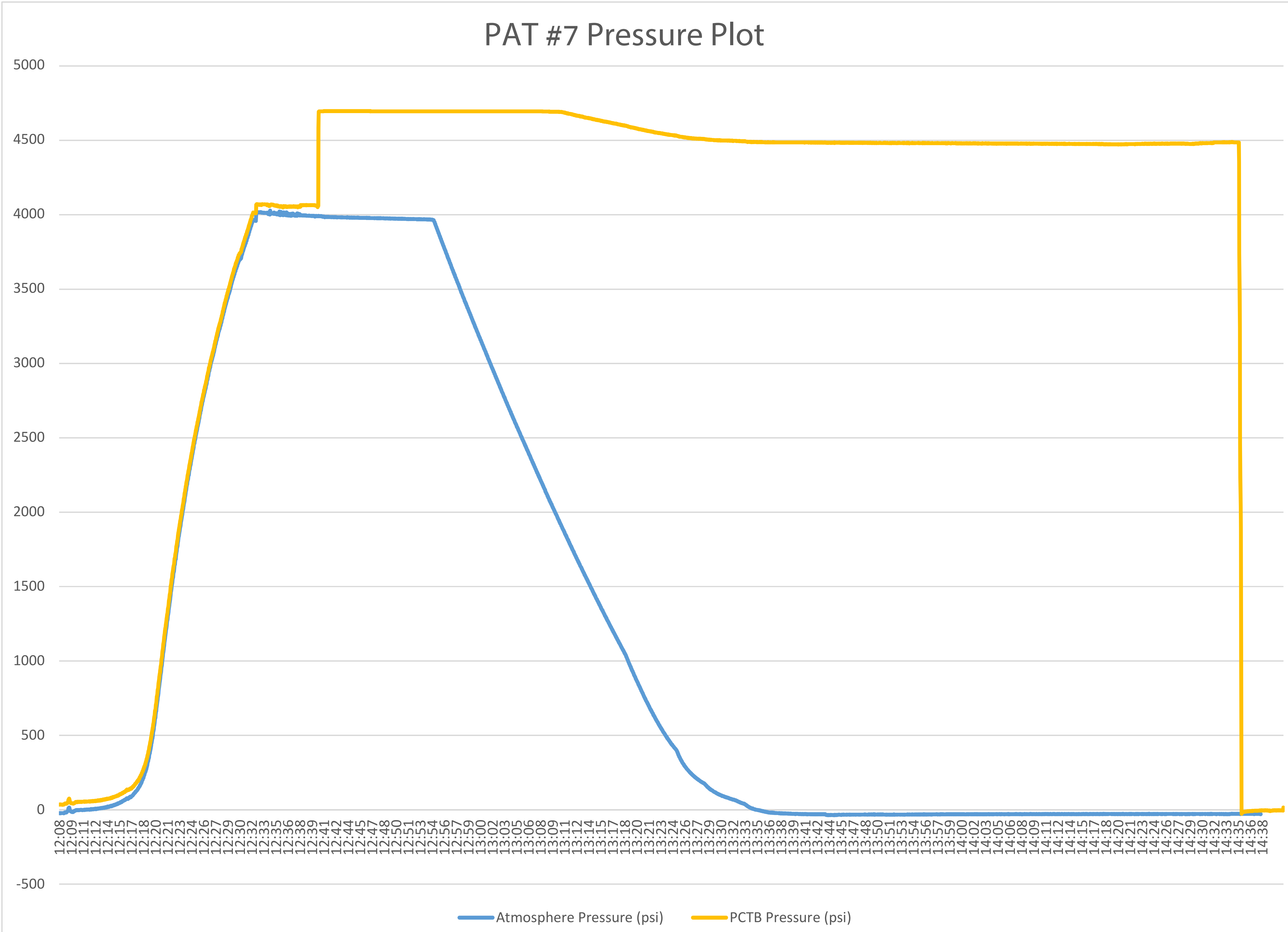
16:59
Atmosphere Pressure (psi)
PCTB Pressure (psi)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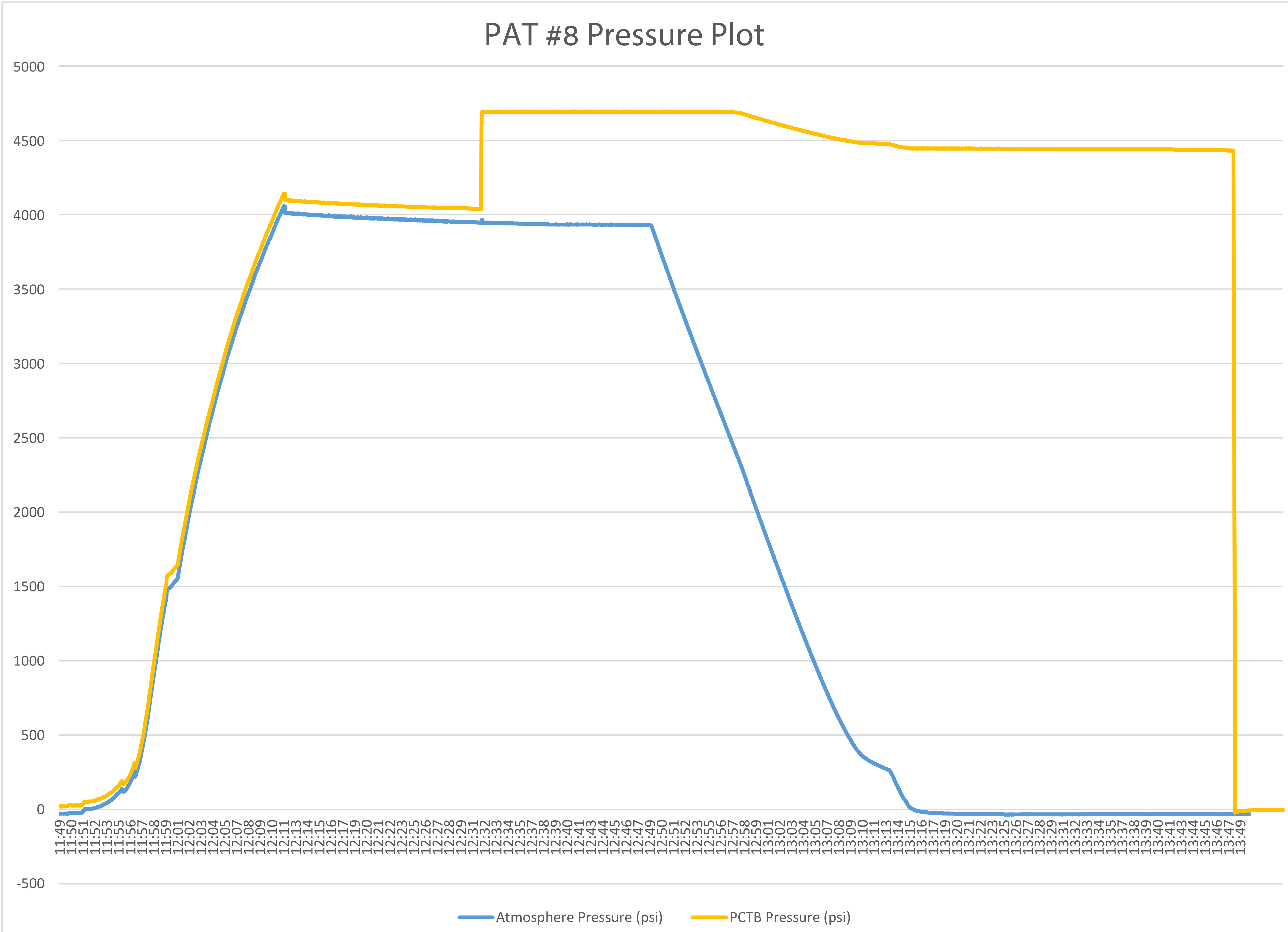
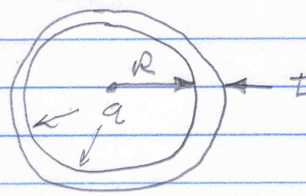
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
12:08
14:38
Atmosphere Pressure (psi)
PCTB Pressure (psi)



PAT #8 Pressure Plot
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-500
Atmosphere Pressure (psi)
PCTB Pressure (psi)

Appendix C: PCTB Autoclave Volume Change Calculations

PCTB AUTOCLAVE VOLUME CHANGE
DUE TO 4500 PSI INTERNAL PRESSURE
REF: ROARK 6th EDITION PG 519
CASE 1C



$$\Delta R = (qR^2/Et)(1+(\nu/2))$$

OD = 3.375 IN
ID = 2.938 IN
R = 1.469 IN
t = 0.219 IN
q = 4,500 LB/IN^2
E = 30×10^6 LB/IN^2
ν = 0.291
Y = LENGTH ≈ 115 IN

$$\Delta R = (4500(1.469^2)/30\times10^6(0.219))(1+(0.291/2))$$

$$\boxed{\Delta R = 0.002 \text{ IN}}$$

$$\frac{\cancel{LB}}{\cancel{IN^2}}\ \frac{\cancel{IN^2}}{1}\ \frac{IN^2}{\cancel{LB}}\ \frac{1}{\cancel{IN}} = IN \checkmark$$

$$\Delta Y = (qRY/Et)(0.5-\nu)$$

$$= (4500(1.469)115)/30\times10^6(0.219))(0.5-0.291)$$

$$\boxed{\Delta Y = 0.024 \text{ IN}}$$

$$\frac{\cancel{LB}}{\cancel{IN^2}}\ \frac{IN}{1}\ \frac{IN}{1}\ \frac{IN^2}{\cancel{LB}}\ \frac{1}{\cancel{IN}} = IN \checkmark$$

$$\Delta V = 2.942^2(0.7854)\ 115.024 - 2.938^2(0.7854)\ 115$$

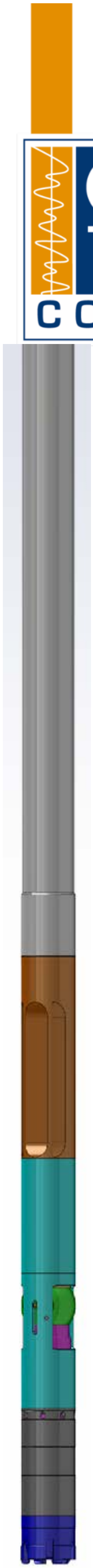
$$\boxed{\Delta V = 2.288 \text{ IN}^3}$$

Appendix G

Pressure Coring Tool with Ball Valve (PCTB) UT2019 Pre-GOM2 Testing

Geotek Coring, Inc.

DE-FE0023919 Phase 3 Scientific/Technical Report
The University of Texas at Austin



PRESSURE CORING TOOL WITH BALL VALVE (PCTB)

UT2019
PRE-GOM2 TESTING

GEOTEK LTD DOCUMENT NO. UT2019 (R1)

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EXECUTIVE SUMMARY

The PCTB (Pressure Coring Tool with Ball valve) has gone through many revisions in order to increase reliability and performance. Most recently, it has been upgraded to the PCTB3 specification. While the tool generally works well sometimes it brings up pressure cores at less than in situ pressure, and sometimes no pressure at all. One of the functional requirements of the PCTB is to boost the pressure to above that of in situ, which almost never happens at higher pressures. The 2019 Pre-GOM3 testing aims to find a solution to these problems and increase the reliability of the PCTB.

Increasing the reliability and performance of the PCTB requires a redesign of the main components of the tool. This was done by making the seal on the top of the tool and the firing of the boost into a single action (Single Trigger Mechanism), instead of two. Some complexity and potential leak paths were eliminated. Additionally, a shear pin was added as a potential stop in the actuation of the tool in between the ball valve closing and the boost firing. This prototype assembly is designated the PCTB4A.

In order to troubleshoot, test and improve the PCTB, a test facility with the ability to replicate downhole coring conditions needed to be designed and fabricated. To do this, the Geotek Test Facility was brought to life. A pressure vessel with the ability to house the entire coring tool and BHA (Bottom Hole Assembly) was built. It can use the same wireline tools used in the field to actuate the coring tool which can be done at speeds similar to those in the field. The entire assembly can be brought up to pressures above and beyond those seen operationally and drilling water/mud circulation can be introduced as it would be done during a coring run.

Commonly in the field the tool has difficulty unlatching from the BHA, requiring time to work the latch to get it to release. The latch components were tested individually to see if there were any components that were troublesome and could be modified for an easier pull. While the PCTB3 configuration showed no tendencies for trouble, a modification made to the PCTB4 cause significant difficulty that will require a redesign and more testing.

The PFT (Pressure Function Test) uses the Geotek Test Facility to perform a simple test to ensure the lower section, where the core is taken, functions as designed. During testing, the PCTB4 performed well at high and low pressure.

The PAT (Pressure Actuation Test) takes advantage of the new capabilities of the Geotek Test Facility. It was discovered during testing that an Overtravel Spring on the upper half of the tool, responsible for latching into the BHA, was too soft for the shear pin and the tool could unlatch without fully actuating the tool. As a quick fix a spacer was put in which solved the problem and worked throughout the rest of the PAT testing. However, as previously noted it caused potential unlatching issues.

The PCTB4 Single Trigger Mechanism works as designed and should increase reliability and performance of the tool. Testing has revealed a few additional recommendations to further improve the PCTB. There is a little more testing to be done to improve the Overtravel Spring, as well as improve the low differential pressure sealing of the tool.

1 INTRODUCTION

1.1 PCTB SPECIFICATIONS AND HISTORY

The PCTB3 (Pressure Coring Tool with Ball Valve mk 3) is a wireline retrievable pressure coring system designed to recover 51mm diameter cores up to 3m long at pressure up to 5000 psi. It is compatible with Geotek PCATS (Pressure Core Analysis and Transfer System) for transferring cores under pressure for analysis and sub-sampling without loss of pressure sensitive materials or changes in mechanical properties due to pressure reduction.

The first version of the PCTB was developed by Aumann & Associates, Inc. in the early 2010s. It was designed as the first successful wireline pressure coring system designed to run in common commercially available 4 1/8" ID drill pipe. Previous pressure coring systems required less readily available, large and heavy 6 5/8" ID drill pipe, which required not only a large capital investment in drill pipe, but also a large ship to handle the drill string. The novel concept that allowed for the diametral reduction in the coring tool was the top sealing ball valve. This allowed for a similar core diameter, with a smaller diameter coring tool. The tool has a regulated Nitrogen gas over water pressure section to "boost" the core pressure as well as provide makeup fluid at pressure in the event of a leak. Several revisions of the tool were made to improve tool handling and performance, most notably the addition of a check valve to eliminate hydro lock of the tool while pulling which later proved to be problematic. The check valve was installed to allow fluid to enter the tool, but not let fluid out of the tool thus preserving the in-situ pressure or better yet boost pressure.

In 2013 the PCTB1 was updated to the PCTB2 to again improve performance. The check valve installed in PCTB1 was prone to plugging up with sediment which caused hydro lock in the tool when attempting to pull out of hole (POOH). The main design improvement of the PCTB2 was to make the tool seal up at the last possible moment before the boost fired. This was done by designing a multi-piece upper Autoclave seal (Inner Tube Plug). While complicated, it eliminated the hydro lock during POOH. The PCTB2 also added an adjustment to the liner length, so the tolerance stack-up and tapered thread makeup of the liner could be adjusted for optimal core catcher placement. The PCTB 2 was tested in 2013 during an offshore coring operation in China. The next year it was again tested at the Catoosa Test Facility for the DOE. During further development the PCTB2 was utilized successfully to recover methane hydrate bearing cores during operations offshore Japan and China in 2015.

The PCTB2 Onshore Test Program at the Schlumberger CTTF (Cameron Test and Training Facility) was designed to test the effectiveness and efficiency of drilling and coring with the PCTB2 tool as a qualification test prior to the proposed 2017 UT/DOE Gulf of Mexico Sea Trial. The CTTF test program did largely confirm that the tools are "fit for purpose" for future offshore coring operations as detailed in the PCTB III 2016 Pre-Sea Trial Test Report. However, the CTTF test program also revealed a potential issue with a late nitrogen boost caused by an incomplete stroke of the tool. This caused the firing of the nitrogen boost after the PCTB was raised most of the way out of the hole or failure of the tool to hold pressure at all.

For continued improvement of the performance of the PCTB, in 2016 the PCTB2 was upgraded to PCTB3. The main improvements were focused on reducing the flow of the debris and pipe scale into the inner workings of the PCTB and preventing the collapse of the core liner at higher flow rates with the addition of a diverter seal on the top of the Autoclave, as well as a thicker Inner Tube. Additionally, improvements were made to IT Plug Seal as well as small changes to improve latch performance. An instrumented core liner was made to hold several DSTs (Data Storage Tag – a compact self-contained temperature and pressure recorder) to determine if the pressure differential that caused liner collapse during high flow rates was reduced. This test was performed on the 2017 UT/DOE GOM2 (Genesis of Methane – Gulf of Mexico) pressure coring test and expedition, where it was determined that the diverter seal did prevent a pressure differential from collapsing the liner. Additionally, during the expedition it was discovered that the PCTB3 modifications had some unintended consequences. When the Inner Tube got thicker the lip that catches on the Thick Wall Release Sleeve got smaller and while performed well during the 2016 VFFPT (Vertical Full Function Test Pressure Test), in the field the Release Sleeve would pop off and thus not fire the Ball Valve. Also, the Sleeve Valve would cause a metal to metal seal on the Middle Barrel requiring some pressure reliefs to be ground. After a rather poor success rate on the first hole, these problems were solved by modifying the parts in question, and the PCTB3.1 had a very high success rate on the second hole of the expedition. During the post job review, it was determined that the Diverter Seal was too tight causing issues attaching and separating the upper and lower of the tool. A new seal was developed and tested on GMGS5 in China in 2017, culminating in version PCTB3.2.

1.2 DESIGN MODIFICATIONS

While the PCTB has had a good success rate, there is room for improvement. At higher pressures and greater depth, the tool comes up at less than in situ pressure more frequently than expected, and the boost is rarely seen. The Volume Compensating device on the IT Plug was designed to allow fluid to bypass the seals as the tool was stroked until the last possible second before firing the boost which should reduce hydro lock. However, since the Volume Compensator was operated by the Pawls in the Seal Sub compressing several springs and the Sleeve Valve on the Pressure Section contacting a shoulder on the Lift Sub, it was theorized that it was possible for the boost to fire before the Volume Compensator had sealed.

In an effort to increase the success rate of the PCTB, an extensive redesign of the IT Plug and Pressure Section was made.

The primary design change suggestion was from Tom Pettigrew of Pettigrew Engineering, whereby the mechanism for providing a leak path until just before the boost is applied should be moved to a single, interconnected action. The idea was to port the bottom of the Accumulator Barrel in the Pressure Section and have a single sleeve that triggers both the seal of the tool and the firing of the boost: The “Single Trigger mechanism”. Since the Single Trigger made the function of the Volume Compensator redundant, there was an opportunity to reduce part count and complexity while at the same time eliminating several potential leak paths. This led Geotek to eliminate the potentially problematic face seal, as well as adding a shear pin to the IT Plug. The shear pin provides two benefits: to keep the IT Plug from extending until the pawls make contact and allowing a potential stop to give the ball plenty of time to close during the wireline pull.

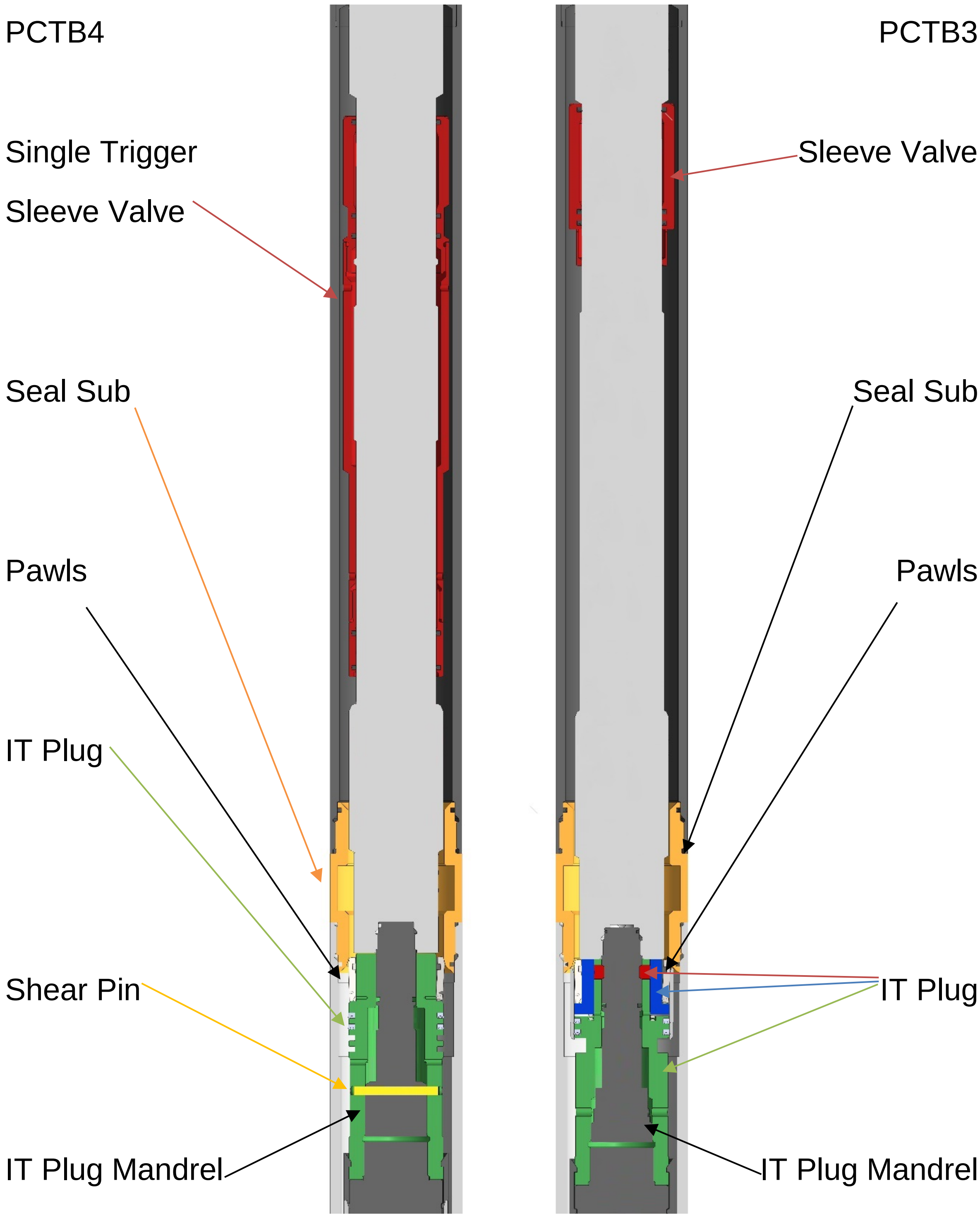


Figure 1: PCTB Design Modification Cutaway

1.3 GEOTEK CORING TEST FACILITY

The GCI Test Facility was purpose built to allow Geotek and its collaborative partners to test tooling fully assembled, in a more realistic working environment. The GCI test facility has the following features (numbers in brackets refer to the images in Figure 2):

- Test bore that is double cased with a depth of 50 feet and ID of 24 inches (1)
- A Pressure vessel that is 50 feet in length, ID of 11.5 inches with a MAX CWP of 5000 PSI (2)
- Fluid Mixing and Storage of – 2500 gallons and up to 5 different fluids at a time (3)
- Custom Built Circulation Pump – Capable of up to 150 GPM with MAX CWP 5000 PSI (4)
- SEMCO S1200 Rig (5)
- Max. Vertical Boom Reach: 40′
- Max. Horizontal Boom Reach: 12′
- Hydro System; Tandem Pump 50 & 30 GPM @ 2000 PSI
- Main Winch with Fail Safe Brake - Capacity: 12000 lb.
- Two Auxiliary Winches – Capacity: 2000 lb.
- Custom Pulling Cylinder – Capable of simulating wire line pulls up to 100 m/min, designed to use actual field wireline tools to actuate tools (6)
- 45 Gallons of accumulation with MAX CWP of 5000 PSI with the ability to control in 15-gallon increments (7)

Figure 2 Geotek Coring Test Facility

2 TEST PROGRAM

2.1 LATCH TESTING

Often when pulling the PCTB from the BHA with the wireline tools the tool does not unlatch easily. There have been many instances where the tool needed to be pulled much harder than reasonably expected, sometimes up to the full wireline pull capacity, requiring extra time to work the latch to get it to release. While there has not yet been a situation where the PCTB was unable to be retrieved, there is a potential pipe trip of the BHA to rig floor to release the PCTB which, would not only waste vessel time for the trip but cause a failed run of the PCTB and re-entry issues.

In order to discover the root cause of the high wireline pull, the complete BHA will be installed vertically in the Test Hole, and the PCTB latch components will be built up incrementally, performing 5 tests of each configuration, until the entire PCTB assembly is being recorded for each test

2.2 PRESSURE FUNCTION TEST (PFT)

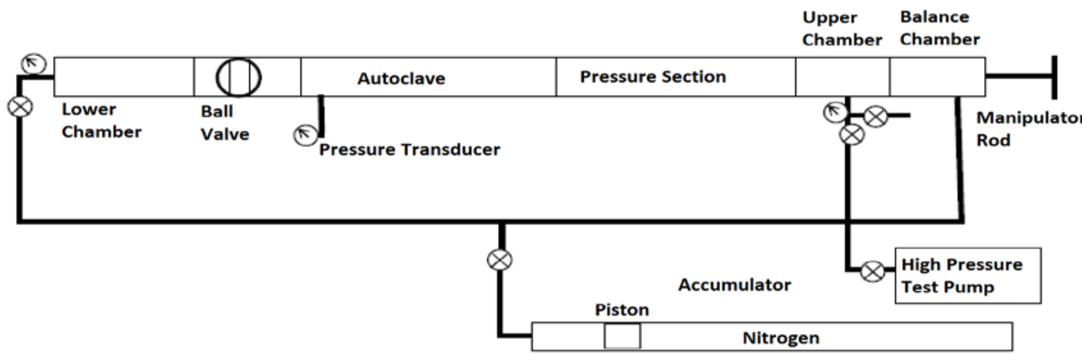


Figure 3 Pressure Function Test schematic layout

The PFT is an excellent way to test changes to the Autoclave Assembly, to ensure proper function of the individual components. The test was formerly known as the Vertical Full Function Pressure Test (VFFT), which was a vertically oriented Full Function Test (FFT). In this test, a complete Autoclave Assembly, with the cutting shoe removed and replaced with a cylindrical cap that covers and seals over the windows in the ball valve thus sealing the bottom of the tool.

Digital Storage Tags (DSTs) are placed within the autoclave and in the simulated atmospheric zone between the cap and the bottom of the PCTB to record pressures and time data for the digital charts.

A special testing Lift Sub attaches to the Middle Barrel on top, designated the Upper Chamber, where the hydraulic balance and pulling cylinder attaches. This assembly seals the top end of the tool, as well as provides a way of hydraulically actuating the tool to simulate a wireline pull. The entire assembly is mounted to a fixture on a forklift and is lifted vertically to most accurately depict coring operations. There is also a linear transducer so the pulling distance of the tool can be monitored from the ground.

Once the assembly is vertical, water is pumped in the Bottom Cap and bled out of the highest point on the hydraulic balance and pulling cylinder until all the air is out of the system. The assembly is then pumped up to test pressure.

To actuate the tool, water is pumped at a designated pressure into the hydraulic balance chamber and pulling cylinder with manipulator rod, pulling the inner of the tool as the wireline would do in the field. Higher pressure not only applies more force, but also actuates faster. This action causes the ball to fire, the IT Plug to activate and seal, and the pressure section to fire. If at any point the actuation stalls, the hydraulic force is increased until the stall is overcome. In the case of getting stuck the pressure is applied and released, simulating wireline pull and slack, until the actuation is complete. Once it is verified by the linear transducer that the tool has reached full stroke the pressure is bled from the atmosphere at approximately 2 psi/sec simulating the wireline pulling the tool at 100 m/min, which is the desired field operation wireline speed.

Figure 4: Partial Function Test. From L-R: PCTB in vertical orientation; Actuating mechanism at top of PCTB; Bottom cap with water lines attached

A pressure test control console is used for the PFT. It incorporates the hydraulic pump, gages, linear transducer readout, and a new hydraulic system to reliably and accurately control the rate of depressurization when simulating the wireline trip out of the hole.

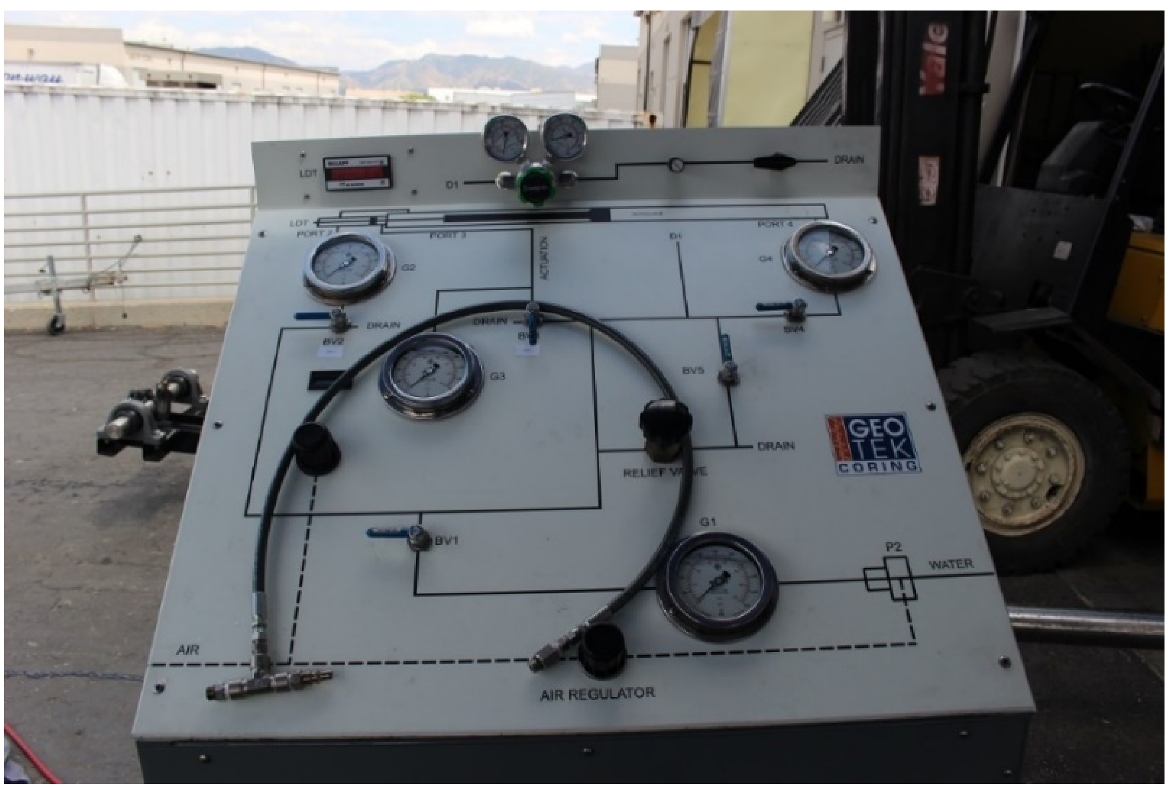


Figure 5: Pressure Test Control Console

2.3 PRESSURE ACTUATION TEST (PAT)

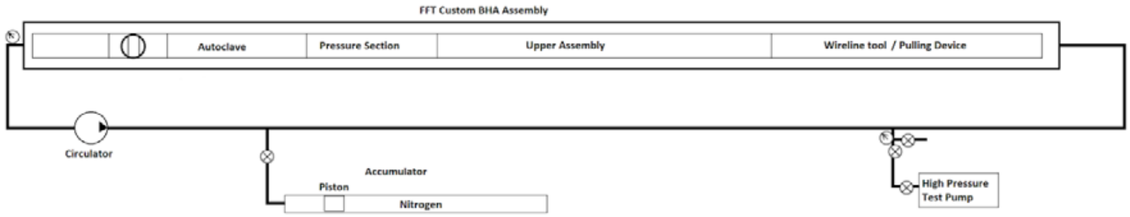


Figure 6: Pressure Actuation Test Layout Diagram

The PAT is a test using the Geotek Test Facility which allows for the tool to be placed in an environment and configuration that is as close to downhole coring conditions as possible without breaking ground thousands of meters below the ocean surface. It consists of a pressure vessel that holds 5000 psi and contains the full length BHA including the bit, float valve, and drive sub. It also incorporates a Balanced Pulling Assembly like the PFT setup but larger in every way. It is designed to be able to pull the tool at up to 100 m/min. There is also a high-pressure circulation pump that can circulate fluid at 150 gal/min at up to 5000 psi. The benefit of this test over the PFT is that the entire tool, including the upper, is operating the way it would in the field, at the pressures it would see. The wireline tools are the same, and the BHA is the same down to the nozzles in the bit.

The PCTB, both upper and lower, is prepared exactly as it would be in the field. The upper is placed in a mousehole next to the test fixture. The lower has a cutting shoe installed, as well as the lifting clamp and assembly clamp. It is picked up vertically with the lifting clamp and run in the hole until the lifting clamp rests on the test fixture. The upper is picked up by its lifting clamp and is attached by the QLS and Quick Release Nut to the lower. The entire PCTB is run into the BHA in the test fixture until it latches in with the wireline running tool. Like the PFT, water is pumped into the test fixture and bled out of the highest point on the Balanced Pulling Assembly until all the air is out of the system. During this process, the circulation pump is run at a slow speed to bleed any air out of it. The assembly is then pumped up to test pressure.

3 TEST RESULTS

3.1 LATCH TEST

TEST #	CONFIGURATION	WIRELINE TOOL	INNER HANGING WEIGHT (LB)	TOTAL HANGING WEIGHT (LB)	MAX. PULL WEIGHT (LB)	OVERPULL WEIGHT (LB)
Outer Latch 1	Outer & Inner Latch	Emergency	n/a	89	112	23
Outer Latch 2	Outer & Inner Latch	Emergency	n/a	89	108	19
Outer Latch 3	Outer & Inner Latch	Emergency	n/a	89	98	9
Outer Latch 4	Outer & Inner Latch	Emergency	n/a	89	102	13
Outer Latch 5	Outer & Inner Latch	Emergency	n/a	89	95	7
Inner Latch 1	Outer & Inner Latch	Pulling	30	89	106	17
Inner Latch 2	Outer & Inner Latch	Pulling	30	89	104	15
Inner Latch 3	Outer & Inner Latch	Pulling	30	89	110	21
Inner Latch 4	Outer & Inner Latch	Pulling	30	89	106	17
Inner Latch 5	Outer & Inner Latch	Pulling	30	89	151	62
Full Upper 1	Full Upper	Pulling	139	417	360*	-57
Full Upper 2	Full Upper	Pulling	139	417	367*	-50
Full Upper 3	Full Upper	Pulling	139	417	360*	-57
Full Upper 4	Full Upper	Pulling	139	417	362*	-55
Full Upper 5	Full Upper	Pulling	139	417	363*	-54
Full Tool 1	Full PCTB4A	Pulling	286	670	1943	1273
Full Tool 2	Full PCTB4A	Pulling	286	670	1642	972
Full Tool 3	Full PCTB4A	Pulling	286	670	1593	923
Full Tool 4	Full PCTB4A	Pulling	286	670	1534	864
Full Tool 5	Full PCTB4A	Pulling	286	670	2213	1543
Full Tool 6	Full PCTB4A, 1" Overtravel Spring Spacer	Pulling	286	670	7949	7279
Full Tool 7	Full PCTB4A, 1" Overtravel Spring Spacer	Pulling	286	670	7189	6519
Full Tool 8	Full PCTB4A, 1" Overtravel Spring Spacer	Pulling	286	670	8310	7640

*Table 1: Latch testing summary data. * Total hanging weight in free air, max. pull weight in water.*

The latch testing was performed as described. It is worth noting that during a normal coring run, the wireline load has an additional couple thousand pounds of pull by wire weight alone. The max pull weight on the full upper was less than the total hanging weight because the tool was in water for the pull test, and in free air for the total hanging weight.

When the full tool was initially tested, the normal configuration without the spacer in the overtravel spring was tested. None of the tests up to this point indicate any sort of difficulty unlatching.

During the PAT tests, it was discovered that the overtravel spring was too weak to overcome the shear pin during a slow pull. Although the tool had no problems unlatching during the tests, we went back and did a few more tests with the spacer. With the addition of the spacer in the Overtravel Spring, there was significant difficulty pulling. The loads were not only over what a normal wireline unit can pull but required more force than our load cell could handle. A new load cell was purchased, and the testing was continued. The Overtravel Spring will need to be redesigned so it ensures the PCTB fully strokes, seals, and fires but also comes out of the BHA easily.

Figure 7: Latch Pulling Test

3.2 PRESSURE FUNCTION TEST (PFT)

		NITROGEN (PSI)		INITIAL (PSI)		FINAL (PSI)		
TEST #	OCEAN ACCUMULATOR	SET	FILL	AUTO-CLAVE	OCEAN	AUTO-CLAVE	OCEAN	PCTB SEAL PRESSURE
1kPFTST1	n	1501	3005	977	977	1522	1539	473
1kPFTST2	n	1445	3070	1052	1007	1567	0	1567
1kPFTST3	y	1463	3025	997	997	1560	0	1560
1kPFTST4	y	1527	3993	998	996	553	0	553
1kPFTST5	n	1529	5007	1074	1077	1659	1493	1659
1kPFTST6	y	1573	4994	1044	1044	1662	1389	1662
1kPFTST7	y	1532	5025	995	997	1638	995	1638
1kPFTST8	y	1526	5025	1170	1005	1608	1006	1608
1kPFTST9	y	1537	5025	1006	1015	1653	1009	1653
1kPFTST10	y	1531	3027	999	994	981	994	0
1kPFTST11	y	1531	3027	1005	990	1710	990	1710
1kPFTST12	y	1517	3021	990	985	1702	1442	1702
4kPFTST1	n	4493	8017	4050	4023	4735	4485	4828
4kPFTST2	y	4494	8047	4053	3857	4563	4027	4547
4kPFTST3	y	4514	8176	3975	3999	4530	4002	4669
4kPFTST4	y	4508	7996	4041	4018	4503	4041	4516

Table 2: PFT summary data.

3.2.1 *1KPFTST1*

This was the first test of the Single Trigger Mechanism using an ocean pressure of 1000 psi. A ¼” diameter polycarbonate shear pin was used as opposed to the designed 3/8” shear pin. ABS was used for the rest of the testing. A tool actuation pressure of 1000 psi was used initially, and the shear pin held up the actuation process. The tool actuation pressure was increased to 2500 psi and the tool actuated completely.

The tool was POOH and the logged pressure indicated that the tool and ocean equalised to the pressure section set pressure. The tool sealed at 473 psi during POOH.

Result: Failed Test

Diagnosis: On disassembly seals were damaged by sharp edged holes on the prototype accumulator barrel

Corrective Action: Deburr the sharp-edged holes

3.2.2 *1KPFTST2*

A repeat of test 1KPFTST1 using a 3/8” ABS shear pin. Actuation stalled using 1000 psi, so the actuation pressure was increased to 5000 psi and actuation stalled again. Test abandoned and tool was POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock

Corrective Action: Use ocean accumulator on next test

3.2.3 *1KPFTST3*

A repeat of test 1KPFTST2 using the ocean accumulator. This did not help, and the actuation stalled again. Whilst attempting to free the actuation mechanism the bleed valve was bumped resulting the tool to fully pull and actuate. Test abandoned and tool was POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock. Examination of the 3D tool model indicated that the was stuck when the lower sleeve valve closed the controlled leak into the tool

Corrective Action: Run the next test with a back charged pressure section

3.2.4 *1KPFTST4*

A repeat of test 1KPFTST3 using a back charged pressure section, the boost function is removed as a result isolating the lower sleeve as a potential cause. This did not help, and the actuation stalled again although the tool did actuate eventually. POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock

Corrective Action: Run the next test with a 300 psi back charged pressure section

3.2.5 *1KPFTST5*

A repeat of test 1KPFTST4 using a 300 psi back charged pressure section, this turns the pressure section into an accumulator, the theory being that the accumulator would allow fluid into the tool to relieve the hydraulic lock. This did not help, and the actuation stalled again. POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock

Corrective Action: Run the next test monitoring ocean pressure above and below the tool

3.2.6 *1KPFTST6*

A repeat of test 1KPFTST5 but monitoring the pressures above and below the tool. This did not provide any insight into the problem and the actuation stalled again. POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock

Corrective Action: Run the next test with the ocean accumulator connected

3.2.7 *1KPFTST7*

A repeat of test 1KPFTST6 but with the ocean accumulator connected. This did not help the actuation process. The tool eventually actuated on POOH.

Result: Failed Test

Diagnosis: Presumed hydraulic lock

Corrective Action: Run the next test with a high-pressure pump connected to the drive sub

3.2.8 *1KPFTST8*

A repeat of test 1KPFTST7 but with a high-pressure pump connected to the drive sub allowing water to be pumped into the tool to relieve the hydraulic lock. Actuation stalled again and even with pumping at 1000 then 1500psi. After a few minutes the actuation started, and the tool stroked out and boosted. POOH.

Result: Failed Test

Diagnosis: After previous tests it was noted that the middle lip seal on the upper sleeve valve was damaged by the ports on the accumulator barrel. It was postulated that a different type of seal (point contact) be used in place of the lip seals

Corrective Action: Run the next test with 5x lip seals (CFS1800), replaced by point seals (CFS1801)

3.2.9 *1KPFTST9*

A repeat of test 1KPFTST7 but with lip seals in the upper sleeve valve replaced by point contact seals. A 4000 psi actuation pressure was used and the tool fully actuated, boosted and stroked

Result: Successful Test

Diagnosis: Subsequent analysis (see below) showed that a diverter seal (CFS1810) was removed from this test run

Corrective Action: None

3.2.10 *1KPFTST10*

A repeat of test 1KPFTST9 but with the diverter seal in place. The tool hydraulically locked as before. This proved the hydraulic lock theory and identified the cause.

Result: Failed Test

Diagnosis: The diverter seal was causing the hydraulic lock observed in all tests bar 1KPFTST9. The design of seal CFS1810 is an improvement and will be included in future configurations but the Regulator Sub will be modified to ensure hydraulic locking cannot occur. This problem is a result of the modifications to the IT plug prior to this testing program and therefore is not a contributor to historical tool failures

Corrective Action: Remove the diverter seal from all subsequent runs but modify the Regulator Sub so that when the diverter seal is used as it should be there is no chance of a hydraulic lock

3.2.11 *1KPFTST11*

A repeat of test 1KPFTST10 but with the diverter seal removed. The tool was reset, and the shear pin replaced after the previous failed run. The tool actuated as per design and boosted correctly.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.2.12 *1KPFTST12*

A repeat of test 1KPFTST12 but with the ocean accumulator disconnected. The tool actuated as per design and boosted correctly. A small increase in ocean pressure was observed because the ocean accumulator was disconnected resulting in a very small volume in the PFT setup.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.2.13 *4KPFTST1*

A high-pressure test similar to 1KPFTST12 with the ocean accumulator disconnected. The tool actuated as per design and boosted correctly. A similar increase in ocean pressure was observed as per the previous test.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.2.14 *4KPFTST2*

A repeat of 4KPFTST1 with the ocean accumulator connected. The tool actuated as per design and boosted correctly. The shear pin held up actuation at an actuation pressure of 2000 psi and broke when the actuation pressure was increased to around 3000 psi.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.2.15 *4KPFTST3*

A repeat of 4KPFTST2. The tool actuated as per design and boosted correctly.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.2.16 *4KPFTST4*

A repeat of 4KPFTST3. The tool actuated as per design and boosted correctly.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.3 PRESSURE ACTUATION TEST (PAT)

		NITROGEN (PSI)			
TEST #	OCEAN ACCUMULATOR	SET	FILL	TEST OCEAN (PSI)	PCTB SEAL PRESSURE (PSI)
1kPATST1	y	1510	3028	1089	1548
1kPATST2	y	1489	2985	1005	1548
1kPATST3	y	1519	3058	1007	1616
4kPATST1	y	4434	7971	3492	3854
4kPATST2	y	4428	8121	4184	4441
4kPATST3	y	4478	8210	4187	0
4kPATST4	y	4478	8210	4040	4497
4kPATST5	y	5006	8268	3979	4371
4kPATST6	y	0	0	3960	2875
4kPATST7	y	0	0	4032	2564

Table 3: PAT summary data.

3.3.1 *1KPATST1*

No DST in the ocean side of the system. It was noted that while lowering the pulling tool there was a pressure increase as a result of a hydraulic lock caused by operator error. The accumulator line was pre-charged, and a fast pull successfully made. The autoclave pressure settled a little lower over time.

Result: Successful Test

Diagnosis: Need to have a DST in the ocean side of the system

Corrective Action: Include DST in the ocean side of the system. Avoid operator error

3.3.2 *1KPATST2*

Included a DST in the ocean side of the system, installed in the circulation pump output manifold. Fast pull at approx. 96 m/min, successful test. The autoclave pressure settled a little lower over time.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.3.3 *1KPATST3*

Repeat of test 1KPATST2. During actuation/POOH the wireline tool came free of the pulling rod, but the tool had already stroked, sealed, and fired. The autoclave pressure settled a little lower over time.

Result: Successful Test

Diagnosis: None

Corrective Action: None

3.3.1 *4KPATST1*

Following three successful tests at lower pressures this run was made at higher pressure although due to time limitations the test was run at 3500 psi rather than the target pressure of 4000 psi. The tool actuated and boosted immediately but, the autoclave pressure settled noticeably lower (5-15%)

Result: Successful Test

Diagnosis: The settling of the pressure in the autoclave was observed in the previous tests and is possibly due to the seating of mechanisms or differential pressure expansion

Corrective Action: Investigate potential causes for settling of autoclave pressure after boost

3.3.2 *4KPATST2*

Fast pull, same pressure settling as observed previously

Result: Successful Test

Diagnosis: None

Corrective Action: Investigate potential causes for settling of autoclave pressure after boost

3.3.3 *4KPATST3*

Test performed with a slow pump up, no ocean accumulator and a slow pull. The test appeared to have been successful but in removal from the BHA it was discovered that the shear pin had not sheared, and the pressure section had not moved or been triggered. The ball was closed.

Result: Failed Test

Diagnosis: It was suggested that the Overtravel Spring in the upper section is too weak for a slow pull – when the shear pin and the sleeve valve contacted the Overtravel Spring compressed enough to unlatch the PCTB from the BHA without fully actuating the tool.

Corrective Action: Investigate the Overtravel Spring strength, add a 1" thick spacer to increase stiffness of the Overtravel Spring

3.3.4 *4KPATST4*

The tool was reset following test 4KPATST3 and a 1" thick spacer was installed on the Overtravel Spring to increase stiffness in an attempt to ensure the tool fully actuates before release from the BHA during a slow pull. The slow pull fully actuated the tool which sealed and boosted although the same pressure settling was observed. However, after POOH the pulling tool could not be released from the PCTB

Result: Successful Test (except the non-release of pulling tool)

Diagnosis: On disassembly it was discovered that one of the fingers on the pulling tool had broken off and jammed the release mechanism

Corrective Action: Replace pulling tool

3.3.5 *4KPATST5*

A repeat of test 4KPATST4 with an increased pressure section set point of 5000 psi and a medium speed pull of 50 m/min. The pulling tool did not latch at the first attempt but did on the second attempt. The test was successful with the same autoclave pressure settling.

Result: Successful Test

Diagnosis: The non-latching of the pulling tool could be attributed to a lack of weight which in the field comes from the wire weight

Corrective Action: None

3.3.6 *4KPATST6*

As the tool had performed well in the previous tests, this test was performed with no boost function (pressure section was not charged or set). The test here was to see if the tool could seal well without a differential pressure being applied via the boost. Although during this test the system accumulator ran out of charge so actuation was briefly halted until a pump was used to finish the actuation process. The tool actuated successfully but pressure record shows that the autoclave lost some pressure during POOH buy sealed at 2875 psi.

Result: Partially Successful Test

Diagnosis: This demonstrates that the differential pressure provided by the boost is required to ensure sealing in situ

Corrective Action: None

3.3.7 *4KPATST7*

A repeat of test 4KPATST6 using the pump for actuation rather than the system accumulator. The tool actuated successfully but pressure record shows that the autoclave lost some pressure during POOH buy sealed at 2564 psi.

Result: Partially Successful Test

Diagnosis: This again demonstrates that the differential pressure provided by the boost is required to ensure sealing in situ

Corrective Action: None

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 LATCH TESTS

While the latch testing does not indicate any problems without the spacer it is recommended that all sliding parts get coated with a friction reducing coating.

This includes all moving parts in the inner and outer latches, as well as the IT Plug Mandrel.

4.2 PFT

Partial Function Test - Tests 1-10 were used to trouble shoot the prototype single trigger mechanism in the PFT test set-up.

All the tests with the diverter were either aborted or were successful with some difficulty.

The tests without the diverter seal were immediately and easily successful.

The CFS1801 Point Contact Sleeve Valve seal eliminated the damage seen on the CFS1800 Lip Seals, which should not only make the system more robust and reliable but reduce the possibility of late boost by the seal getting caught in the nitrogen port holes.

The prototype lift sub seal, CFS1811, which caused difficulty in several tests is a viable modification, which will require minor modifications to the pressure section to be used.

The PCTB4A Single Trigger Mechanism is functionally fit for purpose, and no performance faults were discovered during the Partial Function Test.

4.3 PAT

Pressure Actuation Test – The PAT test proves that the PCTB4A Single Trigger Mechanism is as reliable and capable of recovering pressure cores as the PCTB3. Testing discovered a flaw with the overtravel spring during a slow pull that can cause an incomplete stroke of the tool. It is possible, although unlikely, that the overtravel spring issue can happen to the PCTB3 as there is no shear pin to increase the force needed to pull the inner.

4.4 OVERTRAVEL SPRING

The Overtravel Spring needs to be redesigned to prevent the PCTB from unlatching from the BHA before the tool is fully stroked, sealed, and pressure section fired. It additionally needs to unlatch from the BHA easily.

4.5 SINGLE TRIGGER MECHANISM

PCTB4A Single Trigger Mechanism is an improvement and functions properly. The prototype design has been proven and the tool should be upgraded.

4.6 POINT SEALS

The bi-directional point seal (CFS1801) in the sleeve valve should replace the lip seal (CFS1800) and be deployed immediately in all configurations.

4.7 SHEAR PIN

The addition of the shear pin in the IT Plug adds the ability to hold the actuation between ball valve and boost firing. It also may help unlatch and release the tool from the BHA by causing a slide hammer like action.

4.8 DIVERTER SEAL

Modify the QLS, bearing housing, and lift sub to run the prototype diverter seal. Also modify the Regulator Sub so the seal cannot inadvertently seal and cause hydraulic lock. The prototype seal was successfully run on GMGS5 and eliminated the tool separation issues that were observed on GOM2.

APPENDICES

1 APPENDIX 1: PFT RUN SHEETS AND PRESSURE PLOTS

1.1 1KPFTST1

GEOTEK CORING Inc

3350 W Directors Row, Suite 600
Salt Lake City, Utah 84104
1-385-528-2536 info@geotekcoring.com www.geotekcoring.com

TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 12, 2019	CORE:			1k PFT Single Trigger 1
TOOL ASSEMBLY TEAM:		Alan, Weston			
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
no accumulator	Single Trigger IT Plug
	1/4" Polycarbonate Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,501 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,005 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 12, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	09:00
NOTES:				

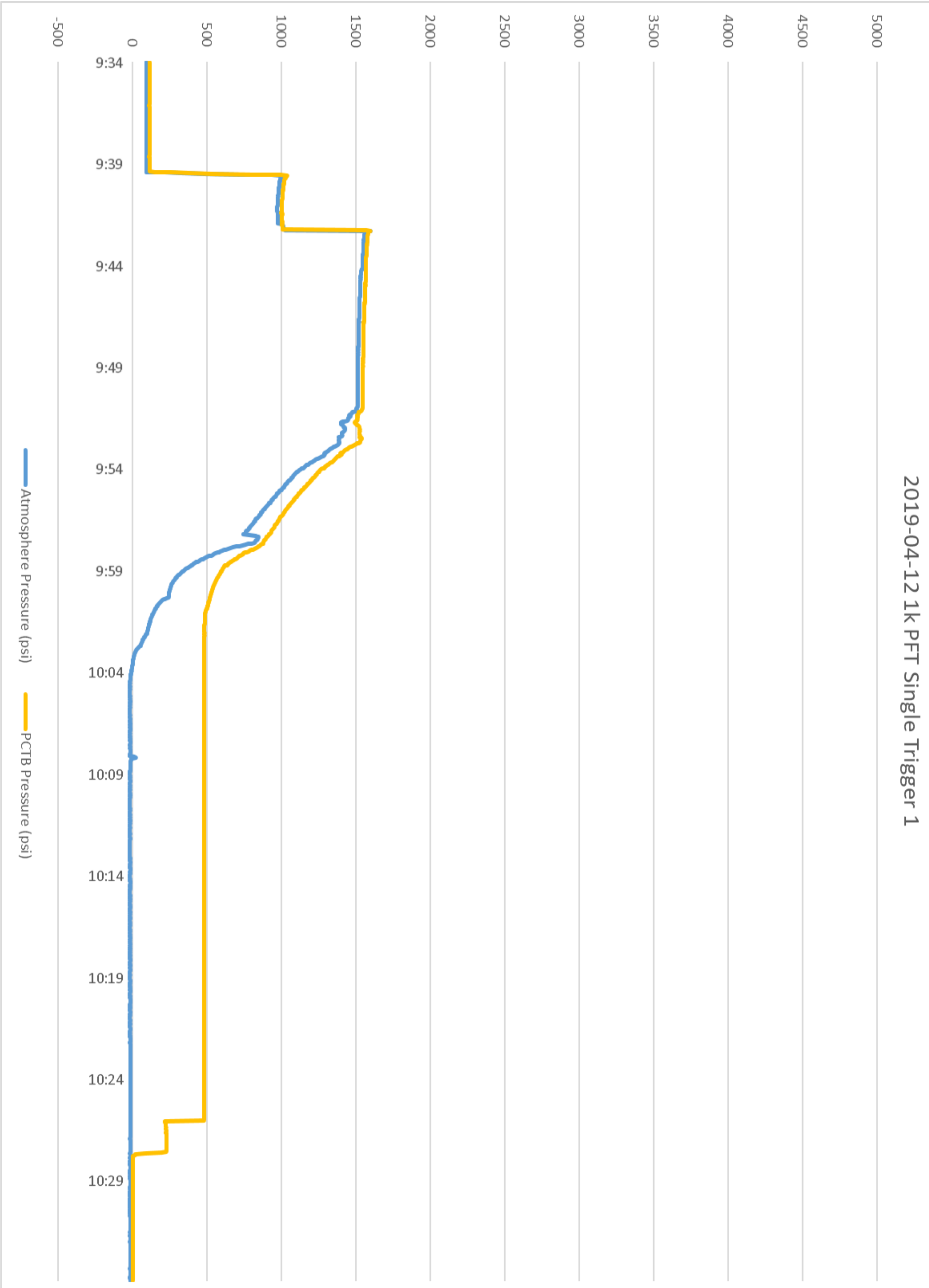
TESTING RUN

TEST DATE:	Apr 12, 2019	TEST START TIME:	09:35
INITIAL LINEAR TRANSDUCER (IN):	0.073	FINAL LINEAR TRANSDUCER (IN):	9.619
INITIAL PCTB PRESSURE (PSI):	977	FINAL PCTB PRESSURE (PSI):	1522
INITIAL ATMOSPHERE PRESSURE (PSI):	977	FINAL ATMOSPHERE PRESSURE (PSI):	1539
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	2500
ACCUMULATOR CHARGE (PSI):	N/A	PCTB Seal Pressure (PSI):	473

NOTES: The single trigger parts were incorporated into the IT Plug and Pressure section. A 1/4" OD Polycarbonate rod was used for a shear pin. The tool was actuated at 1000 psi, and it pulled to 8.792 before contacting the shear pin. It took 2500 psi to shear the pin. Once it did, it pulled slowly until max travel when the pressure section fired boosting the PCTB and atmosphere. Upon POOH, the PCTB leaked pressure until 473 psi when it sealed. A pressure test was performed, but no leak was found. Upon disassembly of the tool, all seals looked good with the exception of the outer piston sleeve and the lowest Sleeve Valve seal, which were nicked by the sharp hole openings of the new Accumulator Barrel. They were cleaned up and the test to be repeated as 1kST2.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-12 1k PFT Single Trigger 1
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
9:34
9:39
9:44
9:49
9:54
9:59
10:04
10:09
10:14
10:19
10:24
10:29
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.2 1KPFTST2

GEOTEK CORING Inc
3350 W Directors Row, Suite 600
Salt Lake City, Utah 84104
1-385-528-2536 info@geotekcoring.com www.geotekcoring.com

TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 12, 2019	CORE:			1k PFT Single Trigger 2
TOOL ASSEMBLY TEAM:		Alan, Weston			
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
no accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST

SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,445 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,070 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 12, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	05:05
NOTES:				

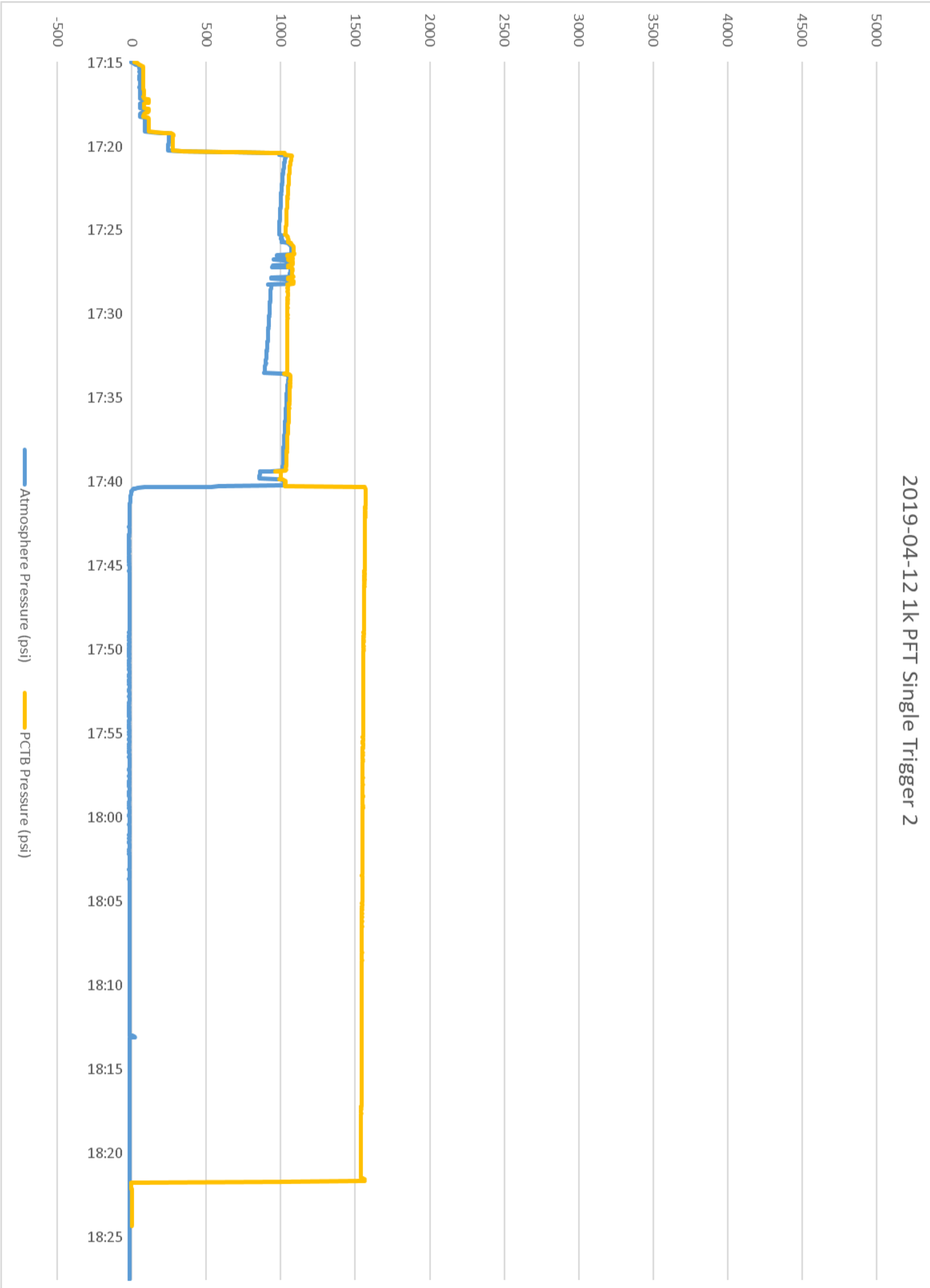
TESTING RUN

TEST DATE:	Apr 12, 2019	TEST START TIME:	17:14
INITIAL LINEAR TRANSDUCER (IN):	0.07	FINAL LINEAR TRANSDUCER (IN):	9.605
INITIAL PCTB PRESSURE (PSI):	1052	FINAL PCTB PRESSURE (PSI):	1567
INITIAL ATMOSPHERE PRESSURE (PSI):	1007	FINAL ATMOSPHERE PRESSURE (PSI):	0
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	2500
ACCUMULATOR CHARGE (PSI):	N/A	PCTB Seal Pressure (PSI):	1567

NOTES: After 1kST1, the holes in the Accumulator Barrel were deburred and the seals changed. A repeat of that test was performed, with a 3/8" ABS shear pin. During actuation at 1000 psi, the shear pin caught at 8.653" of pull. When the pressure was increased, the tool pulled to ~9" and stopped. We attempted to finish the pull by bringing the actuation pressure up to the maximum ot 5000 psi, bleeding it, and hitting it again. The tool would not pull past ~9". Based on the linear transducer measurement the shear pin had sheared and the IT Plug was sealed, but something else was hanging up. We theorized a hydrolock, and dumped the atmosphere pressure, which caused the tool to fully stroke and boost. The DST data seems to indicate that the PCTB sealed immediately, and stayed fairly steady in comparison to the Atmosphere pressure, which varied by ~120 psi, which may indicate a hydrolock. The test will be repeated with the accumulator.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-12 1k PFT Single Trigger 2
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
17:15
17:20
17:25
17:30
17:35
17:40
17:45
17:50
17:55
18:00
18:05
18:10
18:15
18:20
18:25
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.3 1KPFTST3

GEOTEK CORING Inc
3350 W Directors Row, Suite 600
Salt Lake City, Utah 84104
1-385-528-2536 info@geotekcoring.com www.geotekcoring.com

TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 14, 2019	CORE:			1k PFT Single Trigger 3
TOOL ASSEMBLY TEAM:		Alan, Weston			
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
15 gal accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST

SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,463 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,025 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 14, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:00
NOTES:				

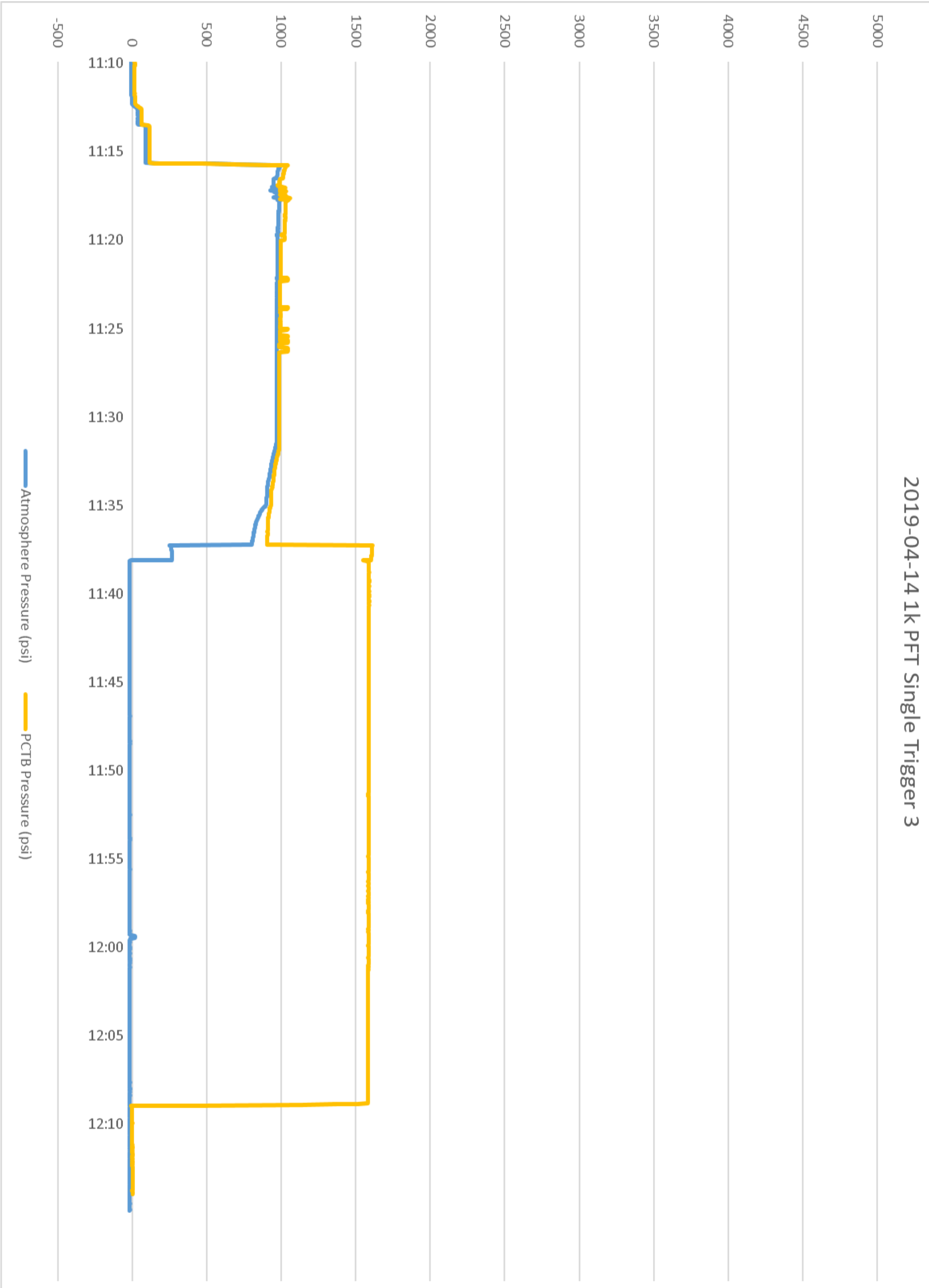
TESTING RUN

TEST DATE:	Apr 14, 2019	TEST START TIME:	11:12
INITIAL LINEAR TRANSDUCER (IN):	0.06	FINAL LINEAR TRANSDUCER (IN):	9.616
INITIAL PCTB PRESSURE (PSI):	997	FINAL PCTB PRESSURE (PSI):	1560
INITIAL ATMOSPHERE PRESSURE (PSI):	997	FINAL ATMOSPHERE PRESSURE (PSI):	0
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	1000	PCTB Seal Pressure (PSI):	1560

NOTES: A repeat of 1kST2, with the same 3/8" ABS shear pin, adding an accumulator to prevent possibility of test fixture hydrolock. During actuation at 1000 psi, the shear pin caught at 8.654" of pull. Again, when the pressure was increased, the tool pulled to ~9" and stopped. While attempting to slowly bleed the atmosphere pressure, the bleed valve was accidentally bumped which caused the tool to stroke and boost. During actuation a pressure drop was noticed in the PCTB which reversed when the actuation pressure was let off, indicating a hydrolock in the tool. Comparison of the 3d model and linear transducer reading indicates that the hydrolock occurs when the lower sleeve valve seals up, keeping the pressure section from firing.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-14 1k PFT Single Trigger 3
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
11:10
11:15
11:20
11:25
11:30
11:35
11:40
11:45
11:50
11:55
12:00
12:05
12:10
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.4 1KPFTST4

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 14, 2019	CORE:		1k PFT Single Trigger 4
TOOL ASSEMBLY TEAM:		Alan, Weston		
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:		1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:		2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT: Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:		L7071	ATMOSPHERE:	L7073
NOTES:				

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
15 gal accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
	1000 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,527 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,993 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 14, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	16:45
NOTES:				

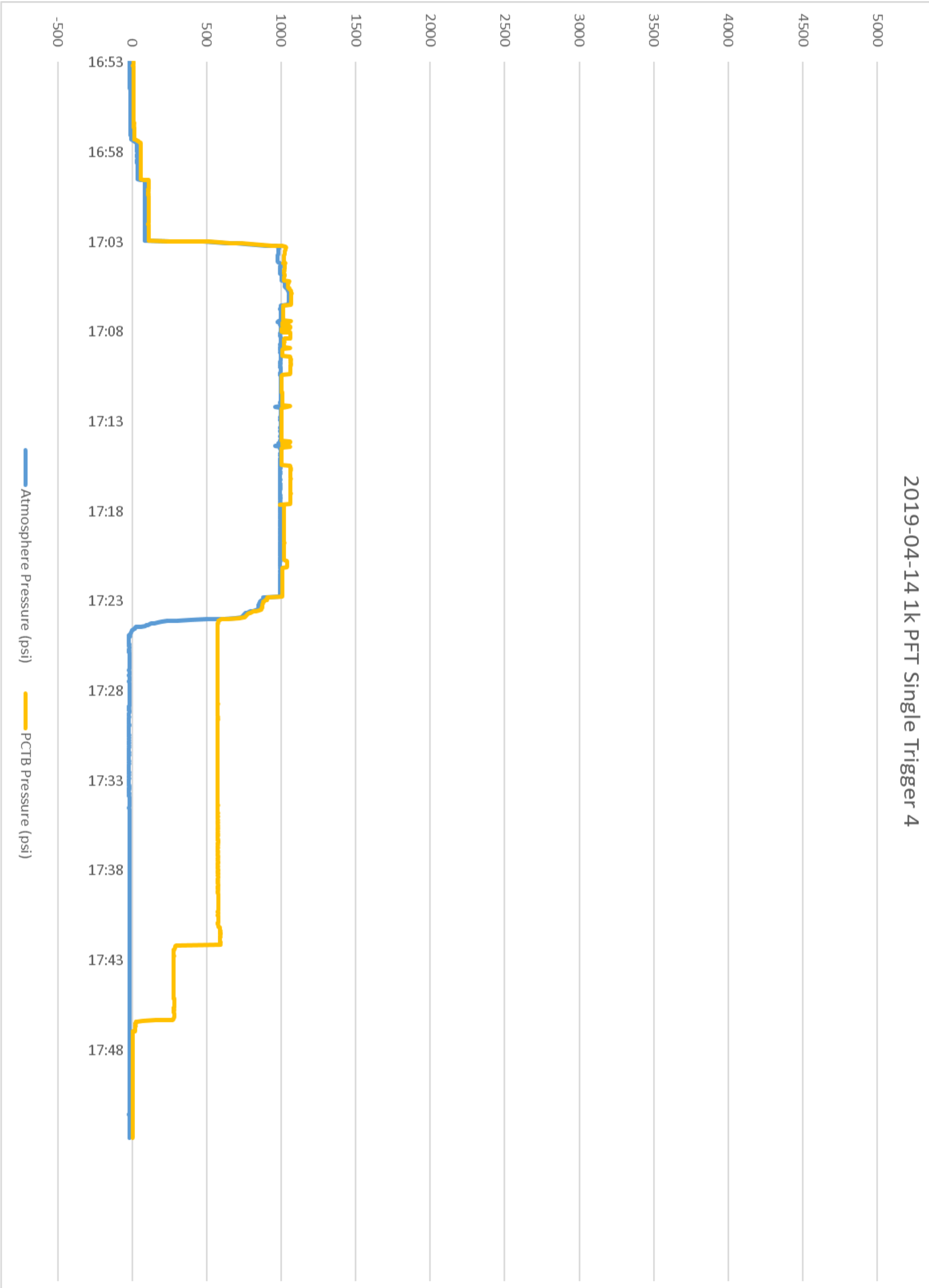
TESTING RUN

TEST DATE:	Apr 14, 2019	TEST START TIME:	17:00
INITIAL LINEAR TRANSDUCER (IN):	0.056	FINAL LINEAR TRANSDUCER (IN):	9.603
INITIAL PCTB PRESSURE (PSI):	998	FINAL PCTB PRESSURE (PSI):	553
INITIAL ATMOSPHERE PRESSURE (PSI):	996	FINAL ATMOSPHERE PRESSURE (PSI):	0
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	553

NOTES: To ensure the Single Trigger Pressure Section wasn't causing any issues, this test was performed with the pressure section backcharged on the top side with 1000 psi. This pumps the piston down. Traditionally a test without a pressure section would be done by closing the "shutoff" valve, but that would eliminate the lower sleeve valve leak point and cause a worse hydrolock. By back charging the pressure section, the piston was already down and therefore would not contribute any boost. The shear pin hit at 8.664, and the tool once again got stuck around ~9. The test was initially run with the accumulator closed, and once the tool was stuck the accumulator was opened to no result.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-14 1k PFT Single Trigger 4
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
16:53
16:58
17:03
17:08
17:13
17:18
17:23
17:28
17:33
17:38
17:43
17:48
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.5 1KPFTST5

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 15, 2019	CORE:			1k PFT Single Trigger 5
TOOL ASSEMBLY TEAM:		Alan, Weston			
SIMULATED CORE DEPTH:	887 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
No accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
	300 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,529 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		5,007 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 15, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	10:45
NOTES:				

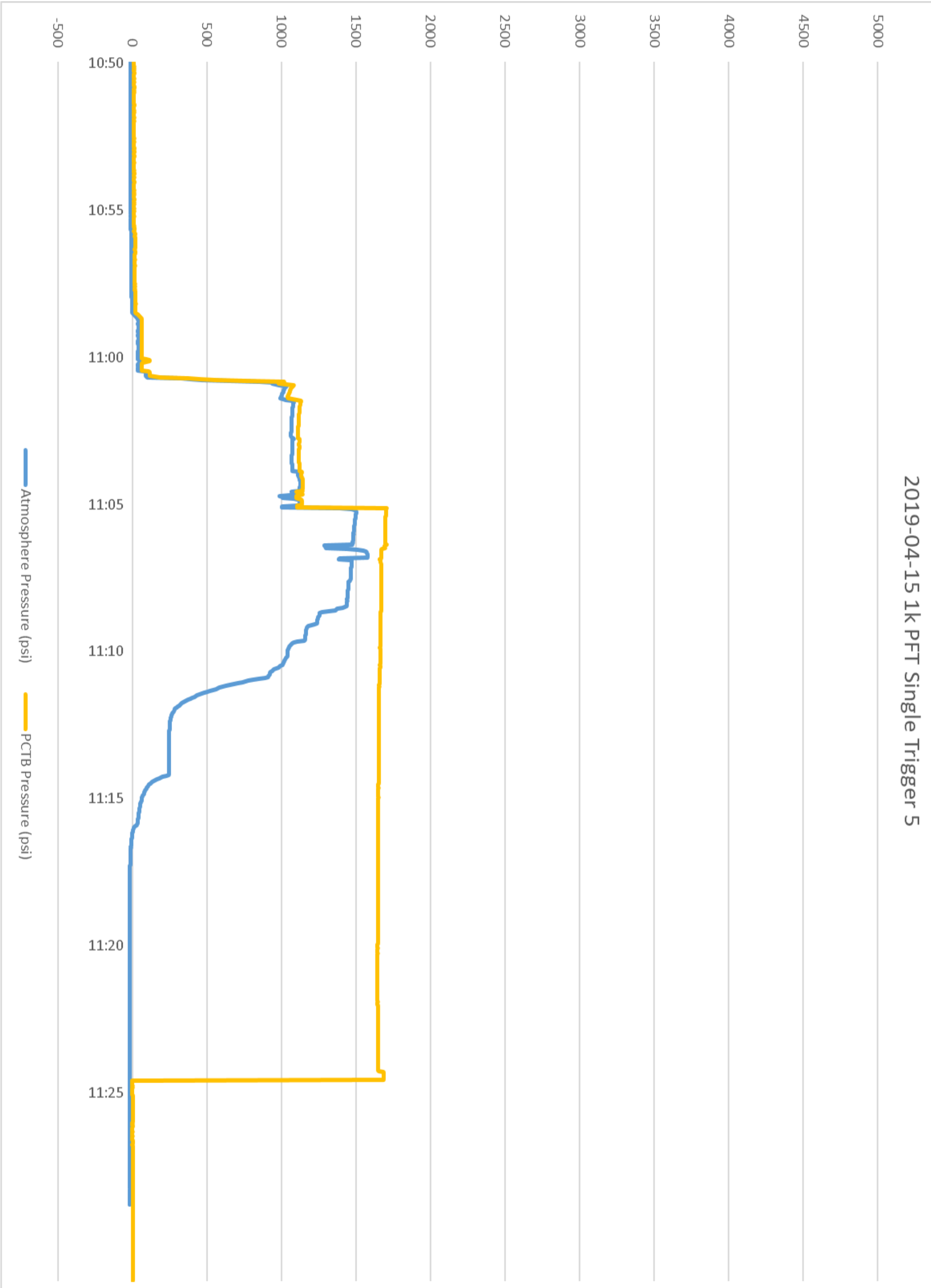
TESTING RUN

TEST DATE:	Apr 15, 2019	TEST START TIME:	10:58
INITIAL LINEAR TRANSDUCER (IN):	0.069	FINAL LINEAR TRANSDUCER (IN):	9.235
INITIAL PCTB PRESSURE (PSI):	1074	FINAL PCTB PRESSURE (PSI):	1659
INITIAL ATMOSPHERE PRESSURE (PSI):	1077	FINAL ATMOSPHERE PRESSURE (PSI):	1493
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	1659

NOTES: The pressure section was back charged with 300 psi nitrogen, which should turn the pressure section into an accumulator to attempt to alleviate the perceived hydrolock in the tool while pulling. The shear pin hit at 8.656, and the tool again got stuck at ~9, but after a couple hits went to 9.235 and boosted. The atmosphere boosted somewhat, but not to full PCTB pressure. The tool did not fully stroke at this point, but after a few more hits did and went to 9.612

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-15 1k PFT Single Trigger 5
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10:50
10:55
11:00
11:05
11:10
11:15
11:20
11:25
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.6 1KPFTST6

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 15, 2019	CORE:	1k PFT Single Trigger 6
TOOL ASSEMBLY TEAM:	Alan, Weston		
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:	1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT: Basket/Rabbit	5" Extension / 5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:	L7073
NOTES:			

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
15 gal accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
	300 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,573 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		4,994 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 15, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	14:00
NOTES:				

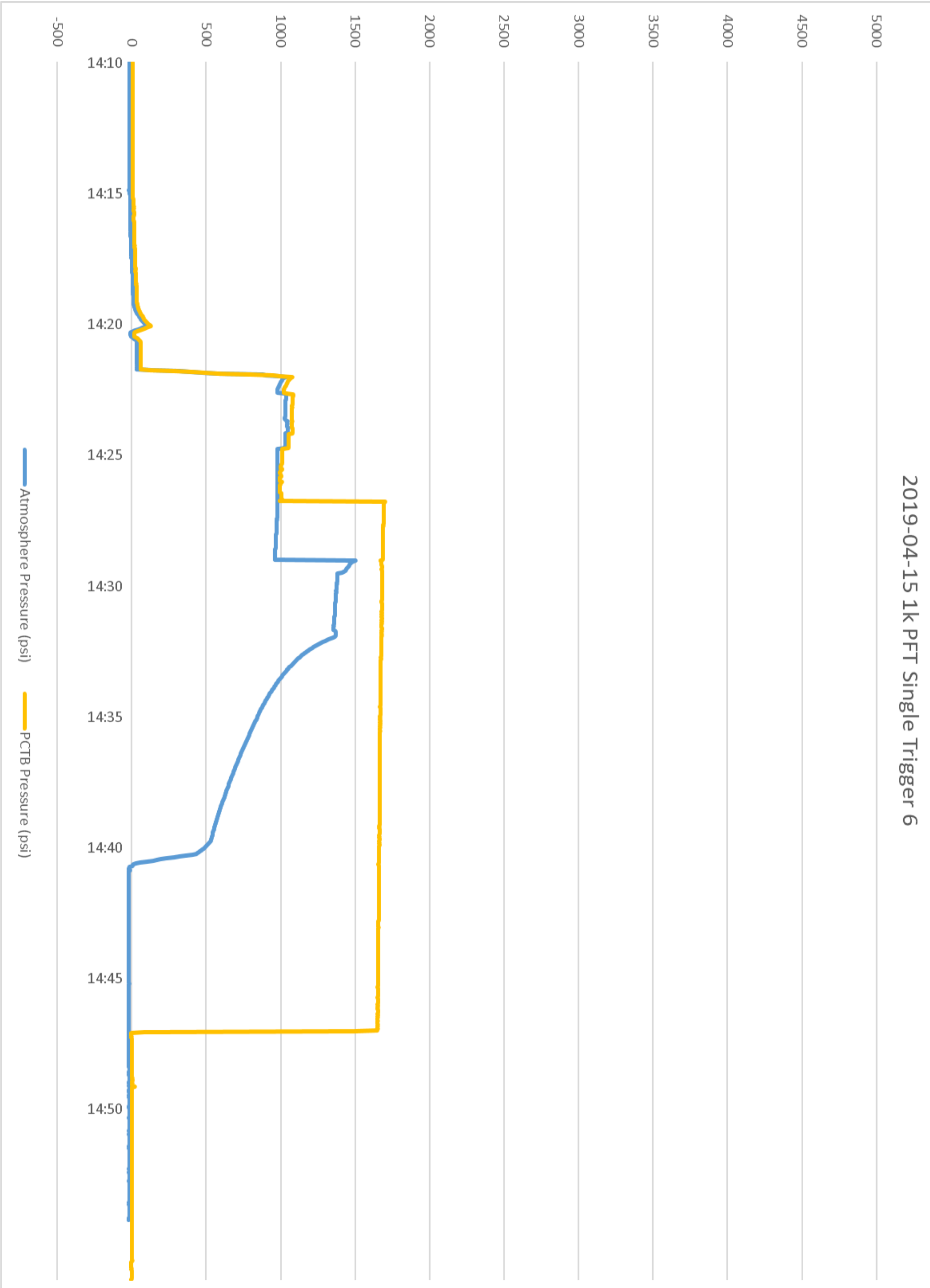
TESTING RUN

TEST DATE:	Apr 15, 2019	TEST START TIME:	14:13
INITIAL LINEAR TRANSDUCER (IN):	0.081	FINAL LINEAR TRANSDUCER (IN):	9.63
INITIAL PCTB PRESSURE (PSI):	1044	FINAL PCTB PRESSURE (PSI):	1662
INITIAL ATMOSPHERE PRESSURE (PSI):	1044	FINAL ATMOSPHERE PRESSURE (PSI):	1389
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	1662

NOTES: Again, the pressure section was back charged with 300 psi nitrogen.The shear pin hit at 8.674, and the tool again got stuck at ~9. Opened accumulator with atmosphere NOT linked. During actuation: 9.077, PCTB 962, Lower Atmosphere 993; During release 8.685, PCTB 976, Lower Atmosphere 993. Pulled to 9.563 and fired boost. Noticed Upper Atmosphere 1662, Lower Atmosphere 993. Linked atmospheres, tool poulled to 9.630 and both atmospheres equalized at 1390.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-15 1k PFT Single Trigger 6
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
14:10
14:15
14:20
14:25
14:30
14:35
14:40
14:45
14:50
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.7 1KPFTST7

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 15, 2019	CORE:	1k PFT Single Trigger 7		
TOOL ASSEMBLY TEAM:	Alan, Weston				
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:	1,000 psi		
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2		
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:	L7073		
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
15 gal accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
	300 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,532 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		5,025 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 15, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	15:50
NOTES:				

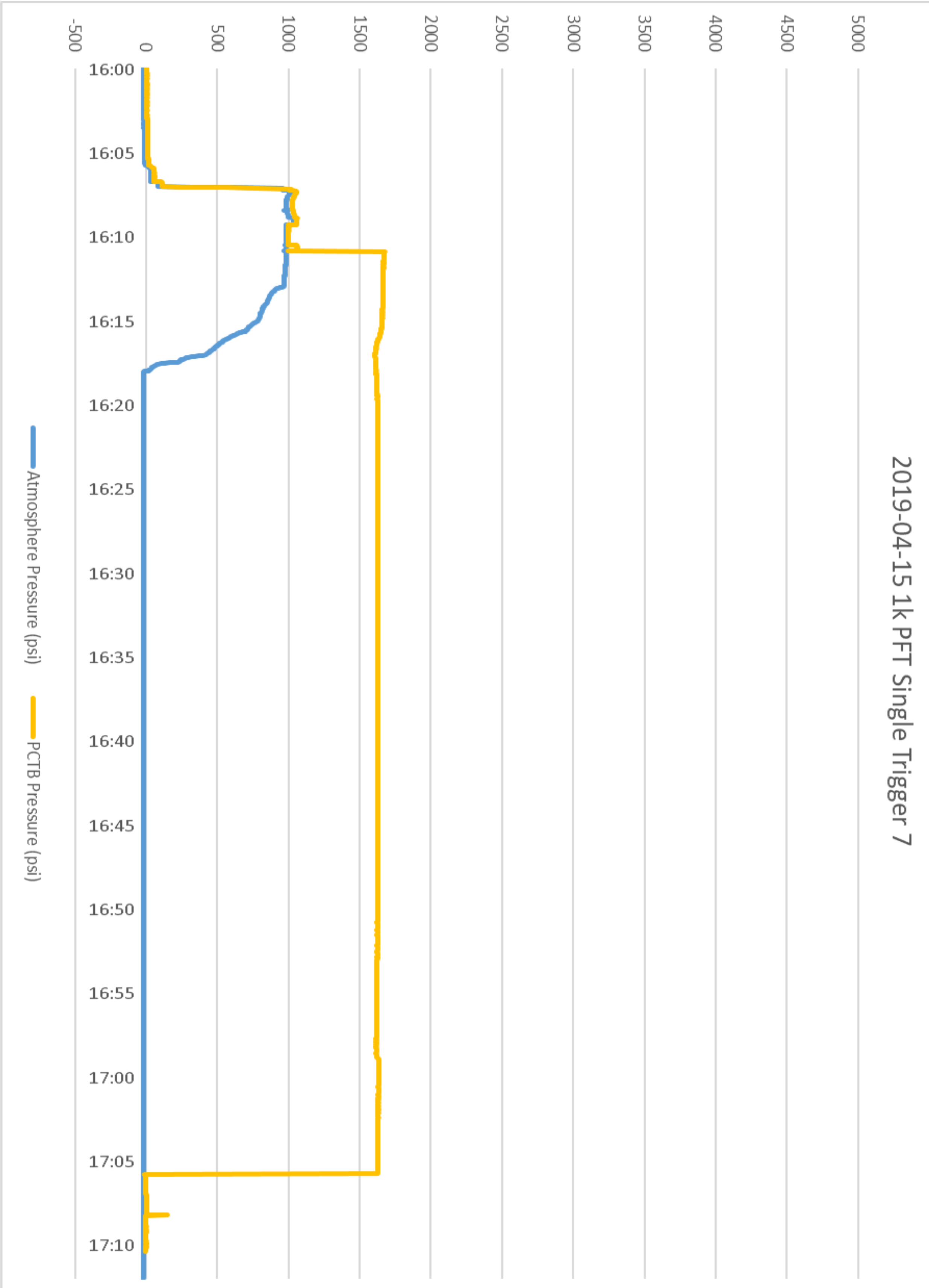
TESTING RUN

TEST DATE:	Apr 15, 2019	TEST START TIME:	16:03
INITIAL LINEAR TRANSDUCER (IN):	0.03	FINAL LINEAR TRANSDUCER (IN):	9.231
INITIAL PCTB PRESSURE (PSI):	995	FINAL PCTB PRESSURE (PSI):	1638
INITIAL ATMOSPHERE PRESSURE (PSI):	997	FINAL ATMOSPHERE PRESSURE (PSI):	995
INITIAL ACTUATION PRESSURE (PSI):	1000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	1638

NOTES: Again, the pressure section was back charged with 300 psi nitrogen.The shear pin hit at 8.620, and the tool again got stuck at ~9. Opened accumulator, but still stuck. During actuation: 8.932, PCTB 967, Atmosphere 995; During release 8.606, PCTB 967, Atmosphere 995. First hit pulled to 9.231 and fired boost. While POOH tool fully stroked to 9.578. Indications that the accumulator barely helps get through hydrolock to fire tool, but doesn't have enough volume makeup at pressure to fully stroke. Once atmosphere pressure differential decreases, it has enough to fully stroke.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-15 1k PFT Single Trigger 7
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
16:45
16:50
16:55
17:00
17:05
17:10
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.8 1KPFTST8

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 16, 2019	CORE:	1k PFT Single Trigger 8
TOOL ASSEMBLY TEAM:	Alan, Weston		
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:	1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT: Basket/Rabbit	5" Extension / 5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:	L7073
NOTES:			

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section
15 gal accumulator	Single Trigger IT Plug
	3/8 ABS Shear Pin
	300 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST

SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,526 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		5,025 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 16, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:35
NOTES:				

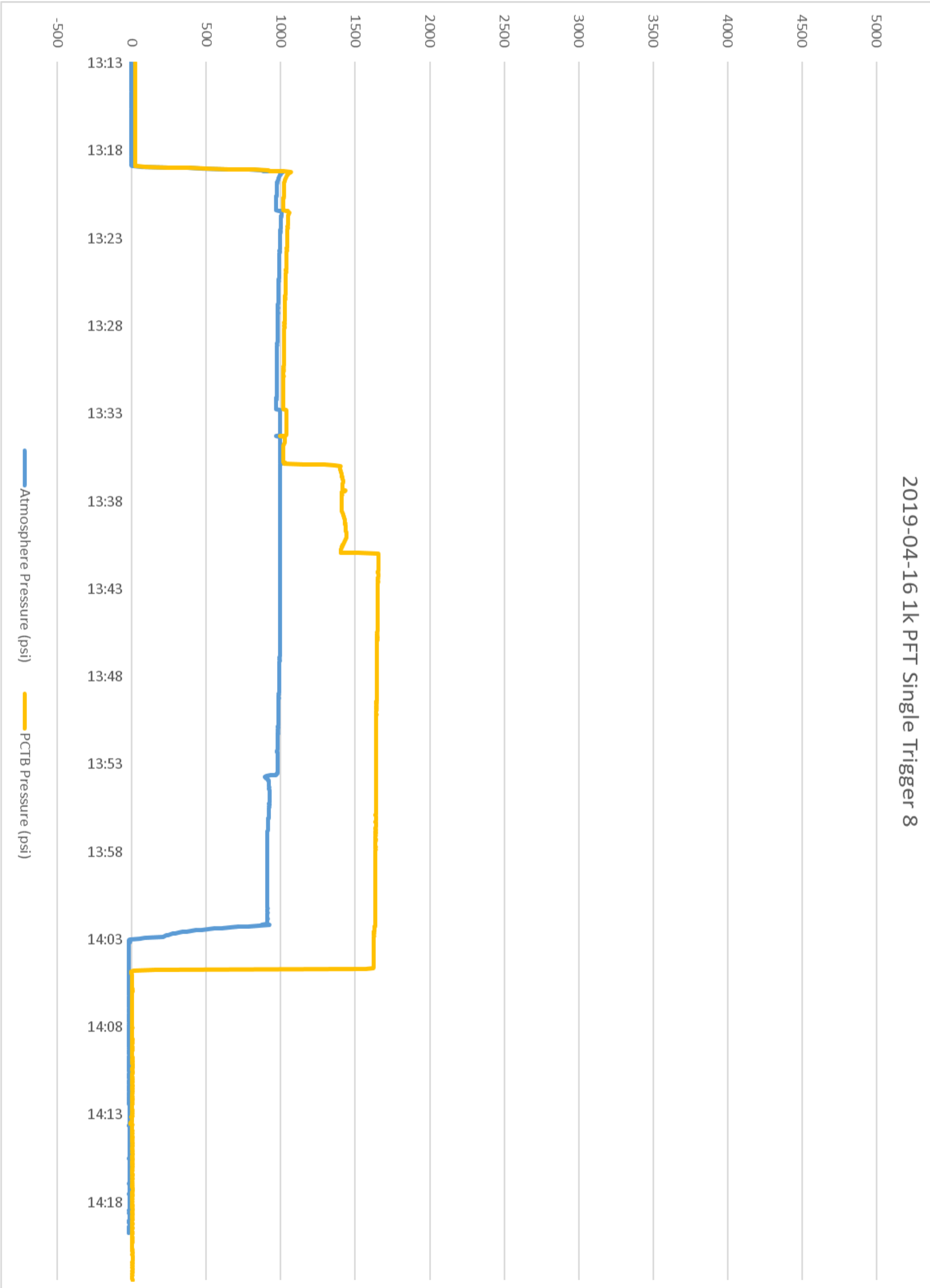
TESTING RUN

TEST DATE:	Apr 16, 2019	TEST START TIME:	13:18
INITIAL LINEAR TRANSDUCER (IN):	0.029	FINAL LINEAR TRANSDUCER (IN):	9.568
INITIAL PCTB PRESSURE (PSI):	1170	FINAL PCTB PRESSURE (PSI):	1608
INITIAL ATMOSPHERE PRESSURE (PSI):	1005	FINAL ATMOSPHERE PRESSURE (PSI):	1006
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	5000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	1608

NOTES: The pressure section was back charged with 300 psi nitrogen. To eliminate any possibility of hydrolock in the tool, a secondary high pressure water pump was hooked up to the drive sub, in the same location as the pressure transducer. The tool was actuated at 4k, which pulled to and immediately broke the shear pin before traveling to 8.879. The accumulator was opened at this point, and the PCTB was pumped to 1000 psi with the second pump. When it did not stroke and fire, the pressure was raised to 1500 psi. Since the atmosphere was accumulated and impossible to hydrolock, the PCTB was pumped up and had as much volume and pressure as it could need, the only possible hydrolock was the actuation cylinder, which was drained. Nothing happened immediately, but several minutes later the tool began slowly stroking (~1 in/min). Once it got to ~9.2, the tool boosted and fully stroked more quickly. The working hypothesis is a hydrolock outside of the autoclave as this test proved a hydro lock didn't exist in the autoclave.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-16 1k PFT Single Trigger 8
Atmosphere Pressure (psi)
PCTB Pressure (psi)
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
13:13
13:18
13:23
13:28
13:33
13:38
13:43
13:48
13:53
13:58
14:03
14:08
14:13
14:18

1.9 1KPFTST9

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 16, 2019	CORE:	1k PFT Single Trigger 9
TOOL ASSEMBLY TEAM:	Alan, Weston		
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:	1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT: Basket/Rabbit	5" Extension / 5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:	L7073
NOTES:			

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug, Removed diverter seal
	3/8 ABS Shear Pin
	300 psi Backcharged Pressure Section
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,537 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		5,025 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	April 16, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	17:10
NOTES:				

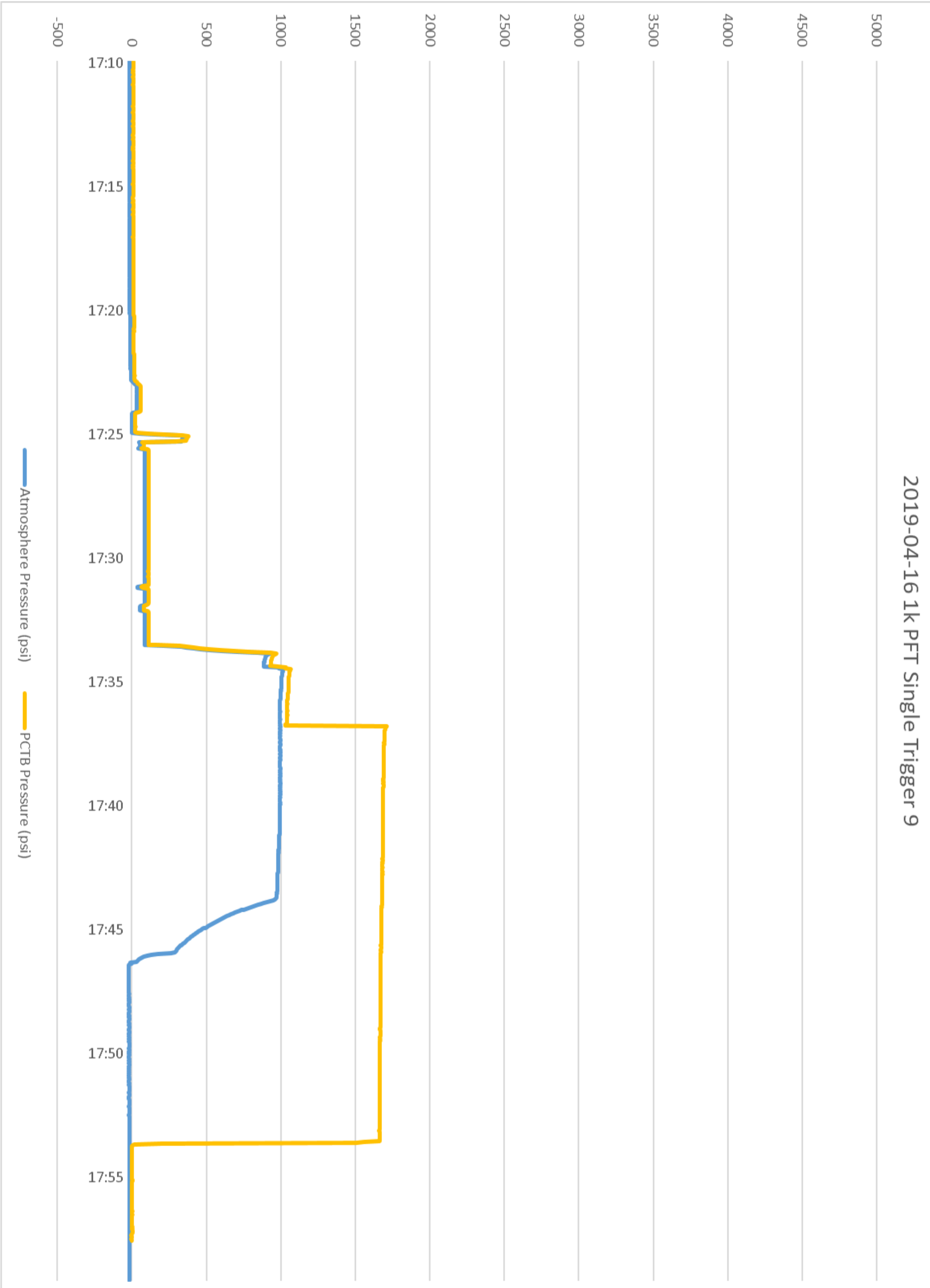
TESTING RUN

TEST DATE:	Apr 16, 2019	TEST START TIME:	17:33
INITIAL LINEAR TRANSDUCER (IN):	0.014	FINAL LINEAR TRANSDUCER (IN):	9.554
INITIAL PCTB PRESSURE (PSI):	1006	FINAL PCTB PRESSURE (PSI):	1653
INITIAL ATMOSPHERE PRESSURE (PSI):	1015	FINAL ATMOSPHERE PRESSURE (PSI):	1009
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	1653

NOTES: The pressure section was back charged with 300 psi nitrogen. It is unlikely there is a hydrolock in the tool but something keeps it from stroking fully. The linear pull distance it gets stuck is approximately where the lower sleeve valve seals. Due to the seal damage and slightly late boost of previous tests it was theorized that the lips were getting caught in the accumulator barrel holes so we ordered a replacement seal for the lip seal that is a point contact seal. All 5 lip seals were replaced with this point seal. The atmosphere accumulator was opened at the beginning of the test and the tool was actuated at 4k which pulled to and immediately broke the shear pin before and quickly boosted and fully stroked. ***2019-04-17 Edit: The prototype diverter seal was removed from the lift sub. See 1kST10**

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-16 1k PFT Single Trigger 9
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
17:10
17:15
17:20
17:25
17:30
17:35
17:40
17:45
17:50
17:55
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.10 1KPFTST10

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 17, 2019	CORE:			1k PFT Single Trigger 10
TOOL ASSEMBLY TEAM:	Alan, Weston				
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug, Diverter Seal
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,531 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,027 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-04-17
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	08:45
NOTES:				

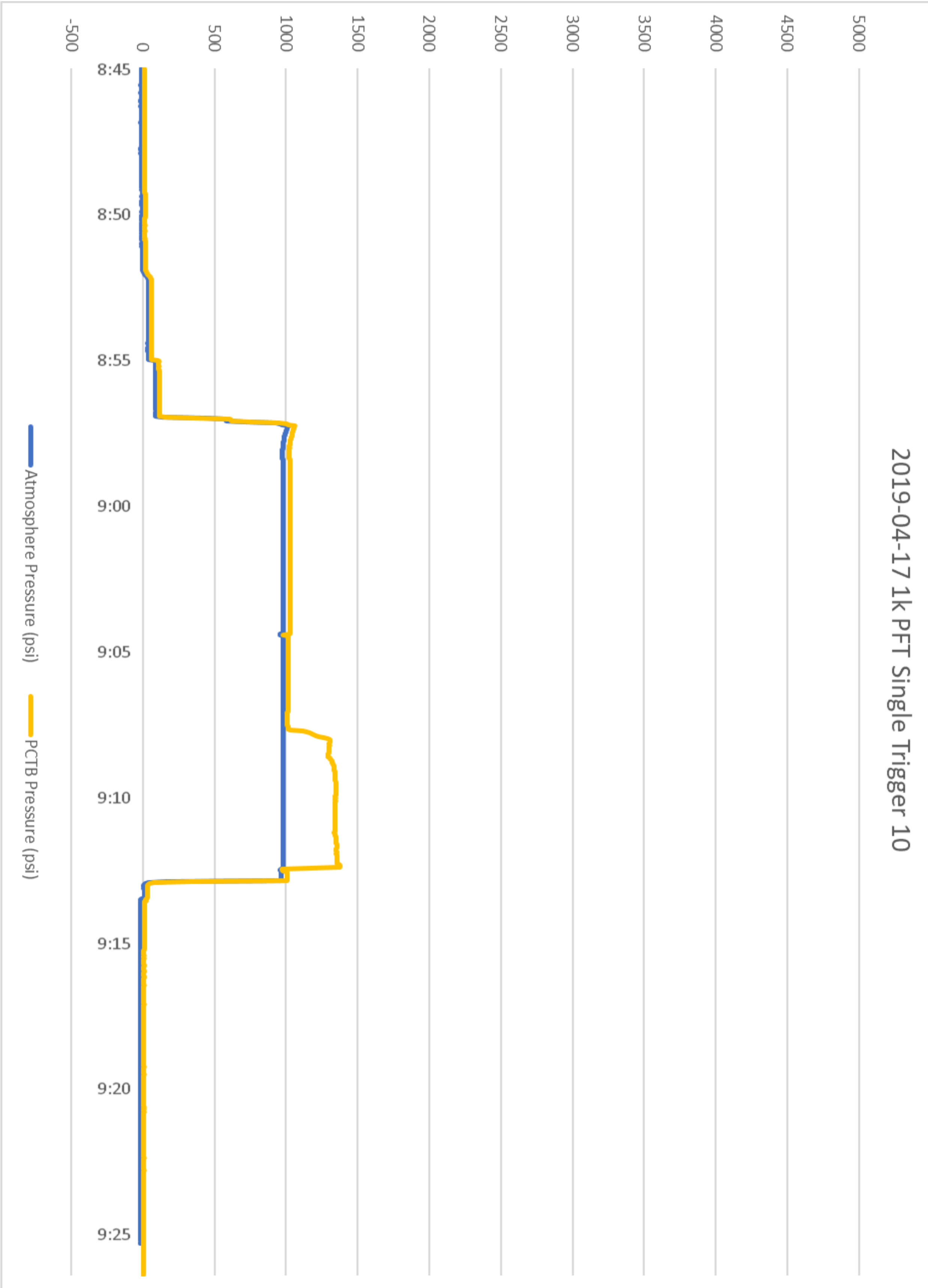
TESTING RUN

TEST DATE:	Apr 17, 2019	TEST START TIME:	08:57
INITIAL LINEAR TRANSDUCER (IN):	0.008	FINAL LINEAR TRANSDUCER (IN):	8.848
INITIAL PCTB PRESSURE (PSI):	999	FINAL PCTB PRESSURE (PSI):	981
INITIAL ATMOSPHERE PRESSURE (PSI):	994	FINAL ATMOSPHERE PRESSURE (PSI):	994
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	0

NOTES: Although 1kST09 was a success with the addition of the point contact sleeve valve seals, one other previously unnoted thing changed. A prototype diverter seal in the lift sub that doesn't make contact with the PCTB inner was removed. This diverter seal was put back in for 1kST10. All parameters of the test were identical to 1kST10, with the addition of this seal. The tool hydrolocked at 8.848, and the test was aborted to save the pressure section from having to be rebuilt for the next tests. Although there is approximately .036" clearance between the seal and the Regulator Sub and the lip is facing the wrong way to seal pressure, it hydrolocks there and keeps the tool from pulling. This proves our perceived hydrolok hypothesis right and we were able to identify and solve the problem by removing this diverter seal for all the future testing as this was sealing pressure into an area not designed to have pressure causing the hydrolok, and also will use a new developed bi-directional seal for the sleeve valve as the replacements are showing to be durable and not being damaged every run.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-17 1k PFT Single Trigger 10
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
8:45
8:50
8:55
9:00
9:05
9:10
9:15
9:20
9:25
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.11 1KPFTST11

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 17, 2019	CORE:			1k PFT Single Trigger 11
TOOL ASSEMBLY TEAM:	Alan, Weston				
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug, Removed diverter seal
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,531 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,027 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-04-17
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	09:45
NOTES:				

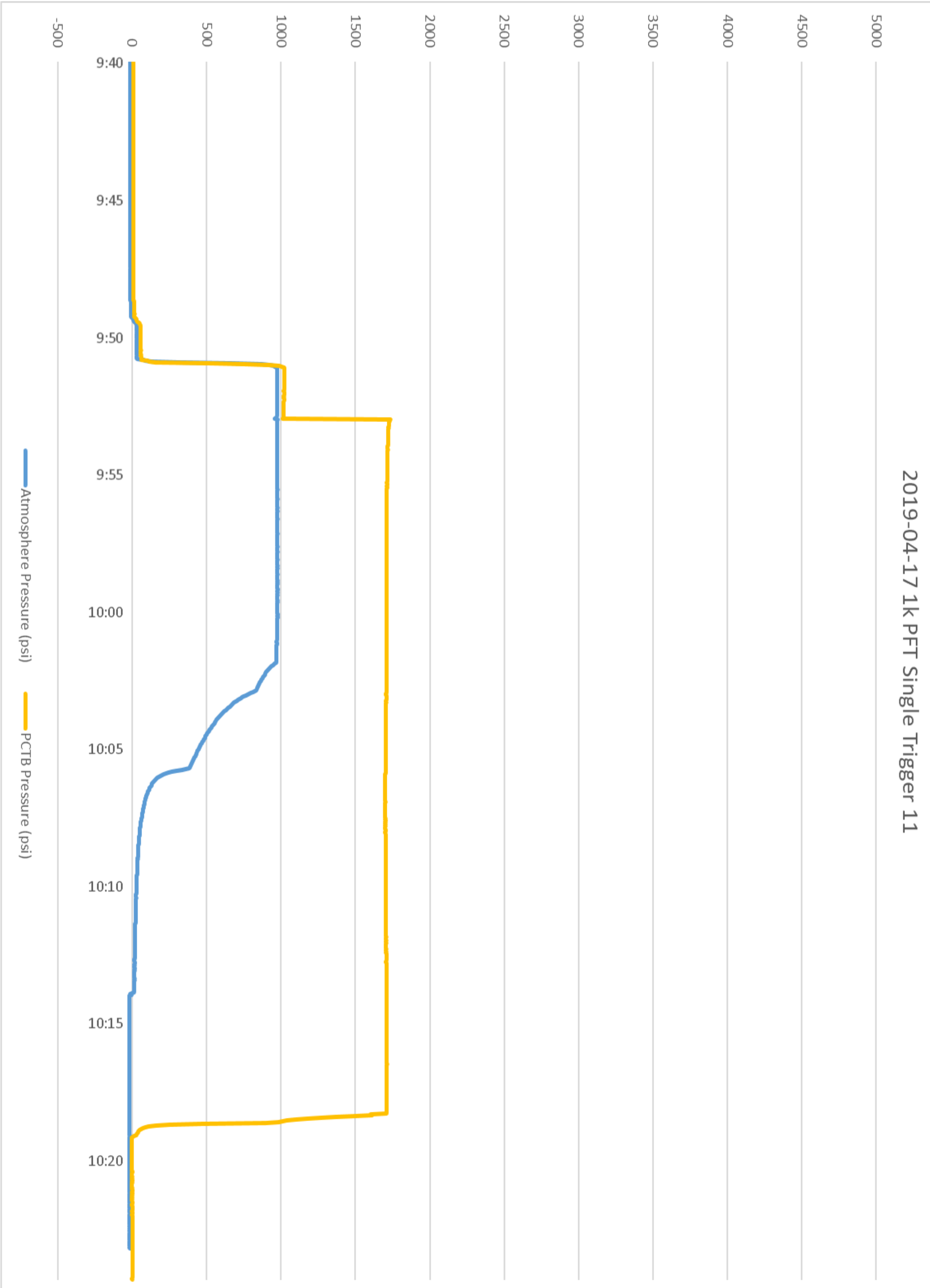
TESTING RUN

TEST DATE:	Apr 17, 2019	TEST START TIME:	09:51
INITIAL LINEAR TRANSDUCER (IN):	0.03	FINAL LINEAR TRANSDUCER (IN):	9.583
INITIAL PCTB PRESSURE (PSI):	1005	FINAL PCTB PRESSURE (PSI):	1710
INITIAL ATMOSPHERE PRESSURE (PSI):	990	FINAL ATMOSPHERE PRESSURE (PSI):	990
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	1000	PCTB SEAL PRESSURE (PSI):	1710

NOTES: As the previous test was aborted, the pressure section did not need to be rebuilt/charged. The shear pin was replaced, tool reset, and tried again. The diverter seal was removed. The tool pulled perfectly and boosted immediately.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-17 1k PFT Single Trigger 11
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
9:40
9:45
9:50
9:55
10:00
10:05
10:10
10:15
10:20
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.12 1KPFTST12

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	April 17, 2019	CORE:			1k PFT Single Trigger 12
TOOL ASSEMBLY TEAM:	Alan, Weston				
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	N/A	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
no accumulator	Single Trigger IT Plug, removed diverter seal
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,517 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,021 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-04-17
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:45
NOTES:				

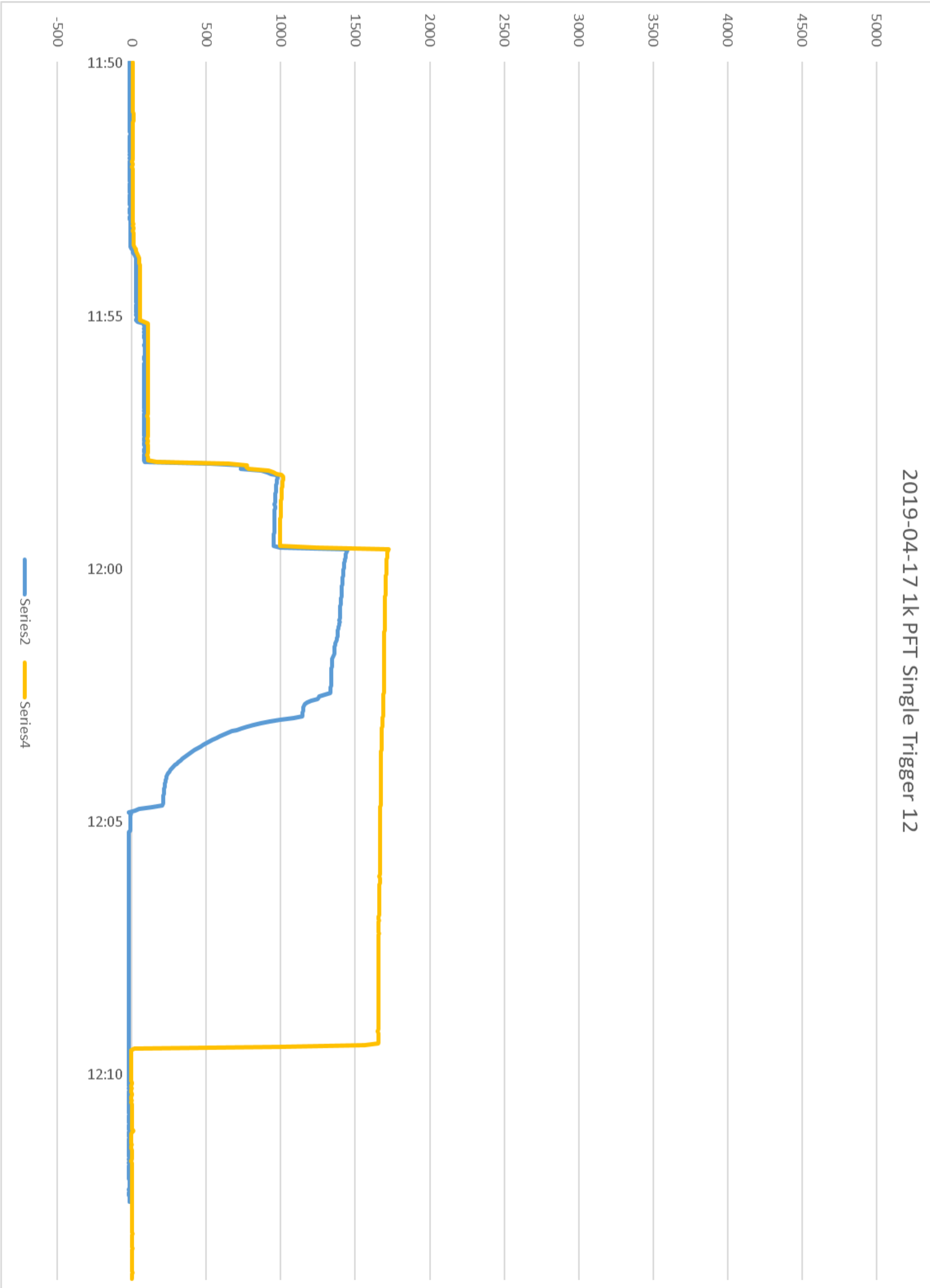
TESTING RUN

TEST DATE:	2019-04-17	TEST START TIME:	11:57
INITIAL LINEAR TRANSDUCER (IN):	0.025	FINAL LINEAR TRANSDUCER (IN):	9.57
INITIAL PCTB PRESSURE (PSI):	990	FINAL PCTB PRESSURE (PSI):	1702
INITIAL ATMOSPHERE PRESSURE (PSI):	985	FINAL ATMOSPHERE PRESSURE (PSI):	1442
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	none	PCTB SEAL PRESSURE (PSI):	1702

NOTES: A repeat of 1kST11 parameters, to see if the absence of the accumulator with the single trigger pressure section still works. The tool pulled perfectly and boosted immediately. There was at atmosphere change in pressure due to the volume being so small in the PFT set-up and no accumulator. Tool seal and worked well.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-04-17 1k PFT Single Trigger 12
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
11:50
11:55
12:00
12:05
12:10
Series2
Series4

1.13 4KPFTST1

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 30, 2019	CORE:			4k Single Trigger 1
TOOL ASSEMBLY TEAM:		Alan Bakken, Weston Barton			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
	Single Trigger IT Plug, No diverter seal
	3/8 PTFE R Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,493 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,019 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-30
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:00
NOTES:				

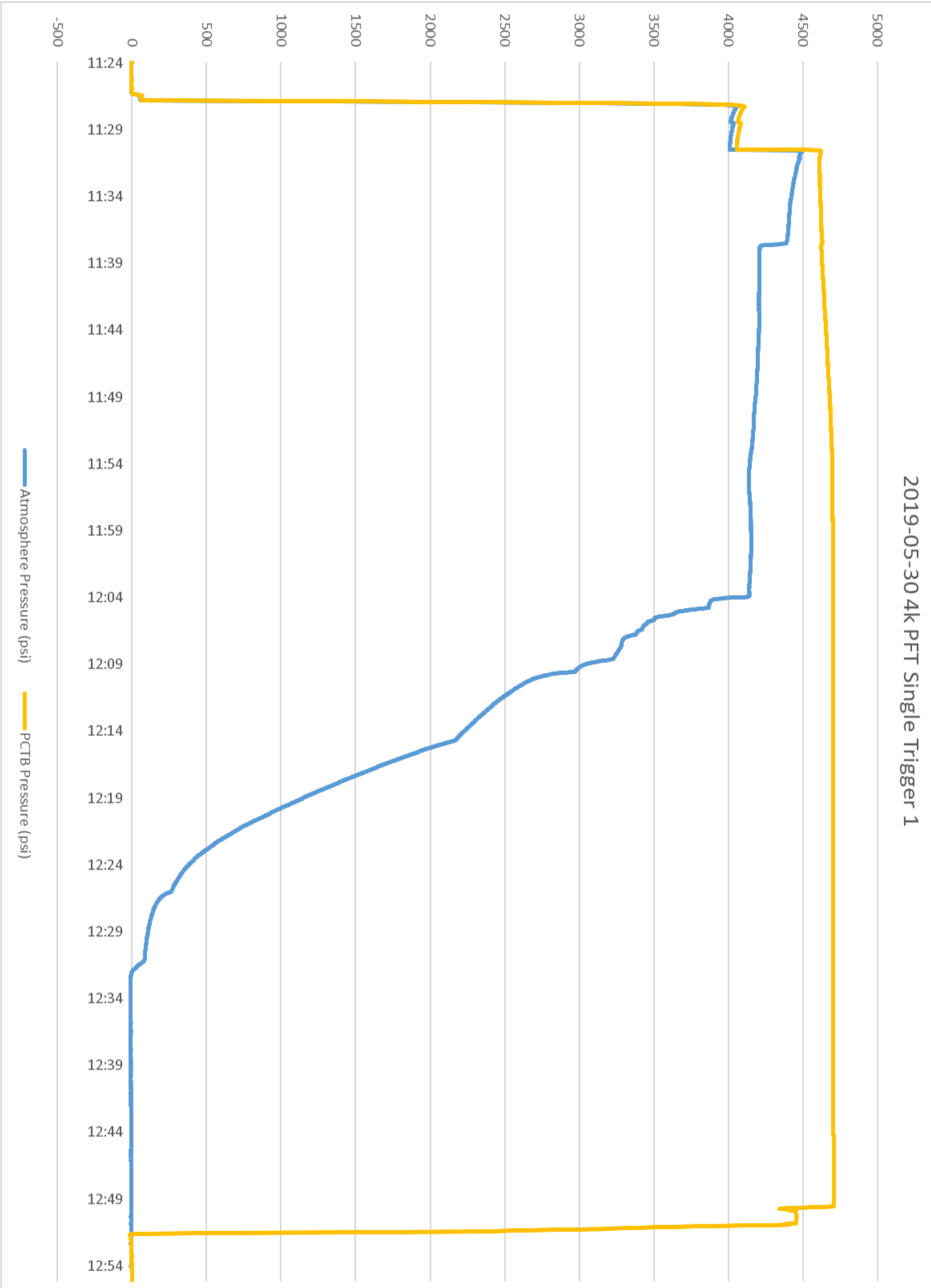
TESTING RUN

TEST DATE:	May 30, 2019	TEST START TIME:	11:25
INITIAL LINEAR TRANSDUCER (IN):	0.013	FINAL LINEAR TRANSDUCER (IN):	9.53
INITIAL PCTB PRESSURE (PSI):	4050	FINAL PCTB PRESSURE (PSI):	4735
INITIAL ATMOSPHERE PRESSURE (PSI):	4023	FINAL ATMOSPHERE PRESSURE (PSI):	4485
INITIAL ACTUATION PRESSURE (PSI):	2000	FINAL ACTUATION PRESSURE (PSI):	3000
ACCUMULATOR CHARGE (PSI):	n/a	PCTB SEAL PRESSURE (PSI):	4828

NOTES: High pressure test, no accumulator. Caught pin at 8.644 and stalled at actuation 2000 psi, broke at about 3000 psi. Tool boosted immediately. Good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-30 4k PFT Single Trigger 1
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
11:24
11:29
11:34
11:39
11:44
11:49
11:54
11:59
12:04
12:09
12:14
12:19
12:24
12:29
12:34
12:39
12:44
12:49
12:54
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.14 4KPFTST2

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 30, 2019	CORE:			4k Single Trigger 2
TOOL ASSEMBLY TEAM:	Alan Bakken, Weston Barton				
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug, No diverter seal
	3/8 PTFE R Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,494 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,047 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-30
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	14:45
NOTES:				

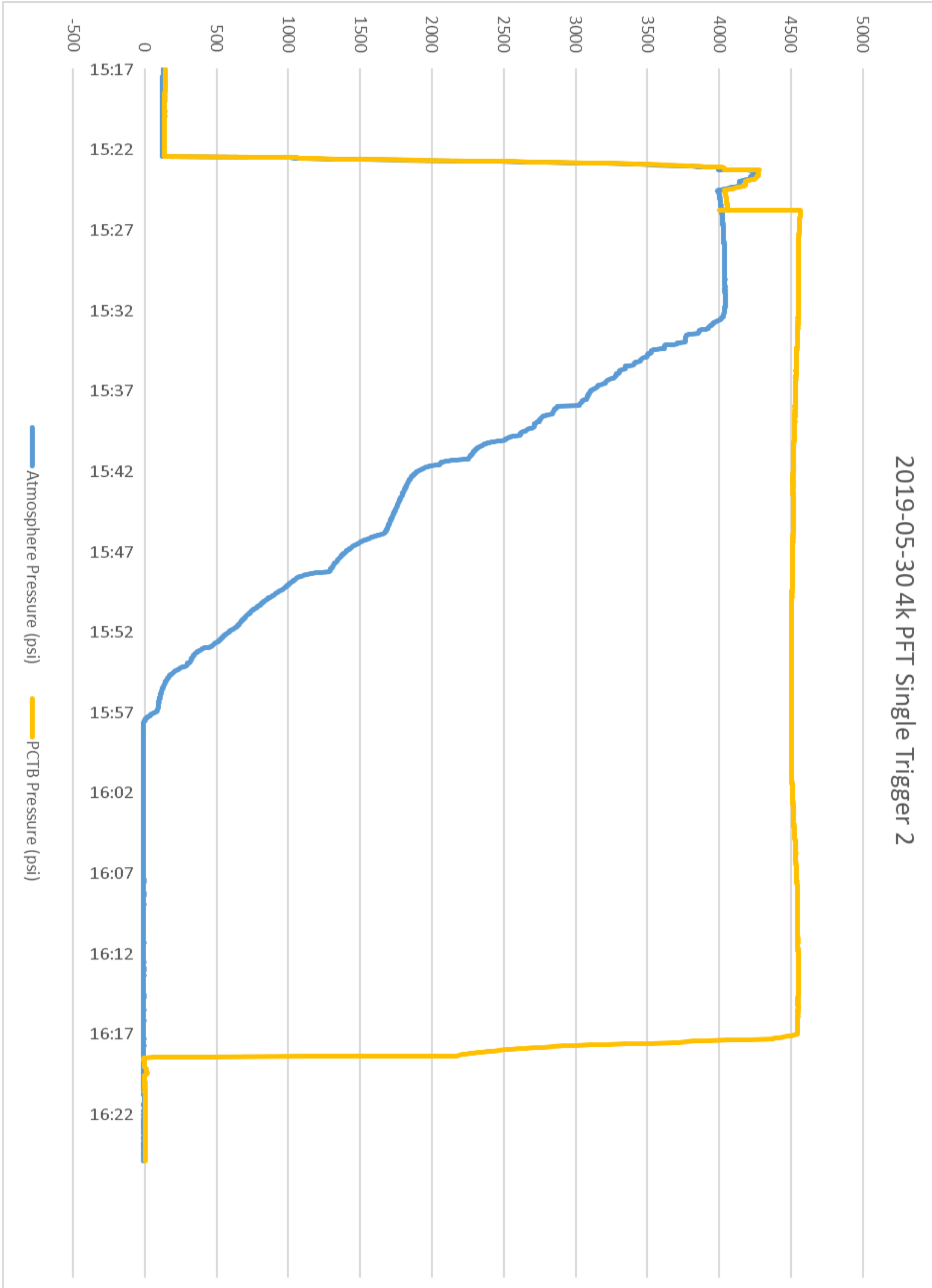
TESTING RUN

TEST DATE:	May 30, 2019	TEST START TIME:	15:19
INITIAL LINEAR TRANSDUCER (IN):	-0.016	FINAL LINEAR TRANSDUCER (IN):	9.541
INITIAL PCTB PRESSURE (PSI):	4053	FINAL PCTB PRESSURE (PSI):	4563
INITIAL ATMOSPHERE PRESSURE (PSI):	3957	FINAL ATMOSPHERE PRESSURE (PSI):	4027
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	800, 1800	PCTB SEAL PRESSURE (PSI):	4547

NOTES: Repeat of the previous test with the accumulator open. Good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-30 4k PFT Single Trigger 2
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
15:17
15:22
15:27
15:32
15:37
15:42
15:47
15:52
15:57
16:02
16:07
16:12
16:17
16:22
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.15 4KPFTST3

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 31, 2019	CORE:			4k Single Trigger 3
TOOL ASSEMBLY TEAM:		Weston			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	1	AUTOCLAVE ASSEMBLY NUMBER:			1
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug, No diverter seal
	3/8 PTFE R Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,514 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,176 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	May 31, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	10:30
NOTES:				

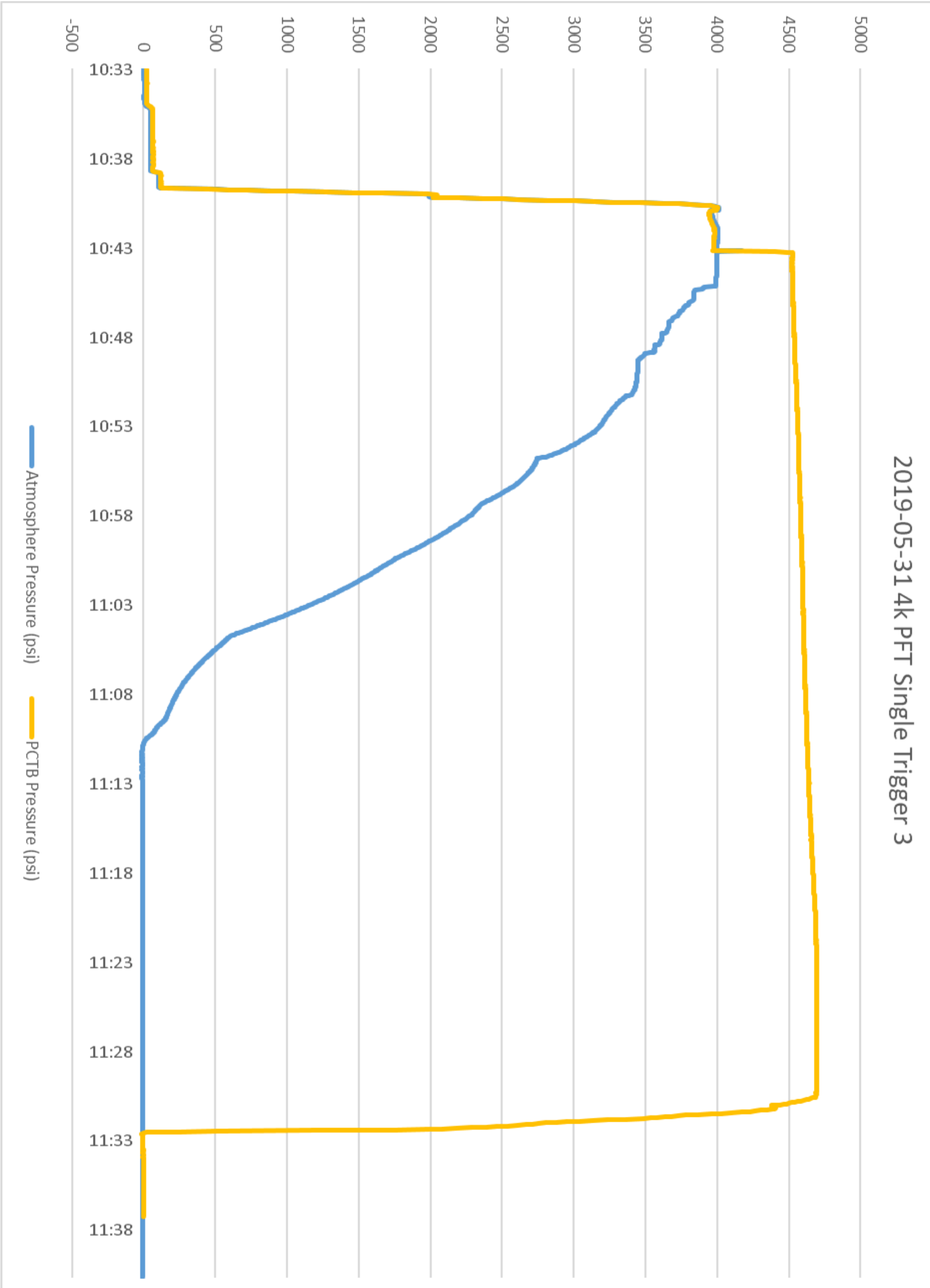
TESTING RUN

TEST DATE:	May 31, 2019	TEST START TIME:	10:40
INITIAL LINEAR TRANSDUCER (IN):	0.033	FINAL LINEAR TRANSDUCER (IN):	9.546
INITIAL PCTB PRESSURE (PSI):	3975	FINAL PCTB PRESSURE (PSI):	4530
INITIAL ATMOSPHERE PRESSURE (PSI):	3999	FINAL ATMOSPHERE PRESSURE (PSI):	4002
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	800, 1800	PCTB Seal Pressure (PSI):	4669

NOTES: A repeat of the previous test, good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-31 4k PFT Single Trigger 3
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10:33
10:38
10:43
10:48
10:53
10:58
11:03
11:08
11:13
11:18
11:23
11:28
11:33
11:38
Atmosphere Pressure (psi)
PCTB Pressure (psi)

1.16 4KPFTST4

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 31, 2019	CORE:			4k Single Trigger 4
TOOL ASSEMBLY TEAM:		Weston			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	1	AUTOCLAVE ASSEMBLY NUMBER:			1
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
ATT7000_00 - PCTB Full Function Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug, No diverter seal
	3/8 PTFE R Shear Pin
NOTES:	

TOOL ASSEMBLY

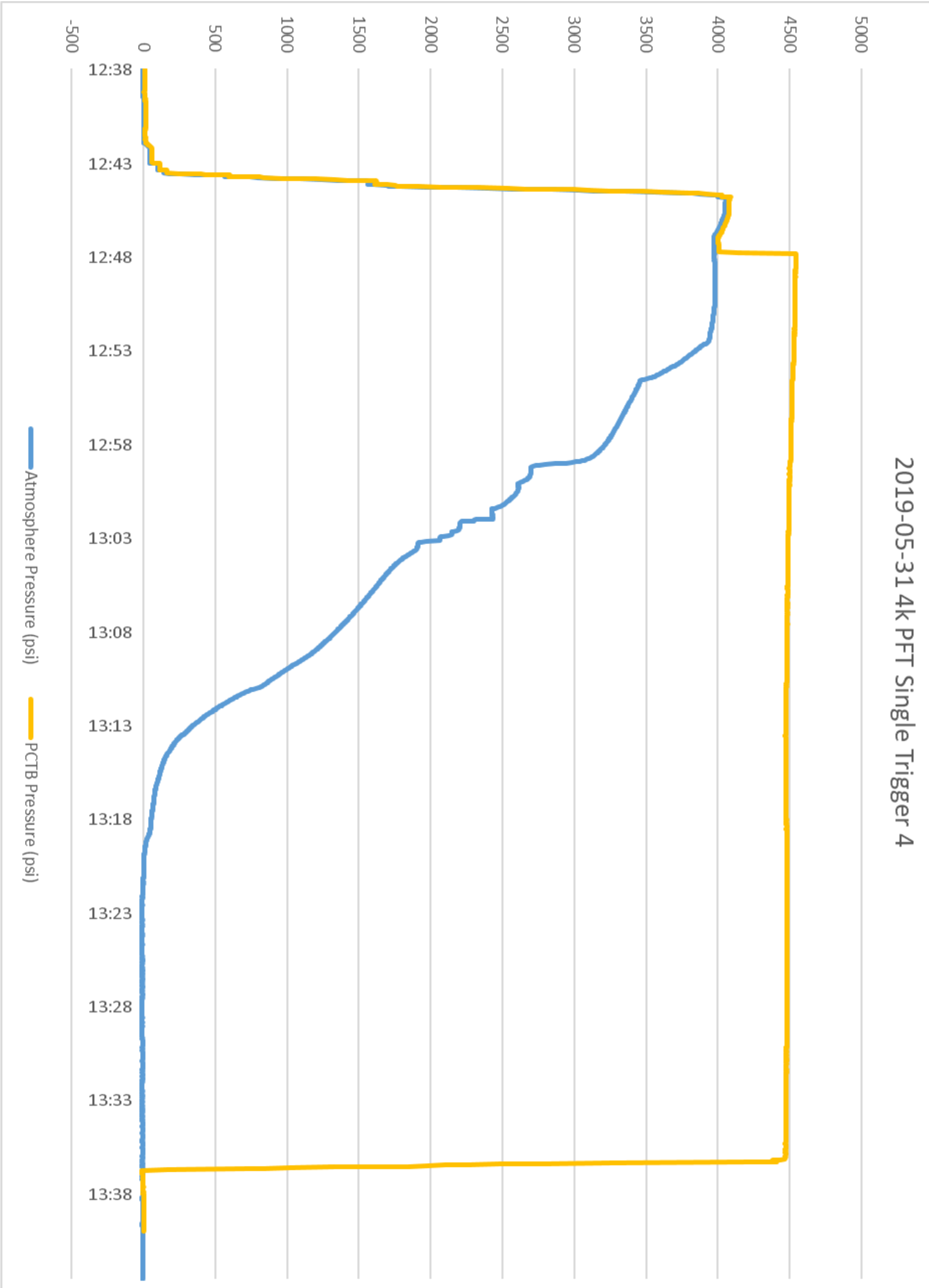
BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,508 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		7,996 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	May 31, 2019
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	12:30
NOTES:				

TESTING RUN

TEST DATE:	May 31, 2019	TEST START TIME:	12:45
INITIAL LINEAR TRANSDUCER (IN):	0.023	FINAL LINEAR TRANSDUCER (IN):	9.551
INITIAL PCTB PRESSURE (PSI):	4041	FINAL PCTB PRESSURE (PSI):	4503
INITIAL ATMOSPHERE PRESSURE (PSI):	4018	FINAL ATMOSPHERE PRESSURE (PSI):	4041
INITIAL ACTUATION PRESSURE (PSI):	4000	FINAL ACTUATION PRESSURE (PSI):	4000
ACCUMULATOR CHARGE (PSI):	1800, 800	PCTB Seal Pressure (PSI):	4516
NOTES: A repeat of the previous test, good test.			

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-31 4k PFT Single Trigger 4
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
12:38
12:43
12:48
12:53
12:58
13:03
13:08
13:13
13:18
13:23
13:28
13:33
13:38
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2 APPENDIX 2: PAT RUN SHEETS AND PRESSURE PLOTS

2.1 1KPATST1

GEOTEK CORING Inc
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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 13, 2019	CORE:			1k PAT Single Trigger 1
TOOL ASSEMBLY TEAM:	Alan, Weston				
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			none
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug
15 gal actuation 2000 psi	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,510 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,028 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-13
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:10
NOTES:				

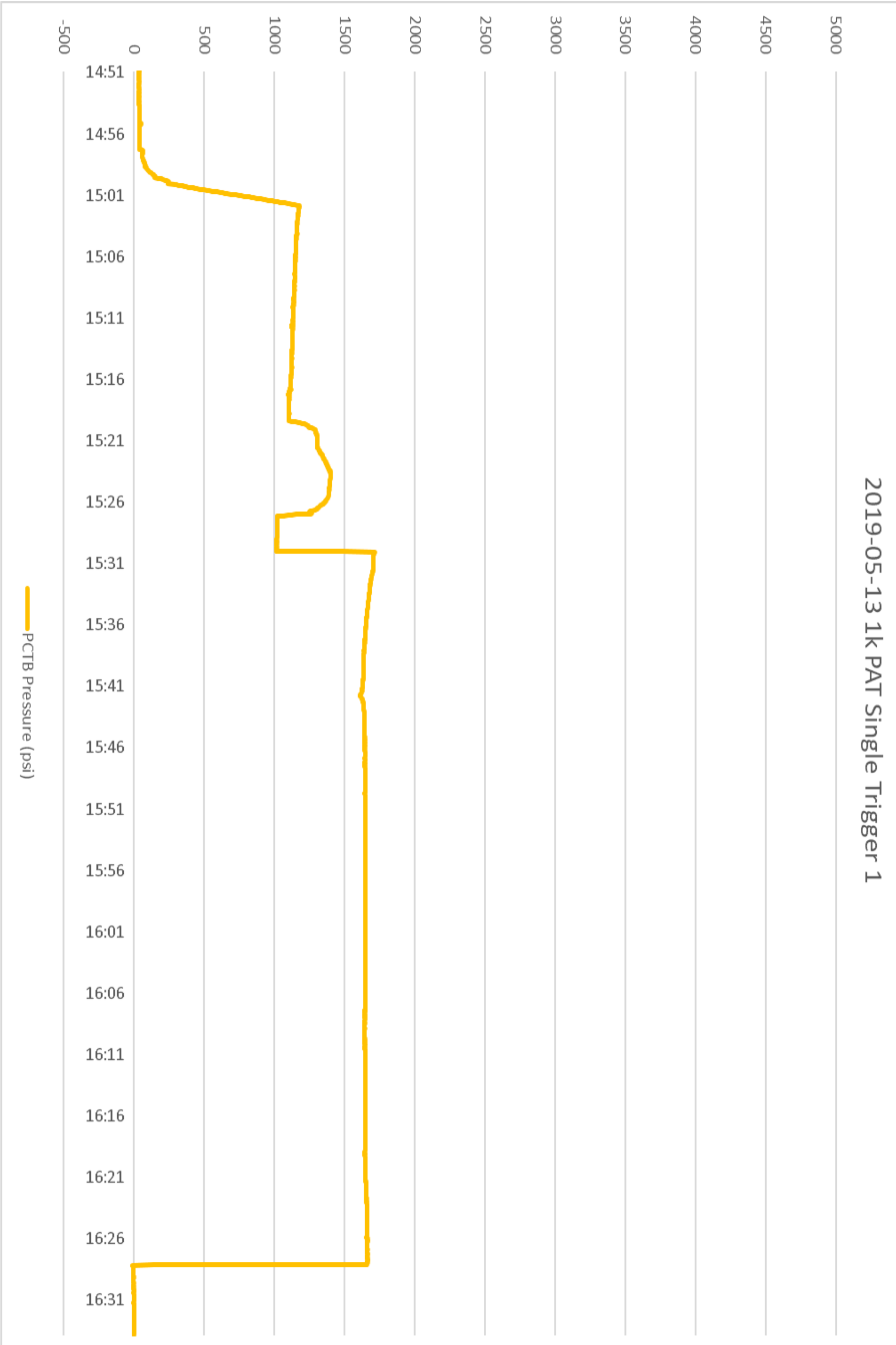
TESTING RUN

TEST DATE:	May 13, 2019	TEST START TIME:	14:58
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	1089
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	800	PCTB SEAL PRESSURE (PSI):	1548

NOTES: The first test of the round. No DST in the atmosphere. Pressure increase while inserting pulling tool due to hydrolock, caused by test technician. Circulate 10 min at 15 gpm. Precharge actuation line until pulling tool starts moving. Good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-13 1k PAT Single Trigger 1
PCTB Pressure (psi)
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
14:51
14:56
15:01
15:06
15:11
15:16
15:21
15:26
15:31
15:36
15:41
15:46
15:51
15:56
16:01
16:06
16:11
16:16
16:21
16:26
16:31

2.2 1KPATST2

GEOTEK CORING Inc
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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 13, 2019	**CORE:**	1k PAT Single Trigger 2
TOOL ASSEMBLY TEAM:	Alan, Weston, Alex		
SIMULATED CORE DEPTH:	687 m	**BOTTOM HOLE PRESSURE:**	1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	**AUTOCLAVE ASSEMBLY NUMBER:**	2
UPPER ASSEMBLY NUMBER:	n/a	**CATCHER KIT:** Basket/Rabbit	5" Extension / 5" Extension
DST SERIAL NUMBERS: **AUTOCLAVE:**	L7071	**ATMOSPHERE:**	L7073
NOTES:			

TEST SETUP

TEST CONFIGURATION:	**PCTB CONFIGURATION:**
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug
15 gal actuation 2000 psi	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	**PAWL POST HEIGHT (0.095-0.105")**		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	**LINER/IT PLUG LENGTH (156.75")**		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	**SET PRESSURE (CONFIRM WITH 3 TESTS):**		1,489 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	**RESERVOIR FILL PRESSURE:**		2,985 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	**TOOL READY FOR TEST**	**DATE:**	2019-05-13
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		**TIME:**	17:40
NOTES:				

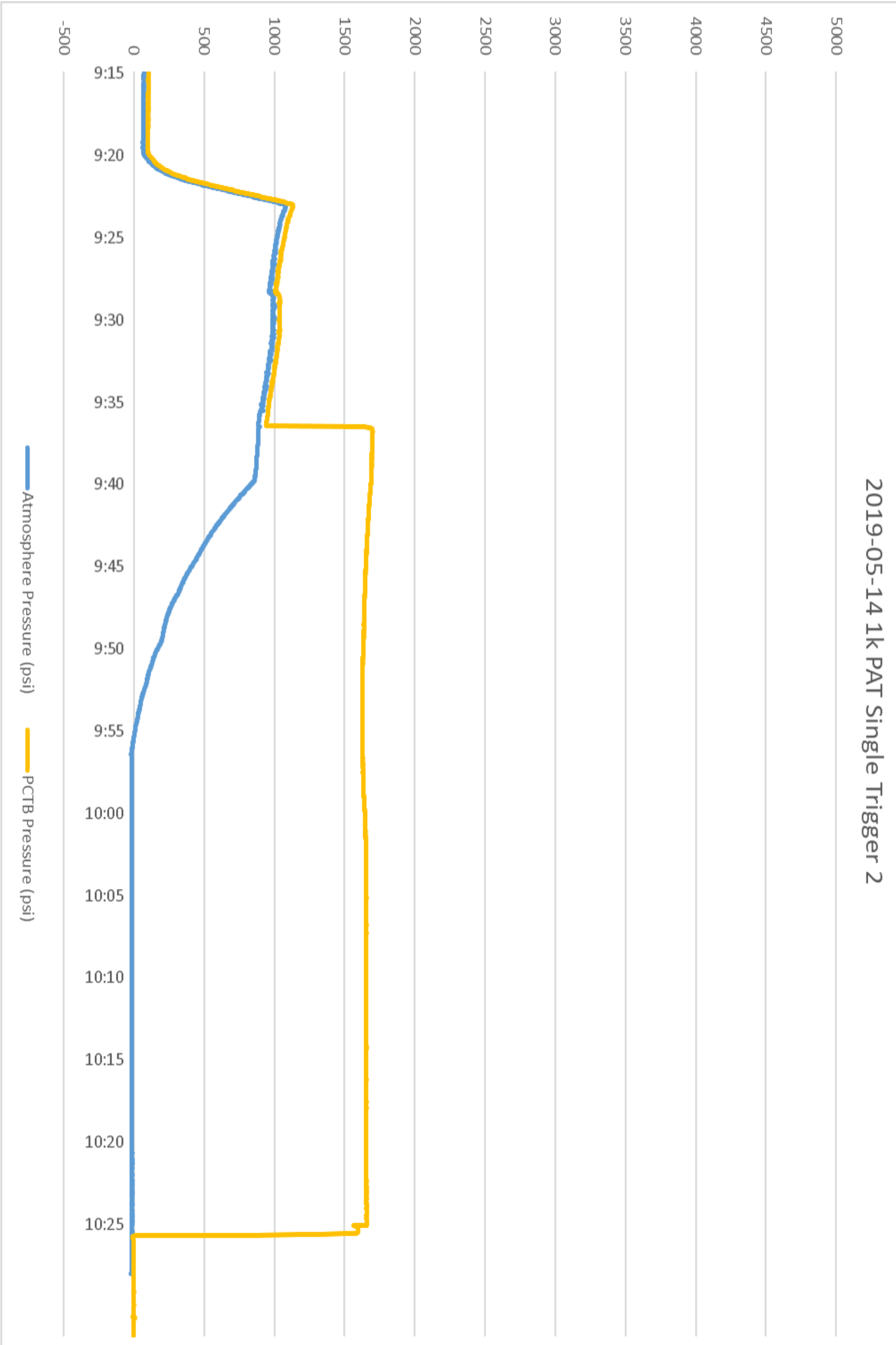
TESTING RUN

TEST DATE:	May 14, 2019	**TEST START TIME:**	09:20
INITIAL LINEAR TRANSDUCER (IN):	N/A	**FINAL LINEAR TRANSDUCER (IN):**	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	**FINAL PCTB PRESSURE (PSI):**	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	**FINAL ATMOSPHERE PRESSURE (PSI):**	1005
INITIAL ACTUATION PRESSURE (PSI):	N/A	**FINAL ACTUATION PRESSURE (PSI):**	N/A
ACCUMULATOR CHARGE (PSI):	800	**PCTB SEAL PRESSURE (PSI):**	1548

NOTES: Circulate at 30 gpm for 10 min. Timed pulling speed, approx 96 m/min. Added DST to atmosphere in circulation pump outlet manifold. Good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		**NOTES**	**PRESSURE SECTION**	
BALL VALVE	CLOSED		**RESERVOIR PRESSURE:**	N/A
LINER	INTACT		**WATER ABOVE PISTON?**	NO
PAWLS	INTACT		**WATER IN REGULATOR?**	NO
PAWL SPRING	INTACT		**REBUILD REGULATOR?**	NO
NOTES:				


2019-05-14 1k PAT Single Trigger 2
Atmosphere Pressure (psi)
PCTB Pressure (psi)
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
9:15
9:20
9:25
9:30
9:35
9:40
9:45
9:50
9:55
10:00
10:05
10:10
10:15
10:20
10:25

2.3 1KPATST3

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 14, 2019	CORE:			1k PAT Single Trigger 3
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	687 m	BOTTOM HOLE PRESSURE:			1,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
15 gal accumulator	Single Trigger IT Plug
15 gal actuation 2000 psi	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		1,519 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		3,058 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-13
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:20
NOTES:				

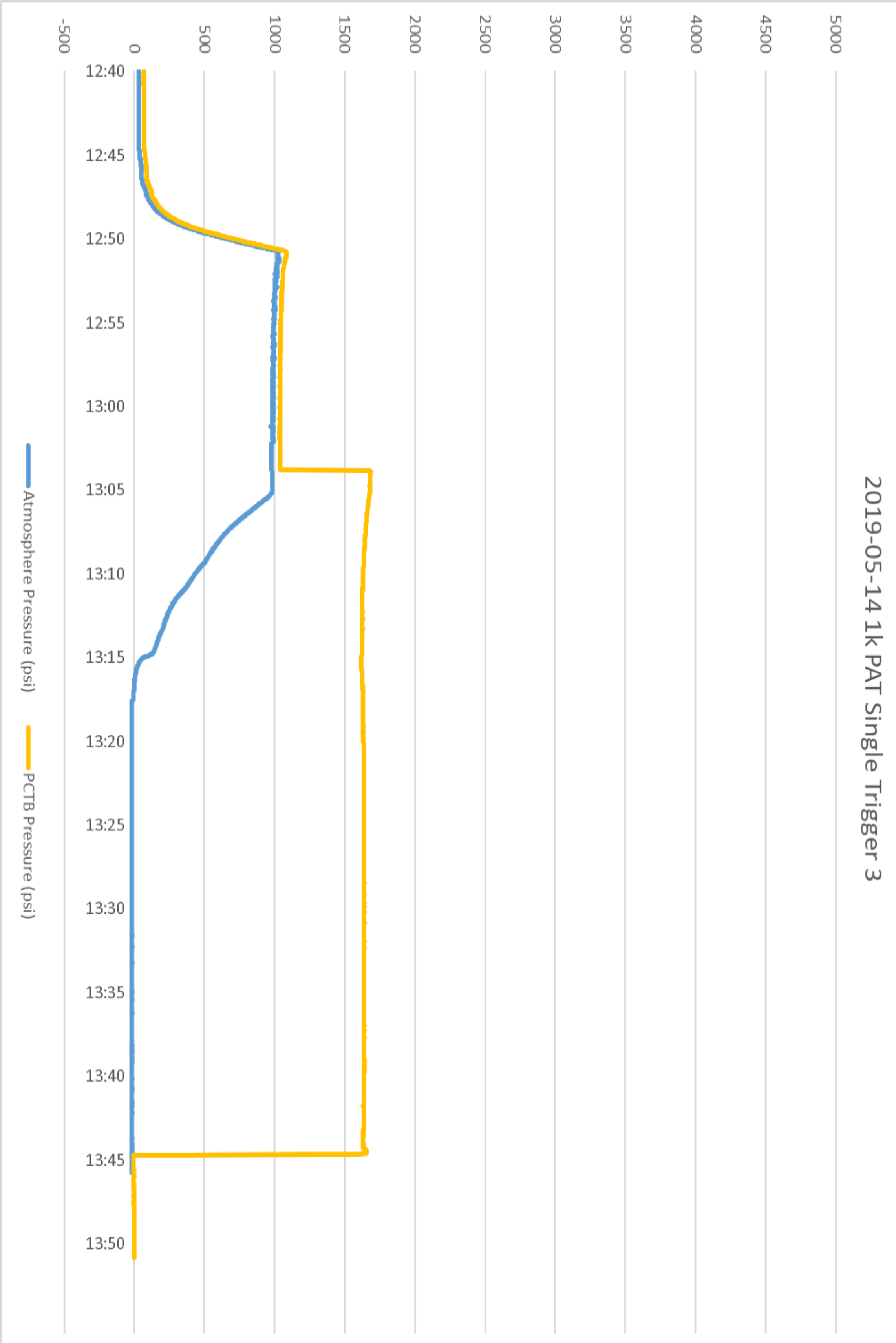
TESTING RUN

TEST DATE:	May 14, 2019	TEST START TIME:	12:47
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	1007
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	800	PCTB SEAL PRESSURE (PSI):	1616

NOTES: During actuation and POOH, the wireline tool broke off the pulling rod, but the tool had stroked, sealed, and fired. Good test.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-14 1k PAT Single Trigger 3
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
12:40
12:45
12:50
12:55
13:00
13:05
13:10
13:15
13:20
13:25
13:30
13:35
13:40
13:45
13:50
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.4 4KPATST1

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 14, 2019	CORE:			4k PAT Single Trigger 1
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	2,406 m	BOTTOM HOLE PRESSURE:			3,500 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
15 gal actuation 2000 psi	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,434 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		7,971 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-13
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	02:55
NOTES:				

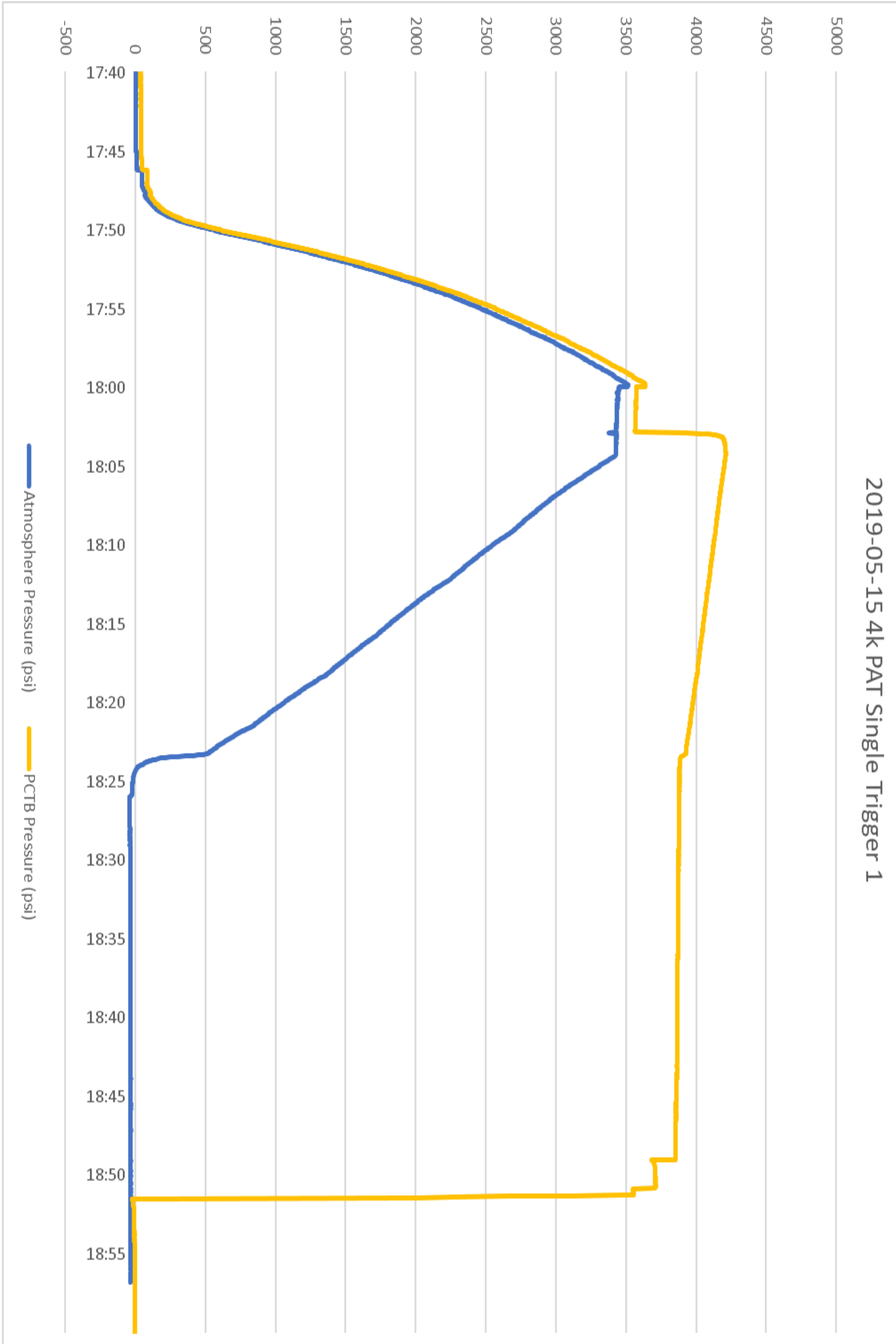
TESTING RUN

TEST DATE:	May 14, 2019	TEST START TIME:	18:00
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	3492
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	3854

NOTES: Test was going to be performed at 4000 psi but due to time constraints caused by the long time pumping up the atmosphere accumulator, it was run decided to run at 3500 psi. The tool initially boosted, but did see settling -due to seating of mechanisms?. Tools seems to have a 5-15% settling from boost pressure?

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-15 4k PAT Single Trigger 1
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
17:40
17:45
17:50
17:55
18:00
18:05
18:10
18:15
18:20
18:25
18:30
18:35
18:40
18:45
18:50
18:55
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.5 4KPATST2

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 15, 2019	CORE:	4k PAT Single Trigger 2		
TOOL ASSEMBLY TEAM:	Alan, Weston, Alex				
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:	4,000 psi		
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2		
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS:	AUTOCLAVE:	L7071	ATMOSPHERE:	L7073	
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
15 gal actuation 2000 psi	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

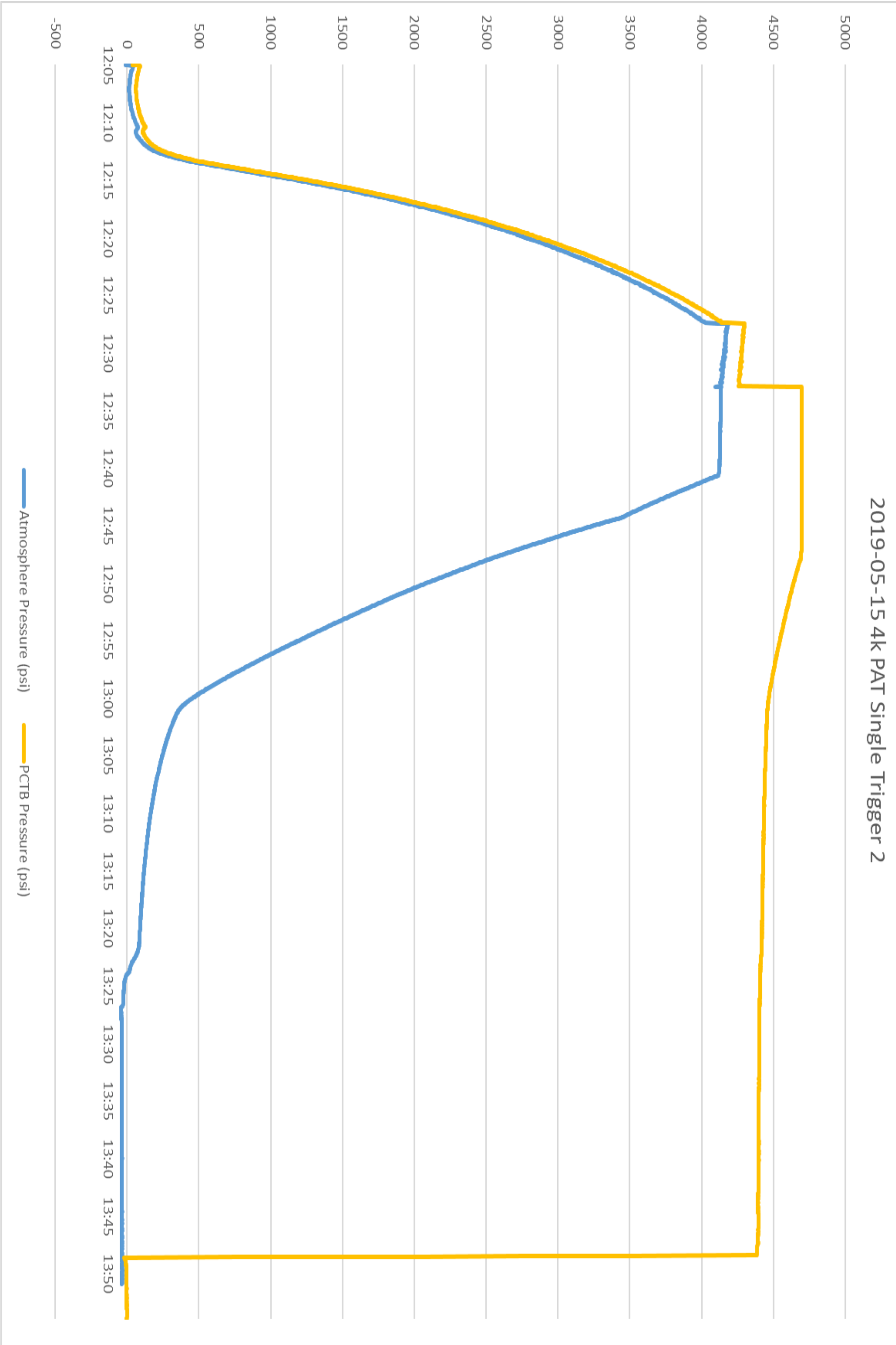
BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,428 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,121 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-15
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	11:15
NOTES:				

TESTING RUN

TEST DATE:	May 15, 2019	TEST START TIME:	12:09
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	4184
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	4041
NOTES: Good Test			

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-15 4k PAT Single Trigger 2
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.6 4KPATST3

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TESTING RUN REPORT
GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 15, 2019	CORE:	4k PAT Single Trigger 3		
TOOL ASSEMBLY TEAM:	Alan, Weston, Alex				
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:	4,000 psi		
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:	2		
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:	L7073		
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")	COMPLETE	
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")	COMPLETE	
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):	4,478 psi	
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:	8,210 psi	
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-15
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	15:20
NOTES:				

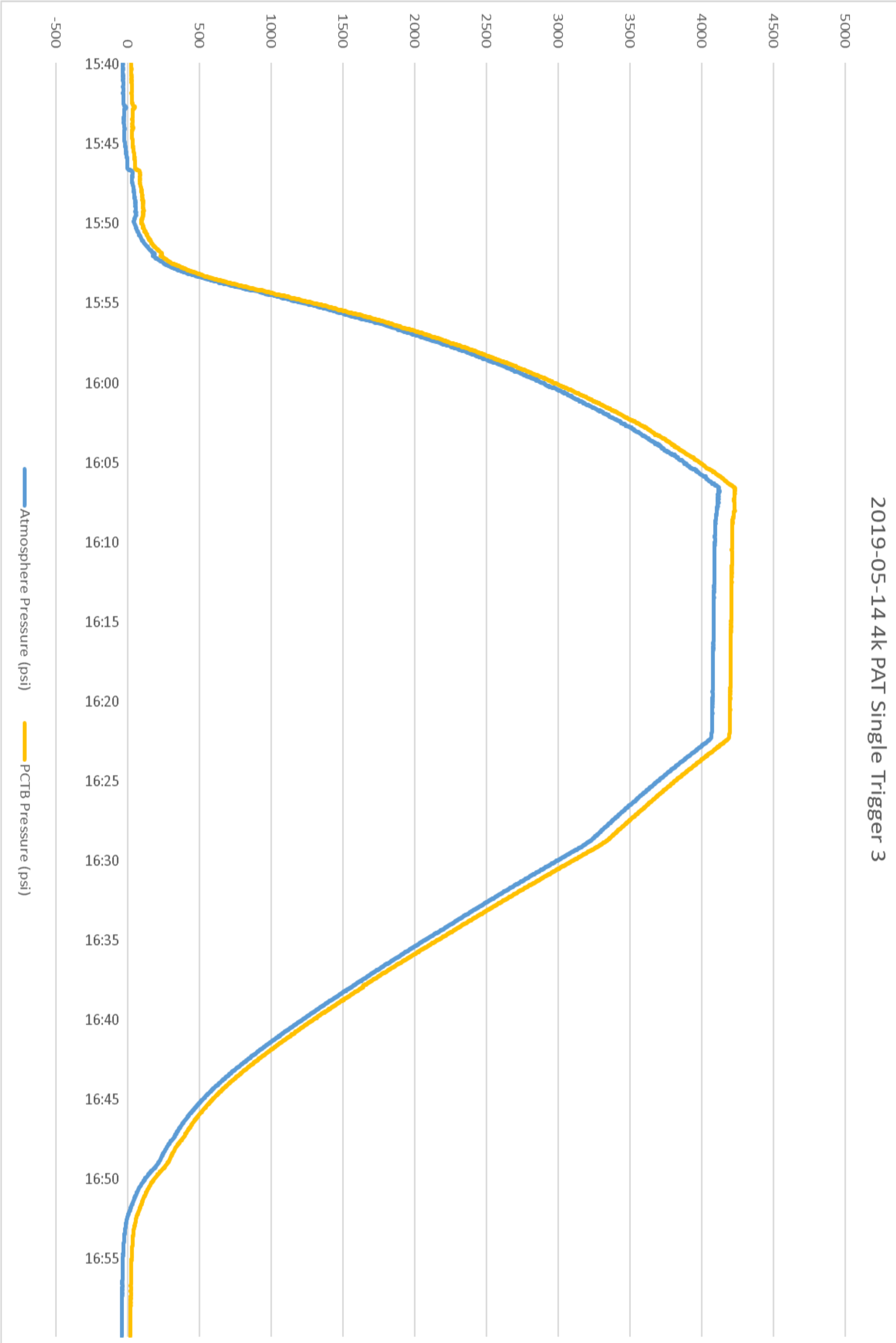
TESTING RUN

TEST DATE:	May 15, 2019	TEST START TIME:	15:49
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	4187
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	0

NOTES: This test was performed with a slow (pump up, no accumulator) pull. The test seemed successful until removal from the BHA, where it was discovered that the shear pin had not broken, nor the pressure section sleeve moved let alone fired. The ball was closed. It was theorized that the overtravel spring is too soft for a slow pull. When it hit the shear pin and sleeve during the pull, the overtravel spring compressed enough to unlatch it from the BHA without firing or sealing the tool.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-14 4k PAT Single Trigger 3
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
15:40
15:45
15:50
15:55
16:00
16:05
16:10
16:15
16:20
16:25
16:30
16:35
16:40
16:45
16:50
16:55
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.7 4KPATST4

GEOTEK CORING Inc

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 16, 2019	CORE:			4k PAT Single Trigger 4
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
	3/8 ABS Shear Pin
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		4,478 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,210 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-15
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	15:20
NOTES:				

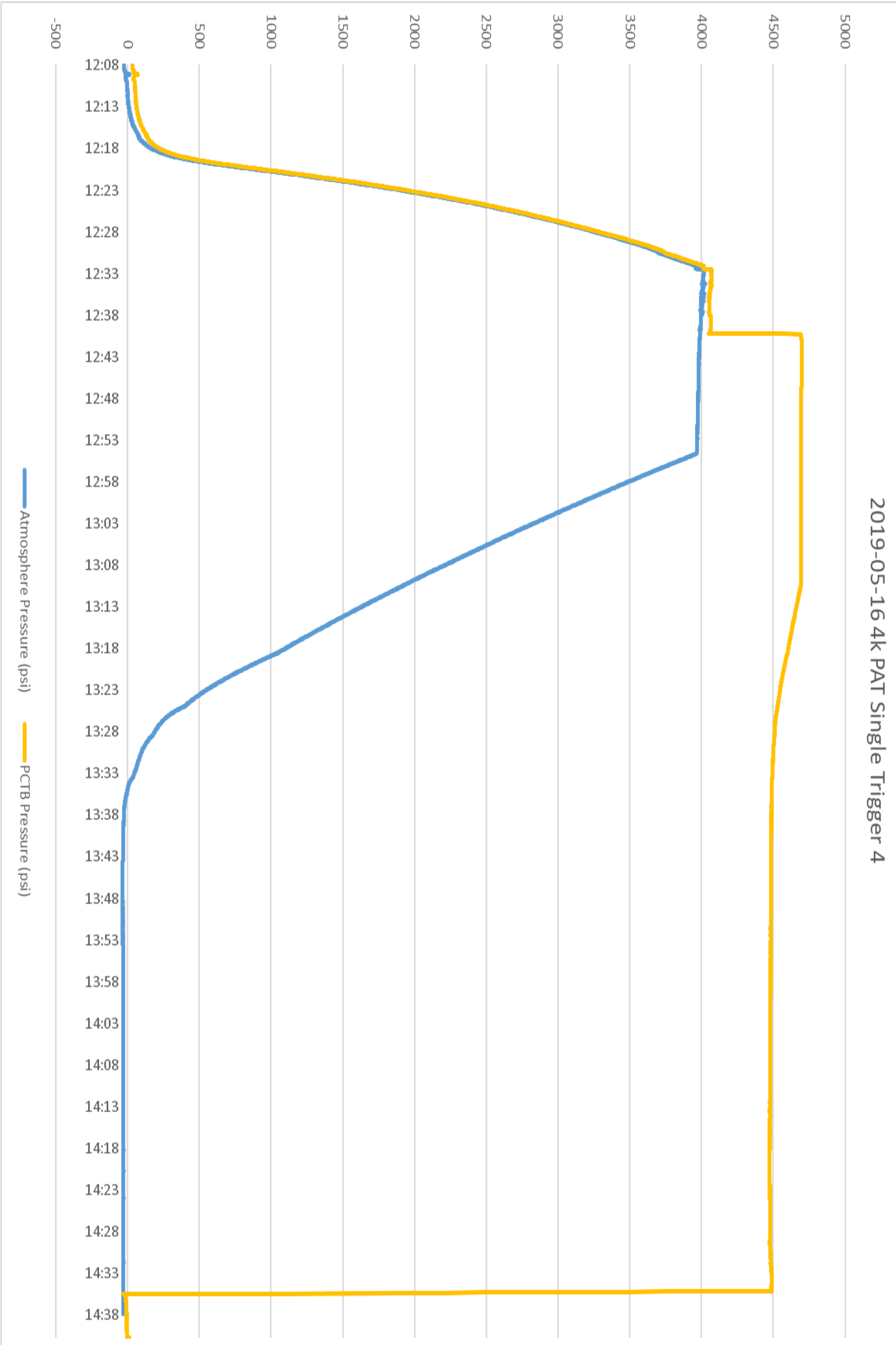
TESTING RUN

TEST DATE:	May 15, 2019	TEST START TIME:	12:16
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	4040
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	4497

NOTES: As it never fired or sealed, the PCTB lower was reused with only a ball valve reset from the previous test. **A 1" thick spacer was placed in the overtravel spring to increase the stiffness, and guarantee that the tool fired before it unlatched from the BHA.** After the test, the pulling tool was unable to be unlatched from the PCTB. The PCTB was found to have operated correctly and boosted properly. Upon disassembly of the upper, it was discovered that one of the fingers of the collet on the end of the pulling tool was bent and broken off, jamming the tool in the latch. 5-15% settling from boost pressure?

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-16 4k PAT Single Trigger 4
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
12:08
12:13
12:18
12:23
12:28
12:33
12:38
12:43
12:48
12:53
12:58
13:03
13:08
13:13
13:18
13:23
13:28
13:33
13:38
13:43
13:48
13:53
13:58
14:03
14:08
14:13
14:18
14:23
14:28
14:33
14:38
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.8 4KPATST5

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 14, 2019	CORE:			4k PAT Single Trigger 5
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:		L7071	ATMOSPHERE:		L7073
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
15 gal actuation 1800 psi, 1/4 bv medium speed pull	3/8 ABS Shear Pin
	1" spacer on Overtravel Spring
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		5,006 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		8,268 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-17
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	09:10
NOTES:				

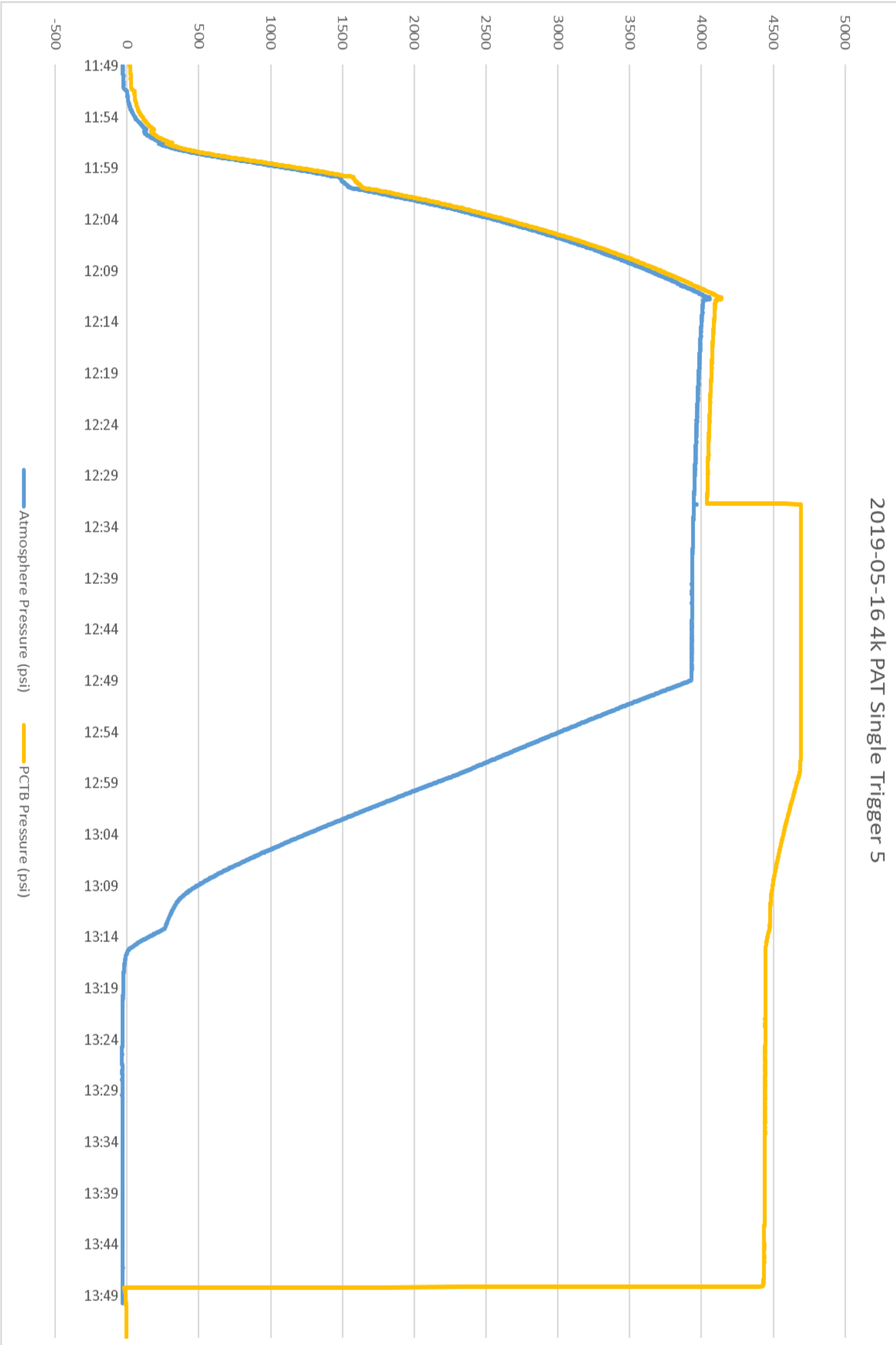
TESTING RUN

TEST DATE:		May 17, 2019	TEST START TIME:		09:45
INITIAL LINEAR TRANSDUCER (IN):	N/A		FINAL LINEAR TRANSDUCER (IN):	N/A	
INITIAL PCTB PRESSURE (PSI):	N/A		FINAL PCTB PRESSURE (PSI):	N/A	
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A		FINAL ATMOSPHERE PRESSURE (PSI):		3979
INITIAL ACTUATION PRESSURE (PSI):	N/A		FINAL ACTUATION PRESSURE (PSI):	N/A	
ACCUMULATOR CHARGE (PSI):	N/A		PCTB SEAL PRESSURE (PSI):		4371

NOTES: Same test as previous, but Pressure Section set increased to 5000 psi. On the first pull attempt, the Pulling Tool did not latch into the Inner Latch, so the tool was not stroked or fired. In the field, you could tell if you were latched by wire weight. On second attempt, the Pulling Tool did latch in. The ball valve between the Actuation Accumulator was opened 1/4 of the way, and the tool was pulled approximately 50 m/min. 5-15% settling from boost pressure?

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-16 4k PAT Single Trigger 5
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
11:49
11:54
11:59
12:04
12:09
12:14
12:19
12:24
12:29
12:34
12:39
12:44
12:49
12:54
12:59
13:04
13:09
13:14
13:19
13:24
13:29
13:34
13:39
13:44
13:49
Atmosphere Pressure (psi)
PCTB Pressure (psi)

2.9 4KPATST6

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 24, 2019	CORE:			4k PAT ST 6
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
15 gal actuation 1800 psi, 1/4 bv medium speed pull	3/8 ABS Shear Pin
	1" spacer on Overtravel Spring
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		0 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		0 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-24
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	09:30
NOTES:				

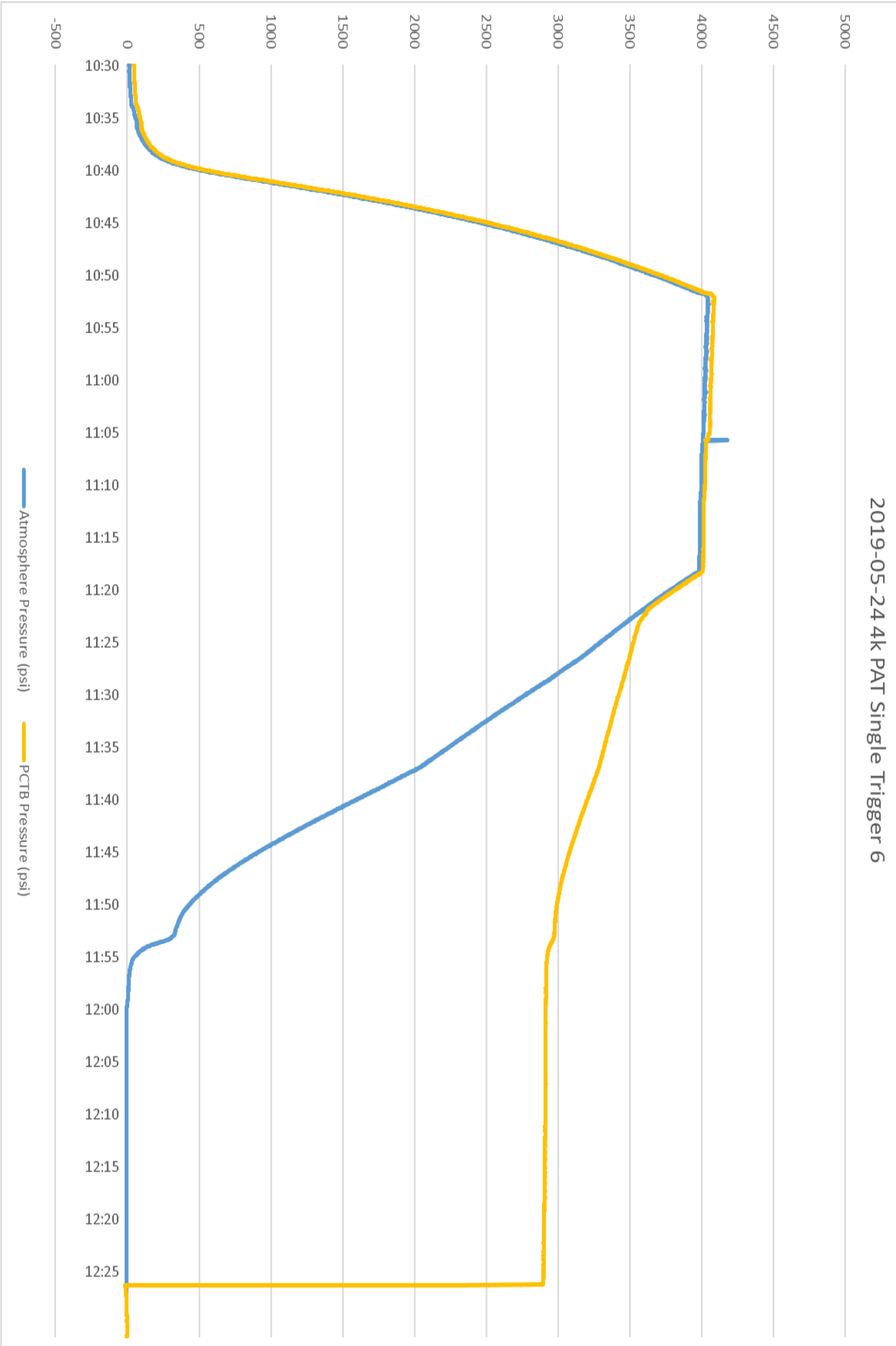
TESTING RUN

TEST DATE:	2019-05-24	TEST START TIME:	N/A
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	3960
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	2875

NOTES: This test was performed without the pressure section charged, to test if the tool will seal without added differential pressure (naturally on its own). Approximately halfway through the pull, it stalled out (ran out of accumulator power). The pressure was increased with the pump, and the tool pumped up the rest of the way through the pull. The tool leaked with the pull a bit as coming up hole, then started to sealed up at 2875 psi.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-24 4k PAT Single Trigger 6
Atmosphere Pressure (psi)
PCTB Pressure (psi)
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10:30
10:35
10:40
10:45
10:50
10:55
11:00
11:05
11:10
11:15
11:20
11:25
11:30
11:35
11:40
11:45
11:50
11:55
12:00
12:05
12:10
12:15
12:20
12:25

2.10 4KPATST7

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TESTING RUN REPORT

GENESIS OF METHANE IN THE GULF OF MEXICO (GoM^3)

DATE:	May 28, 2019	CORE:			4k PAT ST 7
TOOL ASSEMBLY TEAM:		Alan, Weston, Alex			
SIMULATED CORE DEPTH:	2,750 m	BOTTOM HOLE PRESSURE:			4,000 psi
PRESSURE SECTION ASSEMBLY NUMBER:	2	AUTOCLAVE ASSEMBLY NUMBER:			2
UPPER ASSEMBLY NUMBER:	n/a	CATCHER KIT:	Basket/Rabbit	5" Extension	5" Extension
DST SERIAL NUMBERS: AUTOCLAVE:	L7071	ATMOSPHERE:			L7076
NOTES:					

TEST SETUP

TEST CONFIGURATION:	PCTB CONFIGURATION:
Test Console	AES9001_01 - PCTB3.1 Assembly L
GTT1000_00 - Full Vertical Test Assembly	Single Trigger Pressure Section, Point Contact Seals
45 gal accumulator, 1x 800 psi, 2x 1800	Single Trigger IT Plug
Slow pull	3/8 ABS Shear Pin
	1" spacer on Overtravel Spring
NOTES:	

TOOL ASSEMBLY

BUILD CHECKLIST				
SAMPLE VALVE CLOSED AND PORT PLUGGED	COMPLETE	PAWL POST HEIGHT (0.095-0.105")		COMPLETE
SHUTOFF VALVE OPEN	COMPLETE	LINER/IT PLUG LENGTH (156.75")		COMPLETE
SUPPLY VALVE OPEN	COMPLETE	SET PRESSURE (CONFIRM WITH 3 TESTS):		0 psi
FILL VALVE CLOSED/PORT PLUGGED	COMPLETE	RESERVOIR FILL PRESSURE:		0 psi
SET VALVE CLOSED/PORT PLUGGED	COMPLETE	TOOL READY FOR TEST	DATE:	2019-05-28
DRAIN VALVE CLOSED/PORT PLUGGED	COMPLETE		TIME:	09:40
NOTES:				

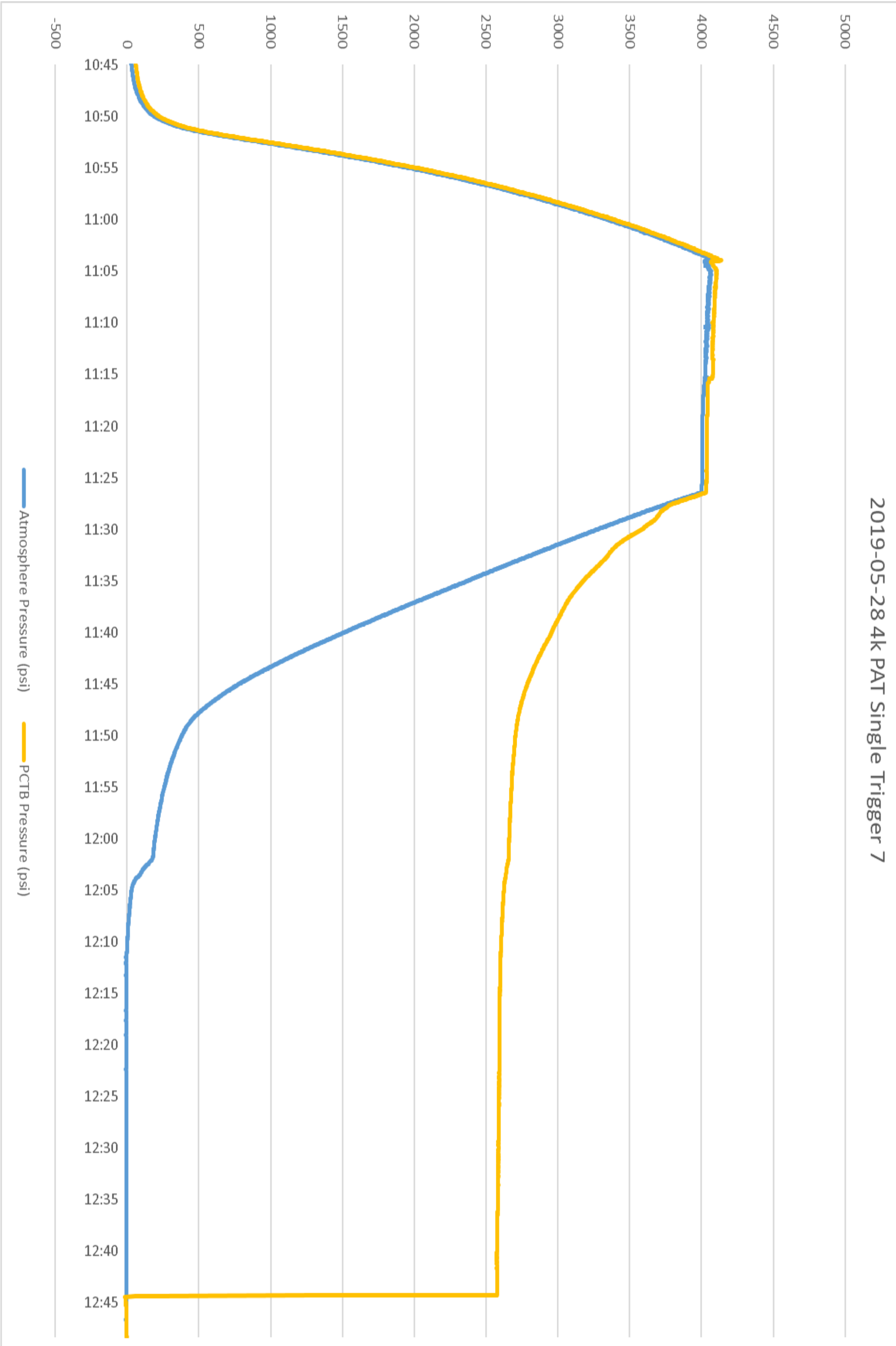
TESTING RUN

TEST DATE:	May 28, 2019	TEST START TIME:	N/A
INITIAL LINEAR TRANSDUCER (IN):	N/A	FINAL LINEAR TRANSDUCER (IN):	N/A
INITIAL PCTB PRESSURE (PSI):	N/A	FINAL PCTB PRESSURE (PSI):	N/A
INITIAL ATMOSPHERE PRESSURE (PSI):	N/A	FINAL ATMOSPHERE PRESSURE (PSI):	4032
INITIAL ACTUATION PRESSURE (PSI):	N/A	FINAL ACTUATION PRESSURE (PSI):	N/A
ACCUMULATOR CHARGE (PSI):	N/A	PCTB SEAL PRESSURE (PSI):	2564

NOTES: A repeat of 4kPATST7, with similar results. It was performed with a slow pump up pull at 500-1000 psi. The tool leaked with the pull a bit as coming up hole, then started to sealed up at 2564 psi.

POST-CORING TOOL ANALYSIS & REBUILD

OBSERVATIONS		NOTES	PRESSURE SECTION	
BALL VALVE	CLOSED		RESERVOIR PRESSURE:	N/A
LINER	INTACT		WATER ABOVE PISTON?	NO
PAWLS	INTACT		WATER IN REGULATOR?	NO
PAWL SPRING	INTACT		REBUILD REGULATOR?	NO
NOTES:				


2019-05-28 4k PAT Single Trigger 7
-500
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
10:45
10:50
10:55
11:00
11:05
11:10
11:15
11:20
11:25
11:30
11:35
11:40
11:45
11:50
11:55
12:00
12:05
12:10
12:15
12:20
12:25
12:30
12:35
12:40
12:45
Atmosphere Pressure (psi)
PCTB Pressure (psi)