GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST II REPORT

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Executive Summary

The UT DOE Hydrates program (DE-FE0023919) performed a field test of the PCTB (Pressure Core Tool with Ball), the Probe Deployment Tool (PDT), and the Temperature-2-Pressure (T2P) probe in March, 2020 at Schlumberger's Cameron Test and Training Facility (CTTF) (PCTB Land Test II). Seven tests of the Pressure Coring Tool with Ball (PCTB) were performed. Two coring tests were performed with the face bit version (PCTB-FB). Five tests were performed with the cutting shoe version (PCTB-CS). At the end of the testing program, the Probe Deployment Tool (PDT) was deployed.

Core recovery and core quality was excellent with both the PCTB-CS and the PCTB-FB. Core recovery was generally 80% or higher. The diameter of the core was consistent in all cores for both the CS and FB configurations, even across transitions between limestone and shale. In 6 out of 7 cases, the ball only partially closed and no increase in pressure was recorded. We interpret that drilling fluid and entrained cuttings are wedging between the outer housing and the seal carrier and jamming the seal carrier which drives the ball.

The Probe Deployment Tool (PDT) is a device designed to deploy a penetrometer through the bottom hole assembly to measure temperature and pressure. It is conveyed by wireline and lands in the Bottom Hole Assembly (BHA). During lowering of the PDT by wireline, the tool was lost and fell to the bottom of the drill string to rest in the BHA. The tool was quickly recovered with the GS pulling tool and no further testing was performed. The detents, or catches, that hold the PDT to the wireline tool are interpreted to have failed. These will be manufactured with stronger material in the future.

1 Introduction

The UT DOE Hydrates program (DE-FE0023919) performed a field test of the PCTB (Pressure Core Tool with Ball) from Monday, 3/9/2020 to Friday 3/20/2020 (PCTB Land Test II). Representatives from Geotek Coring Inc., Pettigrew Engineering, and The University of Texas at Austin participated in the testing. The test was performed at Schlumberger's Cameron Test and Training Facility (CTTF), near Cameron, TX.

The purpose of the test was the following: First, we wished to confirm that after modifications made to the PCTB tools, the tool still functioned as well as it had prior to the modifications. Second, we wished to know whether the modifications improved the tool performance. Third, we wished to test the Probe Deployment Tool (PDT) to determine if it would work in a field environment.

Prior to the PCTB Land Test II, the PCTB was modified based on the results of the Bench Test II, conducted Jan 27-31, 2020 (Geotek, 2020). Twelve pressure actuation tests were performed in which the PCTB was actuated at field-like pressures at the Geotek high pressure test facility in Salt Lake City, Utah. During the PCTB Bench Test II, the PCTB performed with a 100% success rate when properly deployed. The following modifications were permanently incorporated into the PCTB as a result of the Bench Test II:

1. Single Trigger Mechanism: The single trigger mechanism replaced the complex vent port mechanism, making it impossible for the boost to fire prior to closing the vent port while eliminating the O-ring face seal and spring.
2. IT Plug Mandrel Shear Pin: With the introduction of the single trigger mechanism, the IT plug mandrel locking dogs were replaced by a shear pin, with force high enough to ensure the autoclave upper seals are properly engaged while low enough to allow the overtravel spring to function without prematurely unlatching the PCTB from the bottom hole assembly (BHA).
3. Low Friction Coating: All sliding parts and the latch mechanism had a low friction coating applied, to reduce the wireline overpull required to release the PCTB latch from the BHA.
4. Flow Diverter Seals: Introduction of the single trigger mechanism required the flow diverter to be modified, which included replacing the original lip seals with point seals.
5. Regulator Sub: The regulator sub was modified so the diverter seal cannot cause hydraulic lock.
6. Pressure Section Increase: The pressure section length was increased by 24 inches, more than doubling its volume. This helps to ensure adequate high pressure gas is available to activate the autoclave boost in high hydrostatic pressure environments.

On Monday, March 9th, Schlumberger started a new sidetrack for the experiment called Slot #6 Well #8 ST19 (Appendix C). This was completed on Thursday, March 12. Drill pipe arrived on Thursday, March 12. The Geotek containers arrived on Friday, March 13. On Monday March 16, Geotek mobilized and we picked up drill pipe into the derrick, connected utilities to the service vans. On Tuesday, March 17, we began a 3-day testing program. We completed testing on Thursday, March 19, and demobilized on Friday, March 20.

As we describe in detail below, the PCTB tools cut core rapidly and cleanly. This confirmed that the changes made to the tool (state changes) were successful. However, in all but one case we did not seal pressure in the core because the ball valve did not seal. We interpret that grit in the drilling mud prevented the ball valve sealing and we are now developing techniques to overcome this limitation. The Probe Deployment Tool did not successfully deploy.

2 Hole Description

In preparation for the test, a sidetrack was performed. Slot #6 Well #8 ST19 was drilled to 1815 MD from the rig floor and 1811 TVD (Appendix C). All coring occurred within the Austin Chalk Formation, which is of Late Cretaceous age; it is composed of chalk and marl with occasional beds of shale. Figure 2-1 and Figure 2-2 show geologic formations, lithology, well logs, and core section depths for the hole.

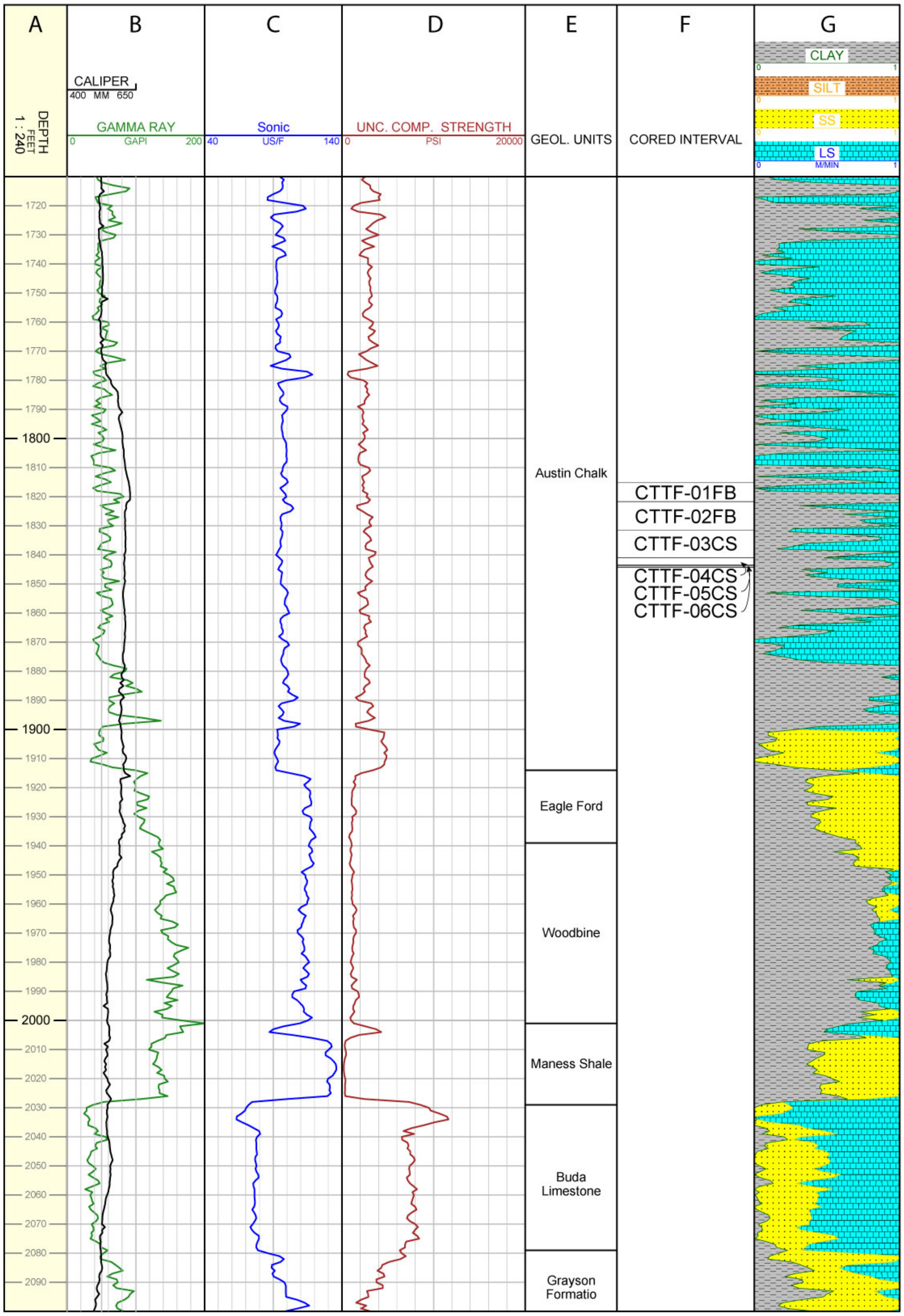

Figure 2-1. Testing was done within the lower part of the Austin Chalk Fm. Log provided by CTTF. A. Depth in MD from rig floor. B, C, D. Wireline logs. E. Geologic unit names. F. Cored intervals. G. Lithology

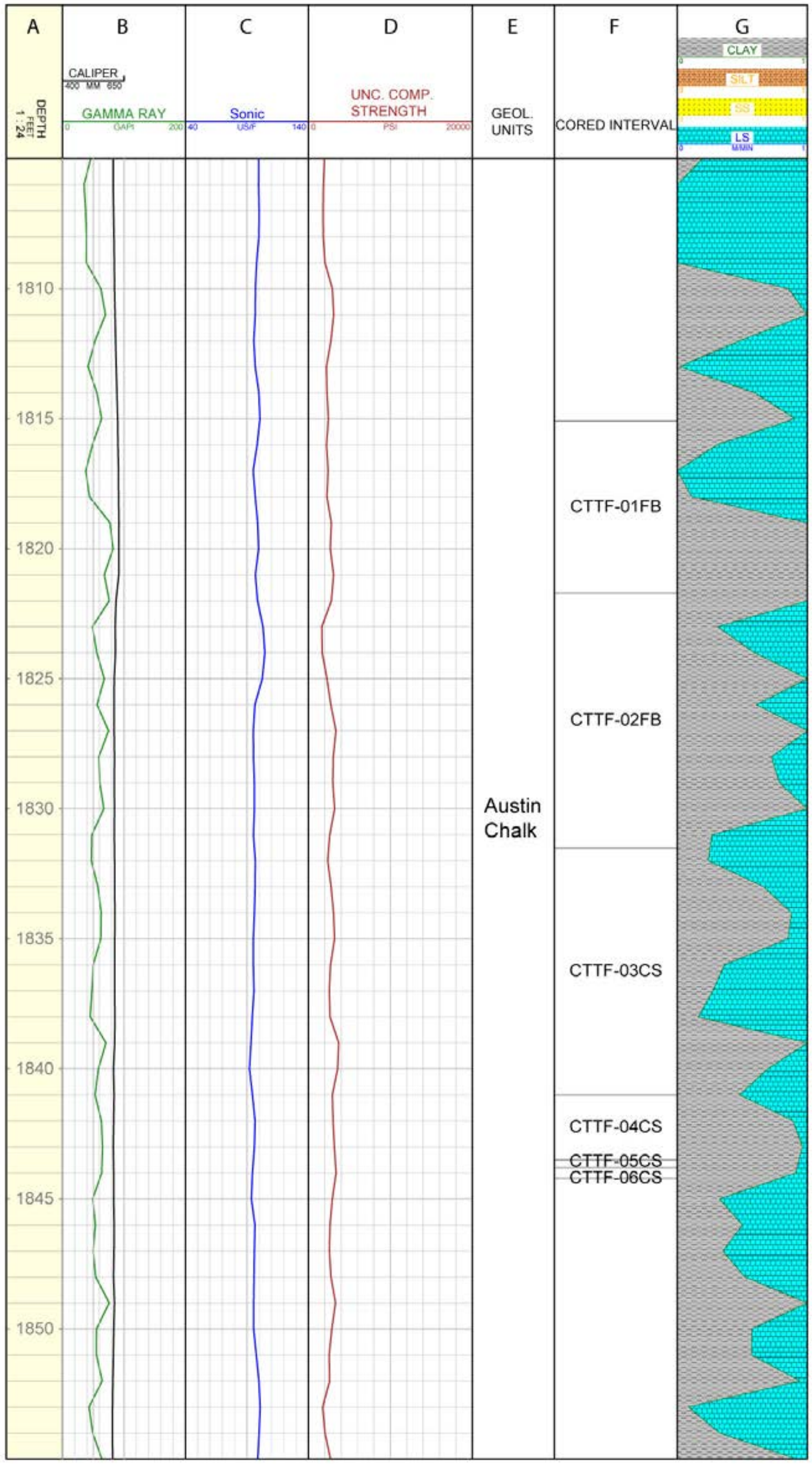

Figure 2-2. Details of the cored intervals. A. Depth in MD from rig floor. B, C, D. Wireline logs. E. Geologic unit names. F. Cored intervals. G. Lithology

3 Test Description

Seven tests of the Pressure Coring Tool with Ball (PCTB) were performed. Two coring tests were performed with the face bit version (PCTB-FB): CTTF-01FB, CTTF-02FB. These were followed by 4 tests with the cutting shoe version (PCTB-CS): CTTF-03CS, CTTF-04CS, CTTF-05CS, CTTF-06CS. One ‘water core’ of the PCTB-CS was performed wherein the PCTB was deployed within the casing without coring (CTTF-07CS). Finally, the Probe Deployment Tool (PDT) was deployed.

3.1 Face-bit (PCTB-FB)

The purpose of the Face-bit test was to test the operation of PCTB in the face-bit configuration (PCTB-FB). These coring tests were operated as full-function tests in which a rock formation was drilled and cored. Two coring tests (cores CTTF-01FB and CTTF-02FB) were taken.

3.2 Cutting-shoe (PCTB-CS)

The PCTB was next run in the cutting shoe configuration (PCTB-CS). Four full function, or coring, tests were run. One ‘water core’ was performed where the PCTB-CS was deployed within casing without coring.

3.3 PDT/T2P Test

The Probe Deployment Tool (PDT) was tested during the PCTB Land Test II at CTTF in Cameron, Texas, on March 19, 2020. The PDT was developed to deploy instrumented probes, such as the pore pressure penetrometer (T2P) and SET(P), from the IODP Drill Ship *JOIDES Resolution*, and replaces the previous MDHD deployment tool. The PDT had not previously been tested in a borehole environment.

The PDT was designed to allow a probe to be hydraulically driven into the formation and then isolated from any drill string/bottom hole assembly (BHA) residual heave movement while collecting data. Upon deployment, the PDT is designed to land in the bottom hole assembly (BHA). Upon landing, it unlatches the inner rod subassembly allowing the probe to be driven by either the weight of the rod, or pump pressure, into the formation. At that point, the probe is independent of the drill string, which compensates for any residual heave.

Prior to the PCTB Land Test II, the PDT locking dogs, lower and upper latching dogs, and all pivot pins were replaced with dogs and pins fabricated from stronger materials, as a result of bench testing conducted at Geotek Coring Inc.’s test facility in Salt Lake City, Utah in January, 2020. Minor brinelling (indenting) of the detents (release mechanism) was observed during the bench testing, but these detents were not replaced with detents fabricated from stronger material.

The mechanical design of the T2P has not changed substantially since 2016. However, the data acquisition system has been redesigned. A new circuit board, battery, firmware, and mounting system has been built. This test was an opportunity to see if the new CDAQ is rugged enough for the borehole environment, to acquire real data using the new system, and to find ways the CDAQ could be improved.

4 Test Results

7 PCTB tests were performed and 1 PDT/T2P test was performed (Table 4-1, Table 4-2). The recovered cores were cut into sections (Table 4-3).

Table 4-1. Summary of daily Events

Date	Activity
Monday, March 9, 2020	Schlumberger began sidetrack drilling
Tuesday, March 10, 2020	Continued sidetrack drilling
Wednesday, March 11, 2020	Continued sidetrack drilling
Thursday, March 12, 2020	Sidetrack drilling completed; drill pipe arrived
Friday, March 13, 2020	Geotek containers arrived
Monday, March 16, 2020	Rig up
Tuesday, March 17, 2020	CTTF-01FB, CTTF-02FB
Wednesday, March 18, 2020	BHA change, CTTF-03CS, CTTF-04CS
Thursday, March 19, 2020	CTTF-05CS, CTTF-06CS, CTTF-07CS, PDT Test
Friday, March 20, 2020	Data compilation, Reporting; Demobilization (UT, Geotek, Containers, Cranes)
Saturday, March 21, 2020	No activity
Sunday, March 22, 2020	No activity
Monday, March 23, 2020	Drill pipe offsite

Table 4-2. Coring summary, whether a pressure boost was recorded and maintained (correct ball closure), and other pertinent information. Depths in MD from rig floor.

Coring Test	Configuration	Core Name	Correct ball valve closure?	Pressure at surface (psi)	Coring begin depth (ft)	Coring stop depth (ft)	Penetration (ft)	Core recovered (ft)	Recovery (%)	Formation	Flow Rate (gal/min)	Date	Start time	End time
1	Face bit	CTTF-01FB	Y	2100	1815.1	1821.7	6.6	5.5	83	Austin Chalk	400	3/17/2020	11:13	11:49
2	Face bit	CTTF-02FB	N	0	1821.7	1831.5	9.8	8.9	91	Austin Chalk	600	3/17/2020	15:09	15:38
3	Cutting shoe	CTTF-03CS	N	0	1831.5	1841	9.5	7.5	79	Austin Chalk	600	3/18/2020	13:46	14:24
4	Cutting shoe	CTTF-04CS	N	0	1841	1843.5	2.5	2	80	Austin Chalk	400	3/18/2020	16:08	16:37
5	Cutting shoe	CTTF-05CS	N	0	1843.5	1843.8	0.3	0.59	197	Austin Chalk	29	3/19/2020	10:15	11:00
6	Cutting shoe	CTTF-06CS	N	0	1843.8	1844.2	0.4	0	0	Austin Chalk	100	3/19/2020	13:05	13:35
7	Cutting shoe	CTTF-07CS	N	0	water core	1235	-	-	-	-	0	3/19/2020	16:00	16:45

Table 4-3. Summary of core section, length, and local location in the core liner.

Section Name	Length (cm)	Top Location (cm)	Bottom Location (cm)
CTTF-01FB-1	95	0	95
CTTF-01FB-2	75	95	170
CTTF-02FB-1	90	0	90
CTTF-02FB-2	100	90	190
CTTF-02FB-3	80	190	270
CTTF-03CS-1	100	0	100
CTTF-03CS-2	100	100	200
CTTF-03CS-3	30	200	230
CTTF-04CS-1	62	0	62
CTTF-05CS-1	18	0	18
CTTF-06CS-1	no core recovered		

4.1 PCTB-FB Results

Two face-bit pressure cores were taken (Table 4-2). The first core (CTTF-1FB) was 5.5 ft long and had 85% recovery. The core was recovered at pressure (2100 psi) and both the ball valve and nitrogen boost worked correctly. The second core (CTTF-2FB) was 8.9 ft long and had 92% recovery. On the second core, the ball valve did not seal. CTTF-1FB was run at a flow rate of 400 gpm and Test 2 was run at 600 gpm (Table 4-2). Both cores recovered had high recovery and were of very good quality.

Detailed summaries of the cores are presented in the daily reports in Appendices D and E.

4.2 PCTB-CS Results

Four cutting shoe pressure cores were taken (Table 4-2). The first core (CTTF-03CS) was 7.5 ft long and had 80% recovery (Table 4-2). We took a shorter core for CTTF-04CS and once again had 80% recovery. Both coring runs were run at a relatively high pump rate (Table 4-2). CTTF-05CS and CTTF-06CS were both short cores, but they also had high recovery: 2 and 0.5 ft of core were recovered respectively (Table 4-2).

In all 4 cases of PCTB-CS coring, the ball valve did not seal.

The final deployment of the PCTB was to test the PCTB-CS within casing, without actually coring rock (a 'water core'). The ball valve did not seal (e.g. Figure 5-6).

For a detailed description of individual core runs, see daily reports in Appendices D & E.

4.3 PDT and T2P Results

4.3.1 Test results

In preparation for deployment of the PDT, the Running/Pulling Tool (RPT) was assembled and a lifting clamp was installed on the top connection. The RPT was then laid out on the catwalk. The PDT was then assembled, a T2P attached, the T2P protection boot installed, and a lifting clamp was installed on the PDT top connection. The PDT/T2P assembly was then laid out on the catwalk.

The PDT/T2P assembly was pulled up the Vee door to the rig floor using a tugger. The PDT/T2P assembly was then lowered down the drill string until the lifting clamp landed on the drill pipe tool joint. The tugger was then disconnected and laid out. The wireline was connected to the RPT and the RPT was then pulled up the Vee Door to the rig floor. The RPT was stabbed into the PDT/T2P assembly and the entire assembly was then picked up to remove the lifting clamp from the PDT top connection.

After removing the lifting clamp from the PDT, the RPT/PDT/T2P assembly was lowered down the drill string on the wireline. At 348 feet below the rig floor the wireline operator reported losing approximately 800 lbs. of weight. This was an indication that the PDT/T2P had prematurely released from the RPT. If this was the case, the PDT/T2P was now landed in the BHA approximately 850 feet below the RPT. Since it appeared that the RPT did not remain latched to the PDT/T2P it was theorized that fishing the dropped PDT/T2P assembly with the RPT would be futile. The decision was made to pull the RPT out of the drill string and lay it out, then fish the PDT/T2P using a GS Pulling Tool.

When the RPT reached the rig floor, visual inspection did not reveal any damage to the tool or the cause of the premature release.

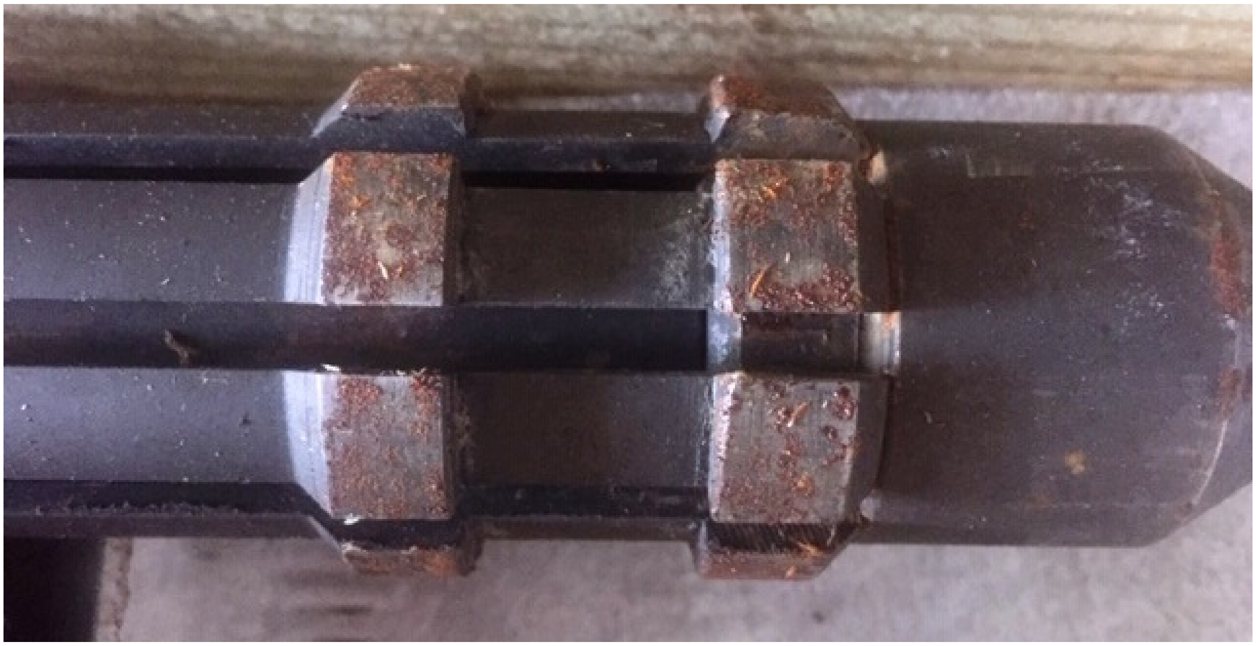

Figure 4-1. PDS Running/Pulling Tool Collet.

The RPT was laid out on the catwalk and a GS Pulling Tool was attached to the wireline. The GS Pulling Tool was then lowered down the drill string until it landed on the PDT/T2P assembly. When the wireline was picked up, an additional 800 pounds of weight was noted, indicating that the PDT/T2P was attached.

The PDT/T2P assembly was then pulled to the rig floor via the wireline where a lifting clamp was installed on the PDT top connection. After landing the PDT on the drill pipe, the GS pulling tool was unlatched from the PDT and laid out. A tugger was attached to the lifting clamp installed on the PDT and the PDT/T2P assembly was pulled out of the drill string. It became evident that the PDT inner rod subassembly had scoped out, probably on impact with the BHA landing shoulder. The PDT was picked up further until the T2P could be accessed. The PDT/T2P quick release was uncoupled allowing for removal of the T2P which was then laid out. The PDT was then laid out on the catwalk with the inner rod subassembly scoped out.

4.3.2 Post Test Inspection

Prior to disassembly of the PDT one of the locking dogs was observed to be missing (Figure 4-2). It appeared that the locking dog had sheared the pivot pin.

Figure 4-2. Missing locking dog.

It was also observed that the latch detent body was still in the locked (down) position (Figure 4-3).

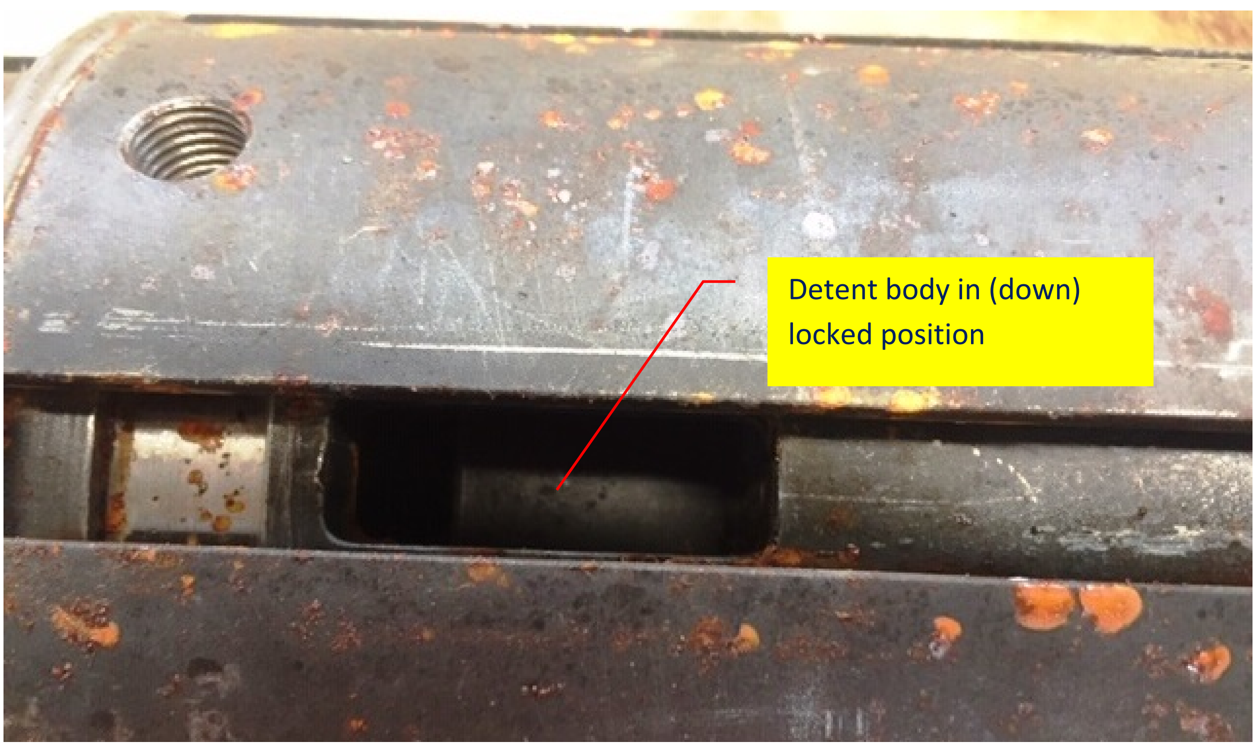

Figure 4-3. Detent body in locked (down) position.

This is an indication that the detents had failed allowing the RPT to release from the PDT.

Upon disassembly of the PDT latch the following was observed:

1. All of the dog pivot pins had been either deformed or sheared (Figure 4-4).
2. Most of the dog retaining pins had been deformed (Figure 4-4).
3. The upper latch dog heels were brinelled on the lower inner corners (Figure 4-5, Figure 4-6).
4. All four detents were missing.
5. The detent retaining spring was missing.
6. The detent body, and all other latch parts, appeared undamaged.

Figure 4-4. Deformed pivot and retaining pins.

Figure 4-5. Upper latch dogs with brinelled heels

Figure 4-6. Close up of upper latch dog brinelled heel.

T2P Observations

Upon tool recovery and disassembly, the connector from the CDAQ to the data/power dump cable was observed to be loose and moderately damaged. This does not impact the function of the CDAQ, but it would prevent recharging or offloading of data without disassembling the tool. The connector from the CDAQ to the sensors was loose and likely the connection was broken during the test, although the connector was undamaged. Sensor disconnection would immediately stop data logging, and may also cause the CDAQ to shut down. The data from the test was not recorded on the CDAQ's chip. It is possible that sensor disconnection is the cause of this data loss. Initial observations and bench tests indicate that, except for the damaged connector, the CDAQ system is undamaged and functions correctly after the test.

5 Discussion

5.1 PCTB Testing

5.1.1 Core Quantity & Quality

The core recovery was very good in both the face bit and cutting shoe configurations of the PCTB. In the two runs of the PCTB-FB, the recovery was 83 and 91% respectively for core throws of 6.6 and 9.8 ft (Table 4-1). In two long core throws of the PCTB-CS (9.5 and 3.5 ft) the recovery was 79 and 80%. For two short core throws of the PCTB-CS the recovery was more variable (0-197%). There appears to be no difference in recovery between configurations of the PCTB.

Core quality was very good in both PCTB configurations. The diameter of the core was consistent in all cores of both configurations, even across transitions between limestone and shale. Grooves on the exterior of the core were minimal. Core 'biscuiting' was common with core biscuits ranging from cm to tens of cm in length. Cores recovered with the PCTB-CS may contain more biscuits, but more detailed analysis will be required to determine differences between configurations.

Figure 5-1. Core CTTF-02FB contained 8.9 ft of limestone and shale after recovery.

Figure 5-2. A closer view of Core CTTF-02FB. The core is consistent in diameter between limestone (light-colored intervals) and shale (dark-colored intervals). Most biscuits are tens of cm in length and very minor spiral grooves are visible.

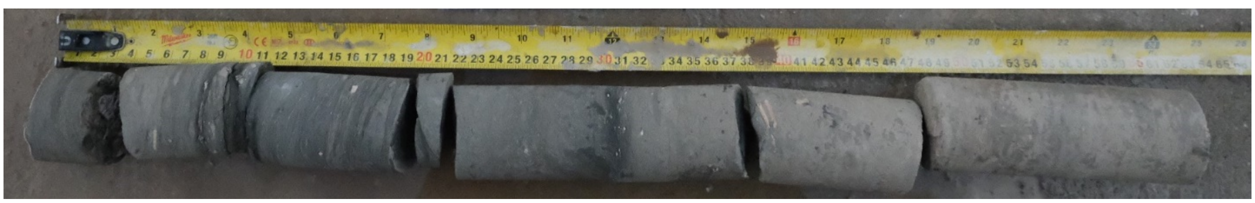

Figure 5-3. Core CTTF-04CS is a high-quality core from the cutting-shoe tool. The pressure was not maintained in the sample, but that core had high recovery (80%) and had good quality.

We interpret that the addition of the diverter system, which allowed for higher pump rates, resulted in increased penetration rate, increased core recovery, and improved core quality with both the CS and FB PCTB systems.

5.1.2 Discussion of DST and Rig parameter plots

For the PCTB Land Test II, the PCTB was deployed with one DST (compact temperature/pressure logger) in the pressure section of the tool. The DST pressure data clearly shows if the pressure boost or tool sealing occurs. We plot DST pressure alongside several relevant rig parameters to describe a successful deployment of the PCTB (core CTTF-01FB, Figure 5-4) and an unsuccessful deployment (core CTTF-05CS, Figure 5-5).

Successful test (CTTF-01FB, 3/17/2020):

Figure 5-4 and Table 5-1 show our interpretation of significant events that occurred during coring run CTTF-01FB which occurred on 3/17/2020. (1) At 10:26 the PCTB was lowered into the hole, shown by the increase in hydrostatic pressure being recorded by the DST. (2) At 11:06 the pumps were turned on. (3) At 11:11 there was weight on bit and coring begins. Bit depth began to increase, and slight pressure perturbations can be seen in the DST pressure. (4) At 11:48 penetration halted. We interpret this to be the bit becoming balled-up. (5) At 11:51 flow rate was increased to try (unsuccessfully) to resume penetration. (6, 7, 8) At 11:55 flow rate was reduced and the bit was raised, ending the coring. (9) At 12:38 the pulling tool actuated the PCTB, closing the ball valve and triggering the pressure boost. The pressure boost was recorded as an increase in DST pressure of ~1300psi. (10) The PCTB was pulled out of the hole from 12:38 to 13:17. DST pressure indicates that tool pressure was held near constant, indicating a good seal. The slight decrease in pressure as the tool was pulled out of the hole has been observed in every previous successful test, and is attributed to compressibility and changing pressure outside of the tool, and does not indicate a poor seal.

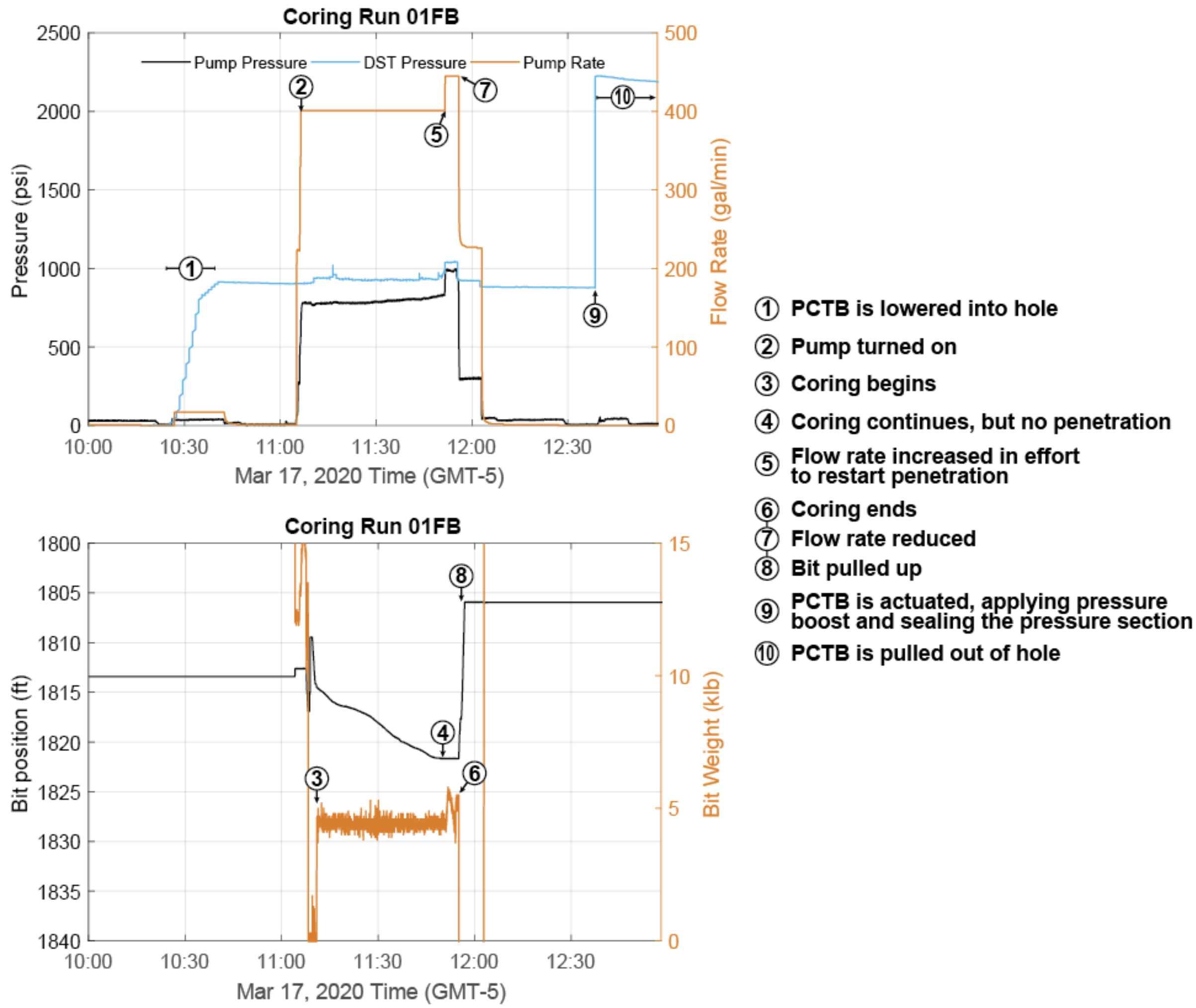

Figure 5-4. DST and rig instrumentation plots for core CTTF-01FB. The PCTB tool boosted and sealed correctly, and pressurized core was recovered. See also Table 5-1. DST data timestamps were shifted +5.5 minutes to match to rig instrumentation timestamps.

Table 5-1. Significant events for core CTTF-01FB.

CTTF-01FB		
Event #	Time	Event Description
1	10:26 - 10:36	PCTB is lowered into hole
2	11:06	Pump turns on
3	11:11	Coring begins
4	11:48	Coring continues, but no penetration
5	11:51	Flow rate increased in effort to restart penetration
6	11:55	Coring ends
7	11:55	Flow rate reduced
8	11:55	Bit pulled up
9	12:38	PCTB is actuated, applying pressure boost and sealing the pressure section
10	12:38 - 13:17	PCTB is pulled out of hole

Unsuccessful test (CTTF-02FB – CTTF-07CS, 3/17/2020 – 3/19/2020):

The PCTB did not properly seal in any subsequent tests. Figure 5-5 and Table 5-2 show our interpretation of the major events during coring run CTTF-05CS which occurred on 3/19/2020. (1) At 09:42 the PCTB was lowered into the hole, shown by the increase in hydrostatic pressure being recorded by the DST. (2) At 10:17 the pumps were turned on. (3) At 10:20 there was weight on bit and coring begins. Bit depth began to increase, and slight pressure perturbations can be seen in the DST pressure. (4) At 10:28 penetration halted. We interpreted this to be the bit balling up. (5,6,7) At 10:50 after no further penetration, the flow rate was reduced, and the bit was raised. This ended the coring. (8) At 11:15 the pulling tool actuated the PCTB which attempted to close the ball valve and trigger the pressure boost. The sealing and pressure boost were unsuccessful. A slight pressure jump in the pressure from the DST data at (8) may record the boost attempt. (9) The PCTB was pulled out of the hole from 11:15-11:30. DST pressure indicates that the pressure decreased as the tool was pulled out of the hole, thus following the wellbore pressure as the tool was raised. At the surface there was no pressure maintained in the PCTB.

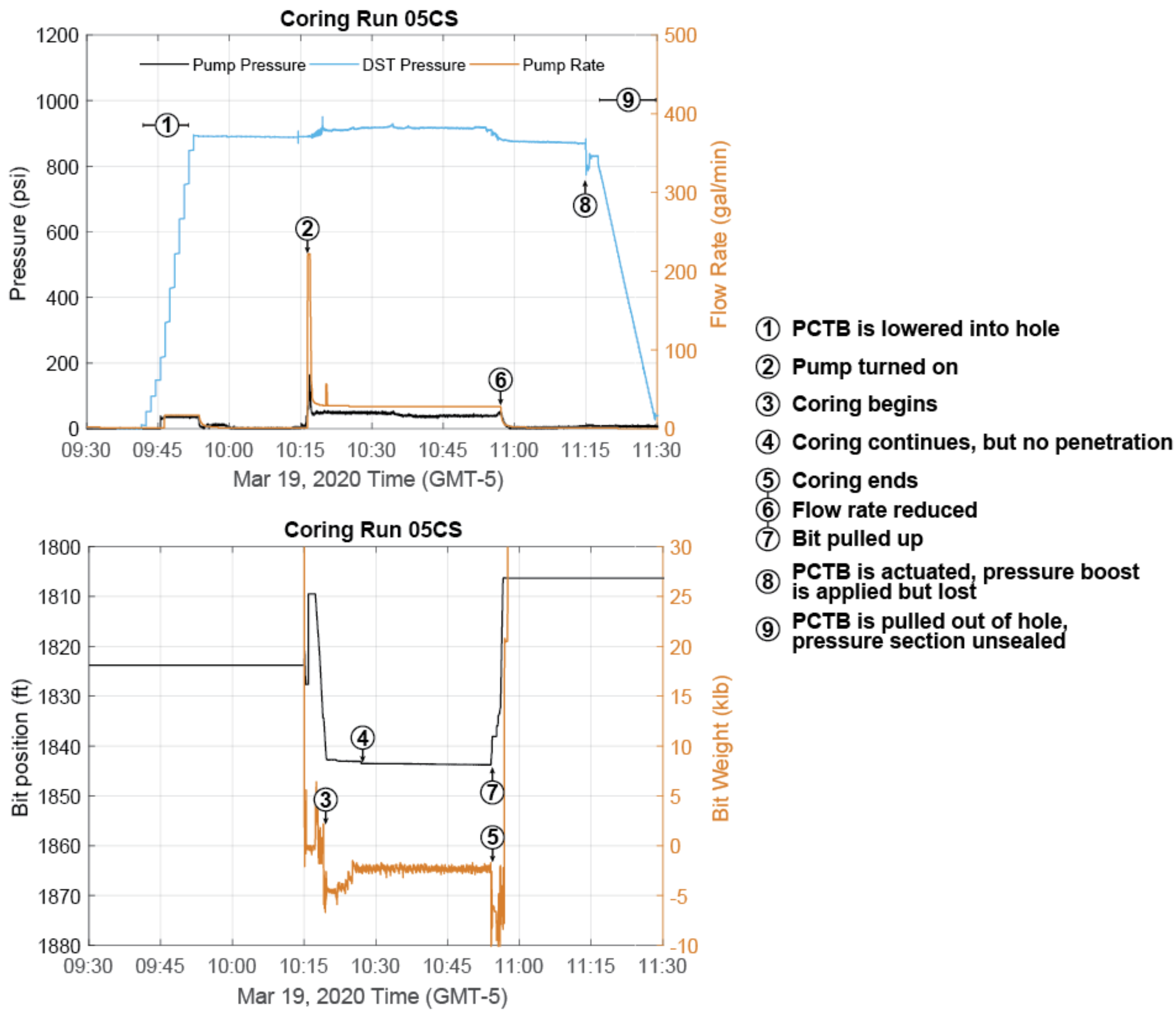

Figure 5-5. DST and rig instrumentation plots for core CTTF-05CS. The PCTB tool did not seal correctly, and the core was recovered with no pressure. The pressure boost can be seen in the DST data but quickly dissipated since the core was not sealed. Our interpretation of significant events during coring is shown. See also Table 5-2. DST data timestamps were shifted +5.5 minutes to match to rig instrumentation timestamps.

Table 5-2. Significant events for core CTTF-05CS

CTTF-05CS		
Event #	**Time**	**Event Description**
1	9:42-9:52	PCTB is lowered into hole
2	10:17	Pump turned on
3	10:20	Coring begins
4	10:28	Coring continues; no penetration
5	10:50	Coring ends
6	10:50	Flow rate reduced
7	10:50	Bit pulled up
8	11:15	PCTB is actuated; pressure boost is applied but lost
9	11:15-11:30	PCTB is pulled out of hole; pressure section unsealed

5.1.3 PCTB Ball Valve Sealing

We had one successful coring test: PCTB-1FB (Table 4-1). In this case, a clear pressure increase was recorded when the tool sealed (Figure 5-4).

In 6 out of 7 cases, the ball only partially closed and no increase in pressure was recorded (e.g. Figure 5-5). In some cases, when the tool was recovered to the surface, the ball valve was partially closed (Figure 5-6). However, in other cases the ball valve appeared closed at the surface (Figure 5-7). We interpret that in cases where the ball valve appeared sealed at the surface, the ball sealed only after the boost was fired, perhaps while being recovered.

Figure 5-6. Illustration of a partially closed ball valve after recovery from the hole. The red object is the seal carrier. When the PCTB is actuated, a spring to the left of the seal carrier drives the seal carrier downward, which in turn drives ball downward (to the right). When the ball is forced downwards, it rotates around a pin into the closed orientation, sealing the bottom of the autoclave.

Figure 5-7. Illustration of an apparently closed ball valve upon recovery from the hole. Although it is apparently sealed, no pressure was held. It is interpreted that either it was a leaky seal or that the ball valve closed after the pressure was boosted. Note the mud and silt between the ball and the seal carrier (red).

We interpret that drilling fluid and entrained cuttings are wedging between the outer housing and the seal carrier. The seal carrier drives and rotates the ball into the closed and sealed position. If cuttings are jammed between the seal carrier and the outer housing it could jam. It is possible that the first run was a fluke success, or that, early in the program, the mud had less detritus than later in the testing program. During the testing, we thought the reason the ball wasn't sealing was potentially due to the high flow rates. For that reason, we significantly reduced the flow rate (Table 4-2, CTTF-05CS, CTTF-06CS). There was no improvement in sealing behavior at lower flow rates. Another possible explanation for the failed runs is that the ball itself is jamming. However, we do not favor this interpretation as it would likely be obvious during inspection and testing.

In previous field expeditions and in the previous land test (Flemings, 2015), there have been repeated cases where the PCTB has not sealed at the time the tool is raised. During UT-GOM2-1, there was only one core that recorded a boost pressure and this was in lithified marl and mudrock and not in a coarse-grained hydrate bearing interval. In drilling the coarse-grained interval, in all cases, the ball valve sealed as the tool was being raised to the surface and a pressure boost was not recorded (Thomas et al., in press).

The PCTB-CS and PCTB-FB sealed perfectly during downhole testing in Salt Lake City (Geotek Coring Inc., 2020). However, this mud did not have detritus or silt within it. The only change in the ball closure mechanism between the Salt Lake City Bench test and the Cameron test was that was to put a low friction coating on it. This was fully vetted in the bench test in Salt Lake City with no issues.

It is our view that incremental improvements in the tool have improved the reliability of the upper pressure seal. However, this field test has now clearly delineated that there continues to be a problem with sealing of the ball valve itself.

To resolve this issue, it will be necessary to be able to systematically recreate the failure mode where sediments jam the seal carrier. Geotek will explore this immediately at Salt Lake by adding sediment to mud to simulate the conditions at Cameron. At the same time, Geotek and Pettigrew Engineering will explore possible design changes to improve sealing in the presence of mud with cuttings.

5.2 PDT

Once the running/pulling tool is stabbed into the PDT, the detents lock the running/pulling tool to the detent body. The detent body in turn is locked to the latch body by the upper latch dogs. It appears the detents sheared, allowing the running/pulling tool to come out of the PDT without the detent body moving into the release position. This situation is exacerbated by the tendency of the detents to roll under load due to limited shouldering within the detent body. Shearing of the detents is indicated by the brinelling of the upper latch dog heels, the fact that the detent body remained in the locked position, and the running/pulling tool released from the PDT. Unfortunately, all of the detents were lost downhole and they cannot be analyzed.

During the bench testing of the PDT, a shortened configuration had to be employed due to lifting height restrictions. The shortened configuration placed a lower load on the detents and upper latching dogs than the full assembly does. The slight brinelling of the detents during the bench testing was an apparent overlooked indication of a potential overloading situation which manifested itself during the land test. Although the detents were designed to hold more than eight times the static load of the PDT, impact loading during handling and deployment were apparently enough to initiate the shear failure.

The loss of the locking dog is believed to be a result of the free falling-PDT slamming into the BHA landing shoulder. It is theorized that upon landing in the BHA, the missing locking dog did not have enough time to clear the landing sleeve as the landing sleeve instantaneously moved upward relative to the latch body. This action caused the locking dog pivot pin to shear, allowing the locking dog to fall out of the latch.

The deformed pivot and retaining pins are a result of the latch dogs being forced outward by the wedging action during shearing the detents. The brinelled corners of the latch dog heels is an indication of the wedging action.

The following upgrades are being considered.

1. Upgrade the detents to stronger material. The upgrade of the locking dogs to stronger material between the bench testing and the land test improved their performance. No bending of the locking dogs was observed after the land test. This same approach should be taken with the detents.
2. Square off the latch dogs load heels to provide a better load bearing surface.
3. Square off the detent latch dog groove load side to provide a better load bearing surface.

5.3 Penetrometer (T2P)

The new mounting system for the new CDAQ performed well and protected the ciruit boards and battery from damage during the test. Better strain relief needs to be implemented on both sensor-side and charging-side connectors. The cause of data loss will be investigated; at minimum, a failsafe function needs to be implemented in the firmware that would salvage data in case of sensor disconnection or CDAQ failure during logging.

6 Summary

The PCTB Land Test II provided additional operational experience with the PCTB, PDT, and T2P downhole tools in a wellbore environment. Every test we make strengthens our understanding of these tools and strengthens their performance. We interpret that the addition of the diverter system, which allowed for higher pump rates, resulted in increased penetration rate, increased core recovery, and improved core quality with both the CS and FB PCTB systems. We also interpret that the implementation of a single trigger mechanism has made the upper seal more reliable. Our testing has now illuminated that cuttings are jamming the seal carrier. The seal carrier drives and rotates the ball into the closed and sealed position. When it jams, the ball valve cannot seal. If we can repeatedly demonstrate this mode of failure in the test facility at Geotek Salt Lake, then we are optimistic that we will be able to design a solution. The PDT and T2P could not be fully exercised because the tool was dropped when it was running in. Minor changes will strengthen the latching mechanism for lowering the tool.

7 References

Flemings, P., Phillips, S., Pettigrew, T., Green, T., 2015. GOM2 Pressure Coring Tool With Ball Valve (PCTB) Land Test Initial Report. In Flemings, P. (Principle Investigator), *DOE Award No.: DE-FE0023919 Quarterly Research Performance and Progress Report (Period Ending 12/31/2015), Deepwater Methane Hydrate Characterization & Scientific Assessment, Project Period 10/01/14-09/30/20, Appendix A*. Institute for Geophysics, The University of Texas at Austin.

Geotek Coring, Inc., 2020. Pressure coring Tool with Ball Valve (PCTB) UT2020 PCTB4 Lab Testing 2. In Flemings P. B. (Principle Investigator), *DOE Award No.: DE-FE0023919 Quarterly Research Performance and Progress Report (Period Ending 03/31/2020) Deepwater Methane Hydrate Characterization & Scientific Assessment, Project Period 4: 10/01/19-09/30/20, Appendix A..* Institute for Geophysics, The University of Texas at Austin.

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 press. Pressure-coring operations during Expedition UT-GOM2-1 in Green Canyon Block 955, northern Gulf of Mexico. American Association of Petroleum Geologist Bulletin.

GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX A: DST Plots

Appendix A: DST plots

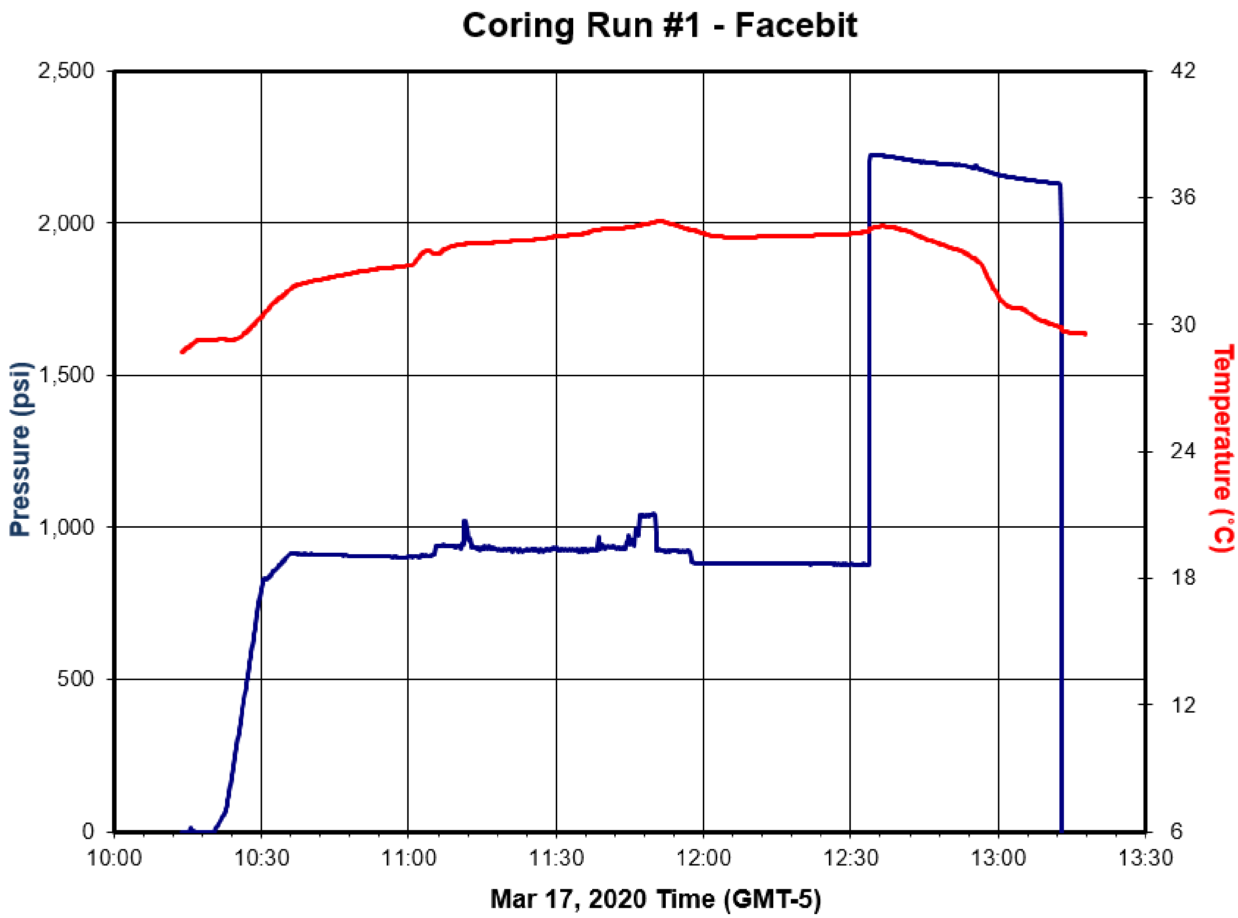

Figure A1. DST pressure and temperature record for CTTF-01FB. Boost pressure clearly recorded.

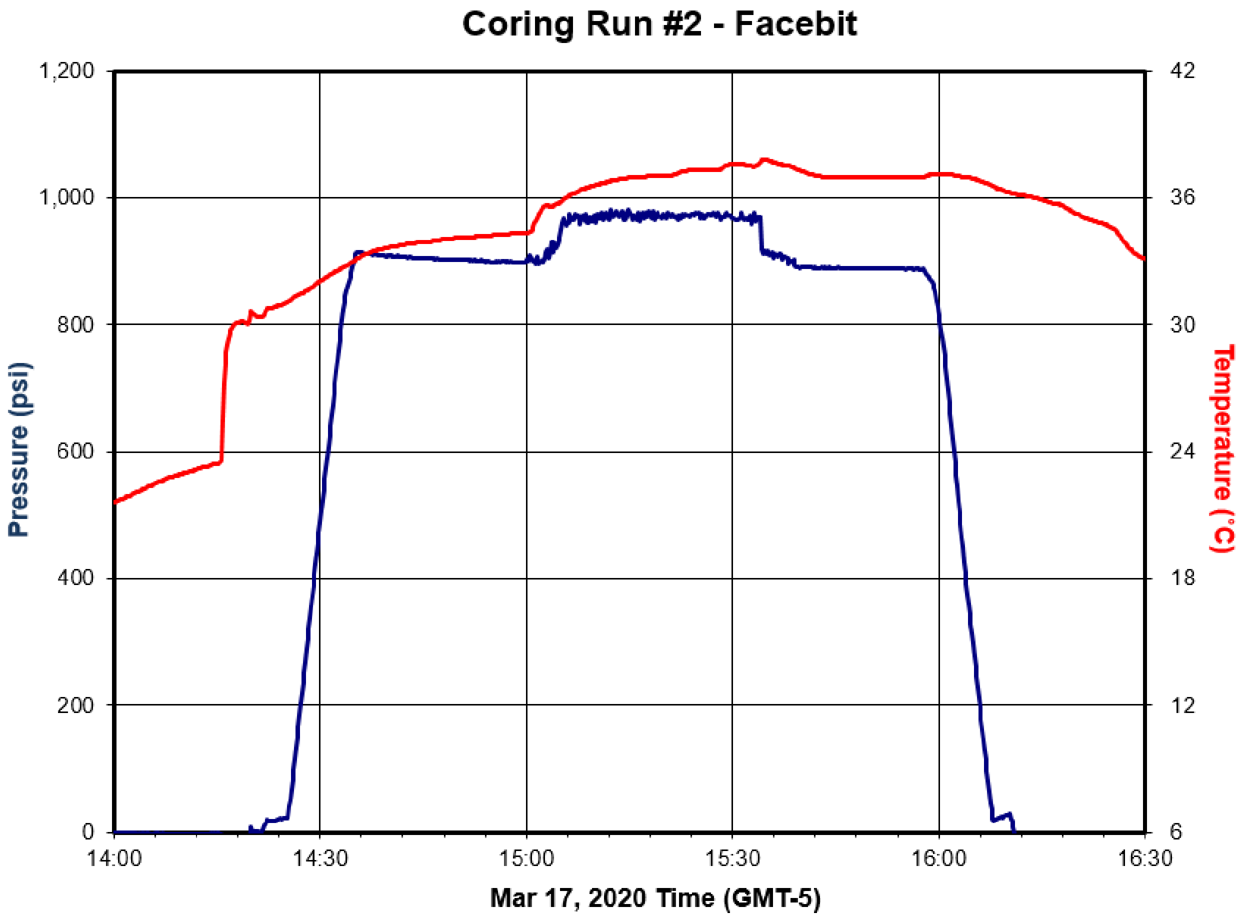

Figure A2. DST pressure and temperature record for CTTF-02FB. No boost pressure recorded.

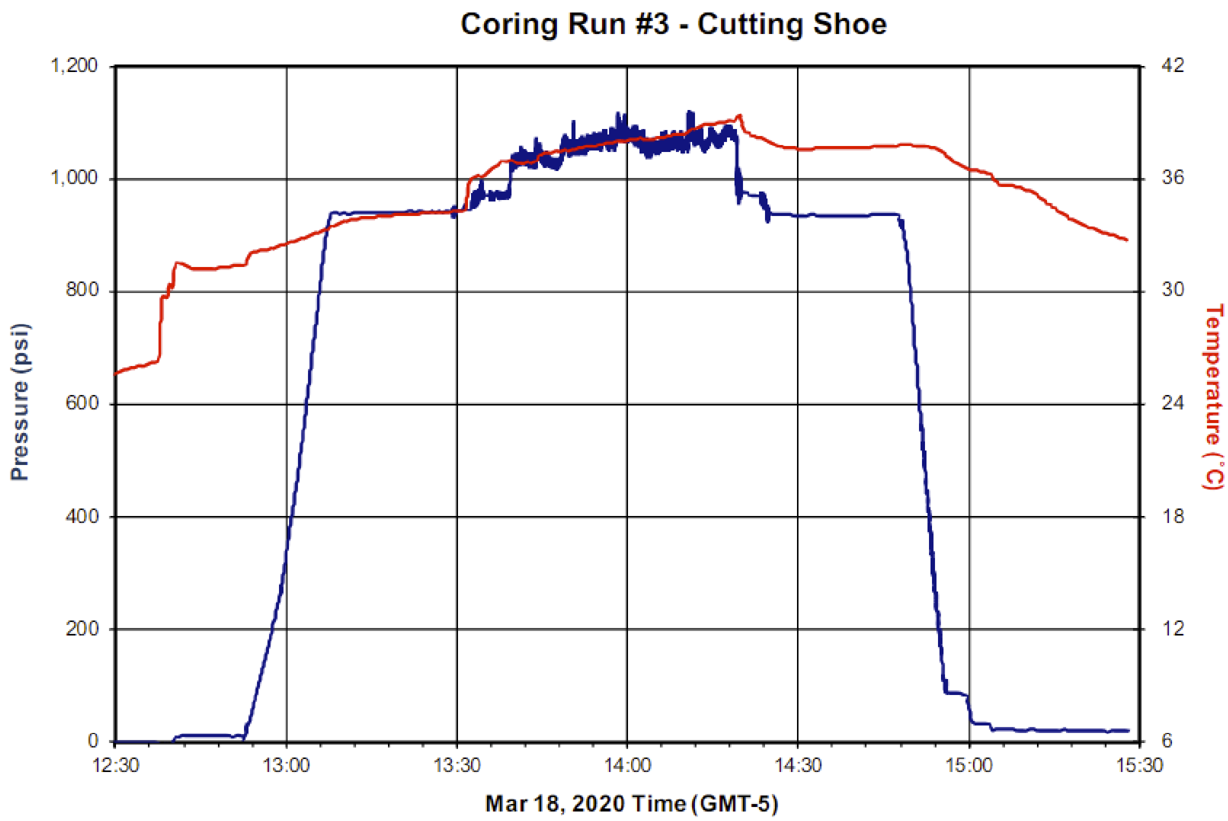

Figure A3. DST pressure and temperature record for CTTF-03CS. No boost pressure recorded.

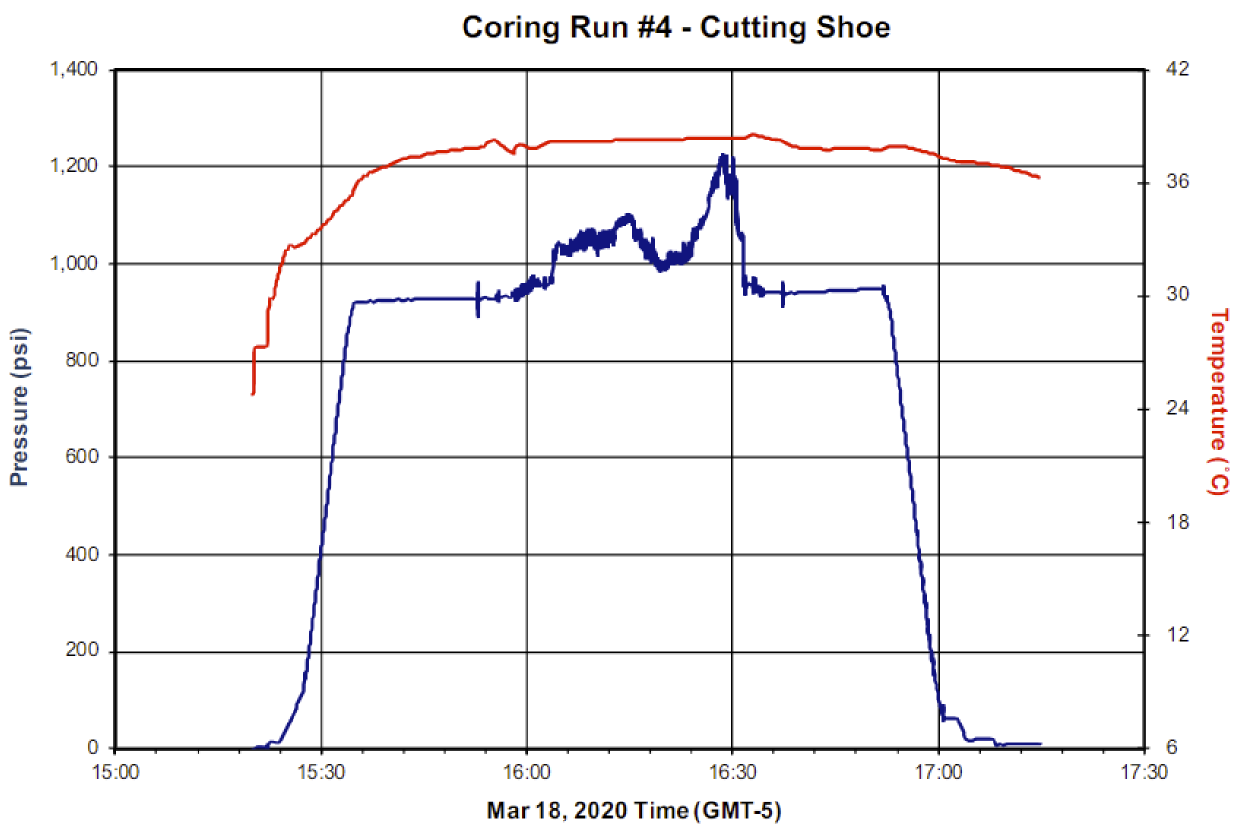

Figure A4. DST pressure and temperature record for CTTF-04CS. No boost pressure recorded.

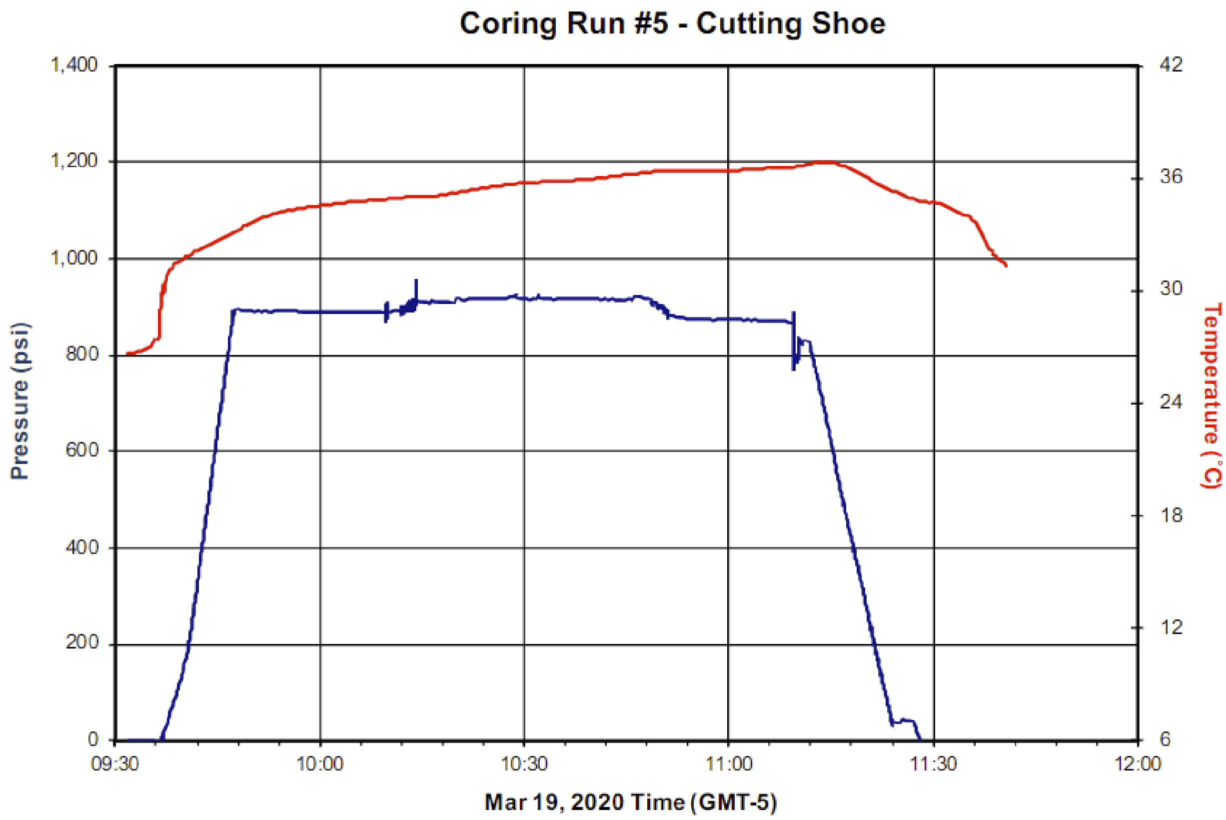

Figure A5. DST pressure and temperature record for CTTF-05CS. No boost pressure recorded.

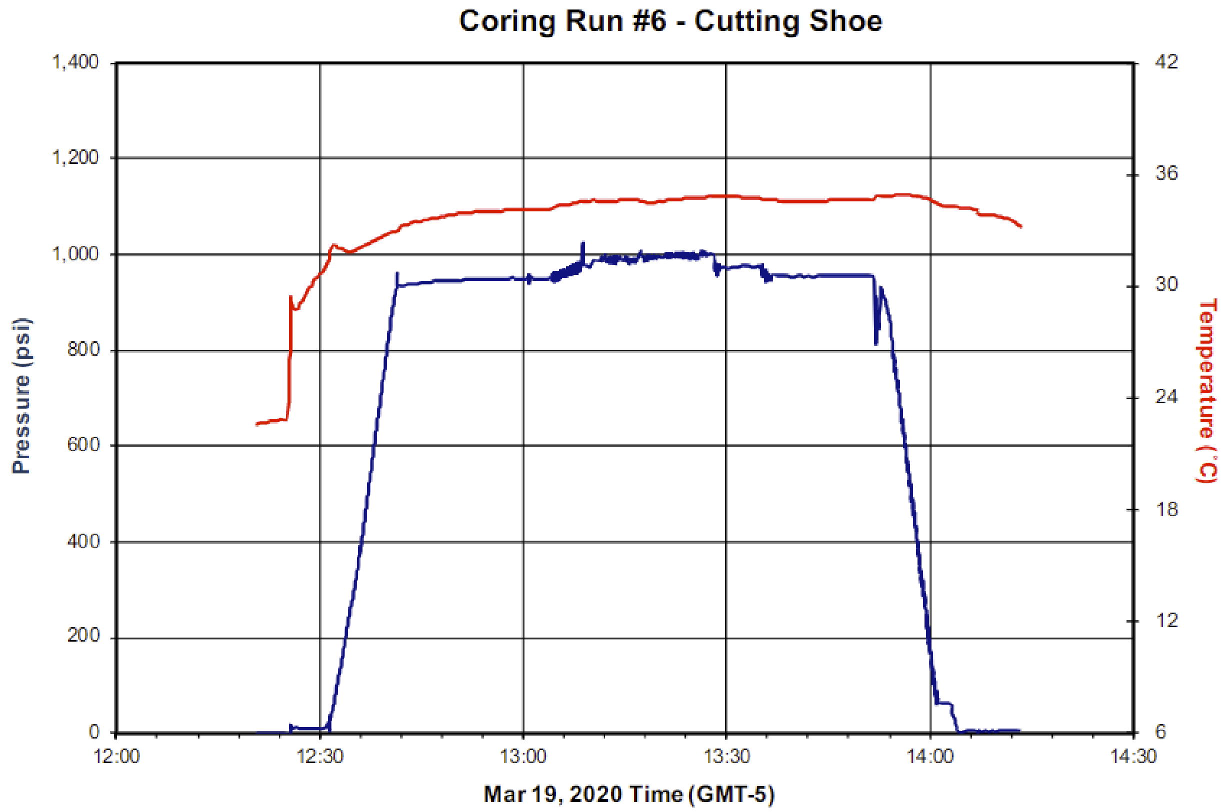

Figure A6. DST pressure and temperature record for CTTF-06CS. No boost pressure recorded.

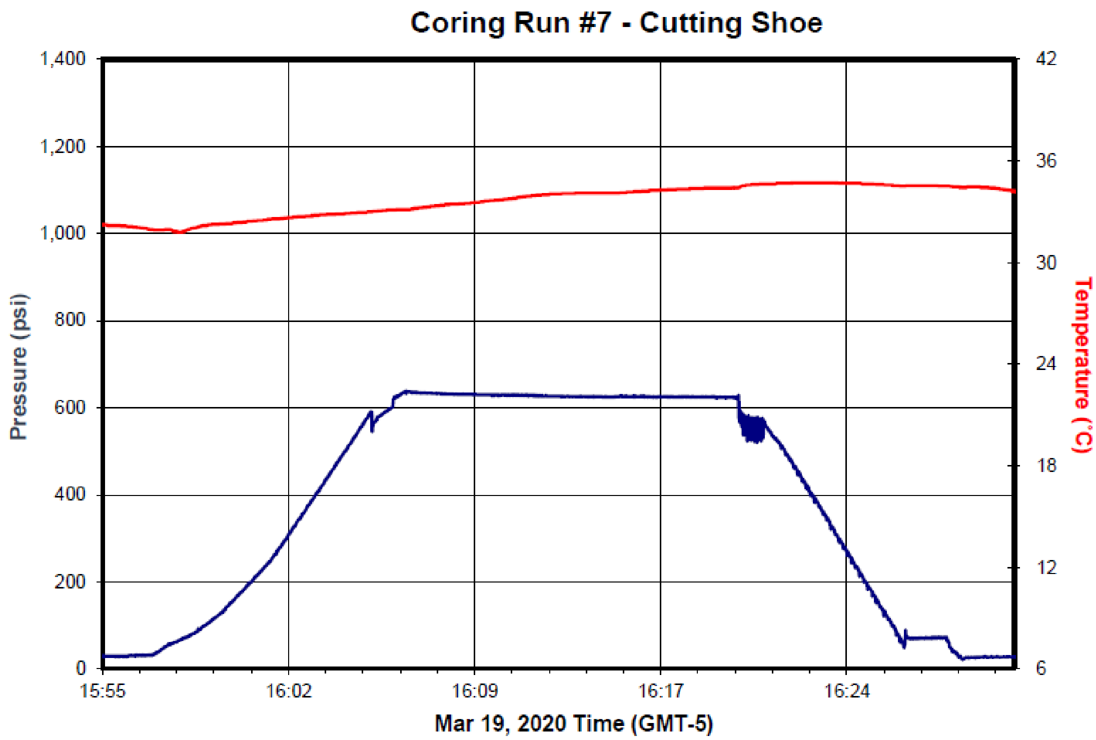

Figure A7. DST pressure and temperature record for CTTF-07CS. No boost pressure recorded.

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APPENDIX B: Rig Instrumentation Plots

Appendix B: Rig Instrumentation Plots

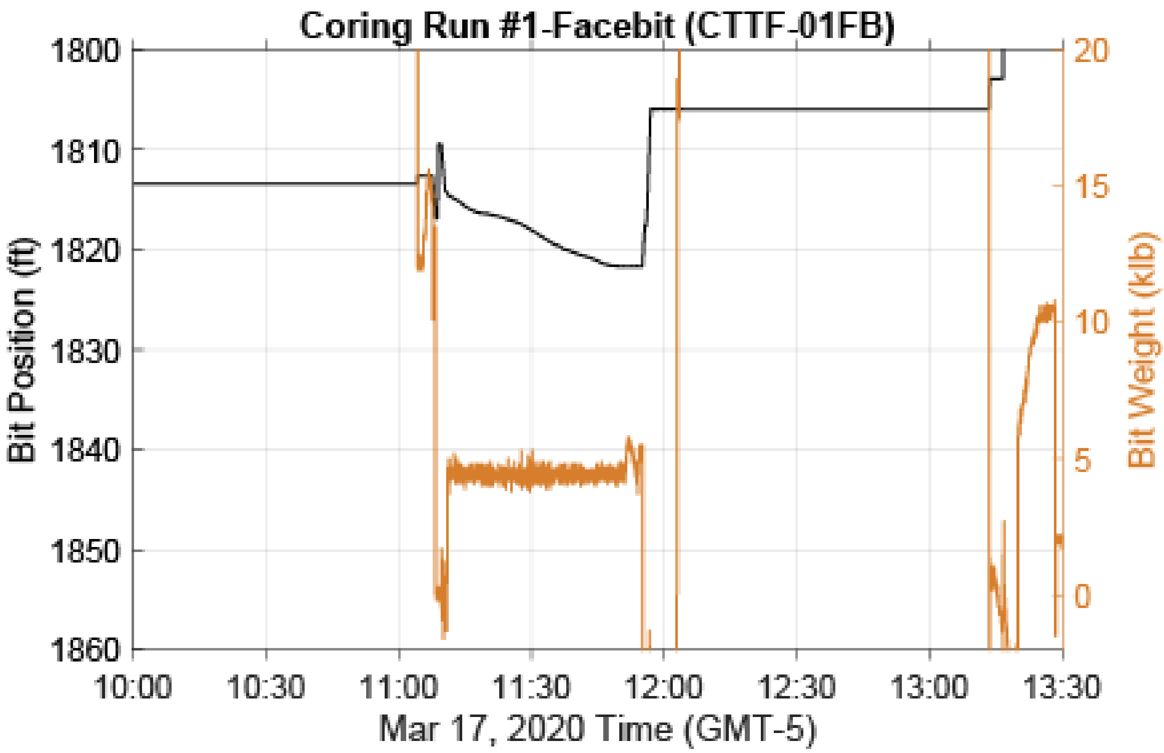


Figure B1. Bit position and bit weight record for coring CTTF-01FB.

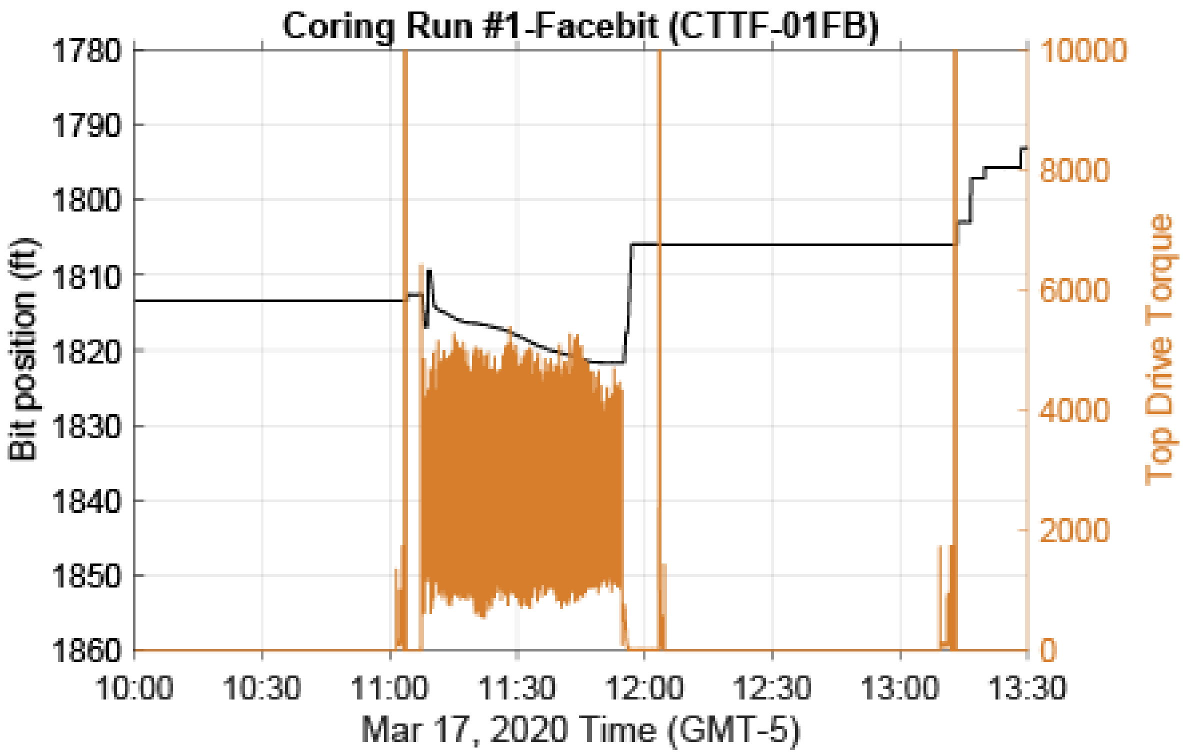


Figure B2. Bit position and top drive torque record for coring CTTF-01FB.

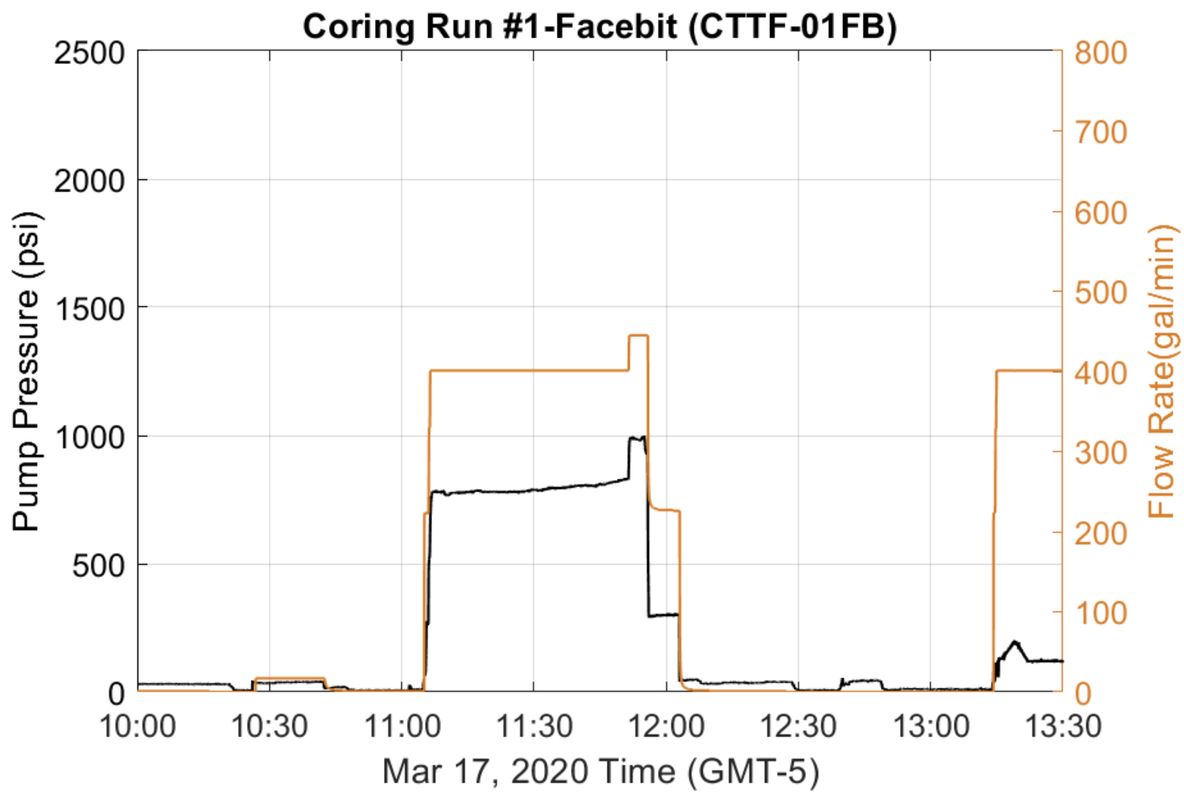


Figure B3. Rig pump pressure and flow rate record for coring CTTF-01FB.

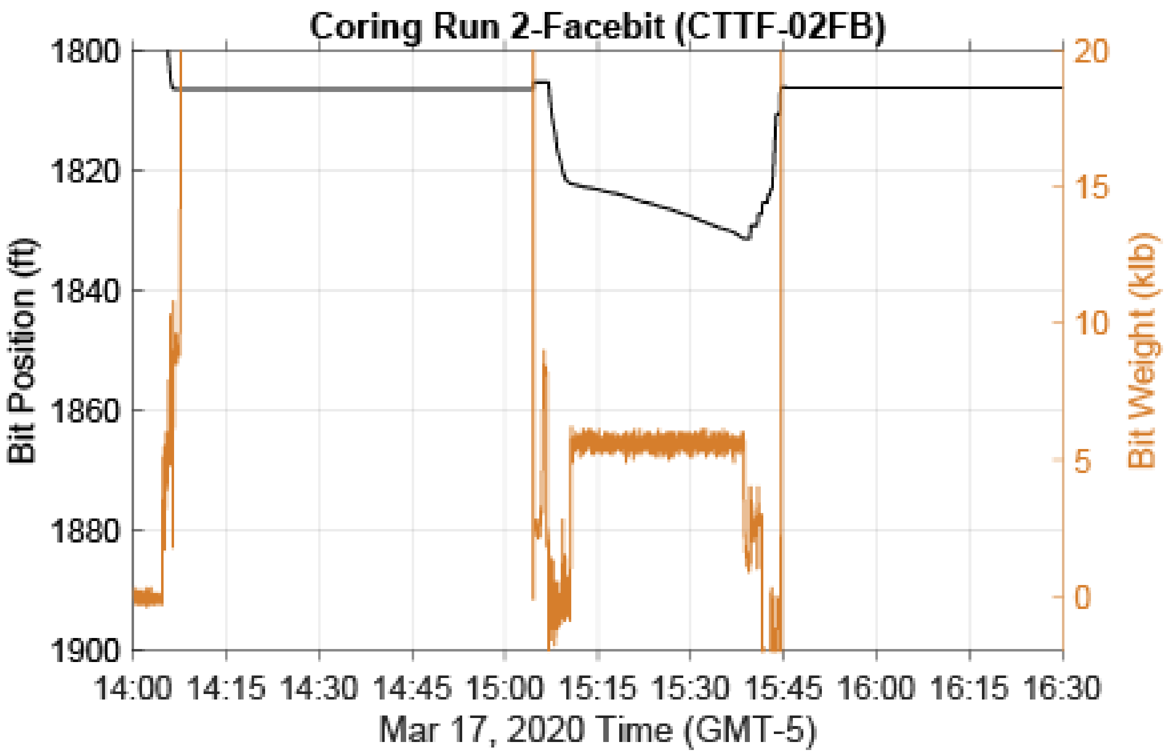


Figure B4. Bit position and bit weight record for coring CTTF-02FB.

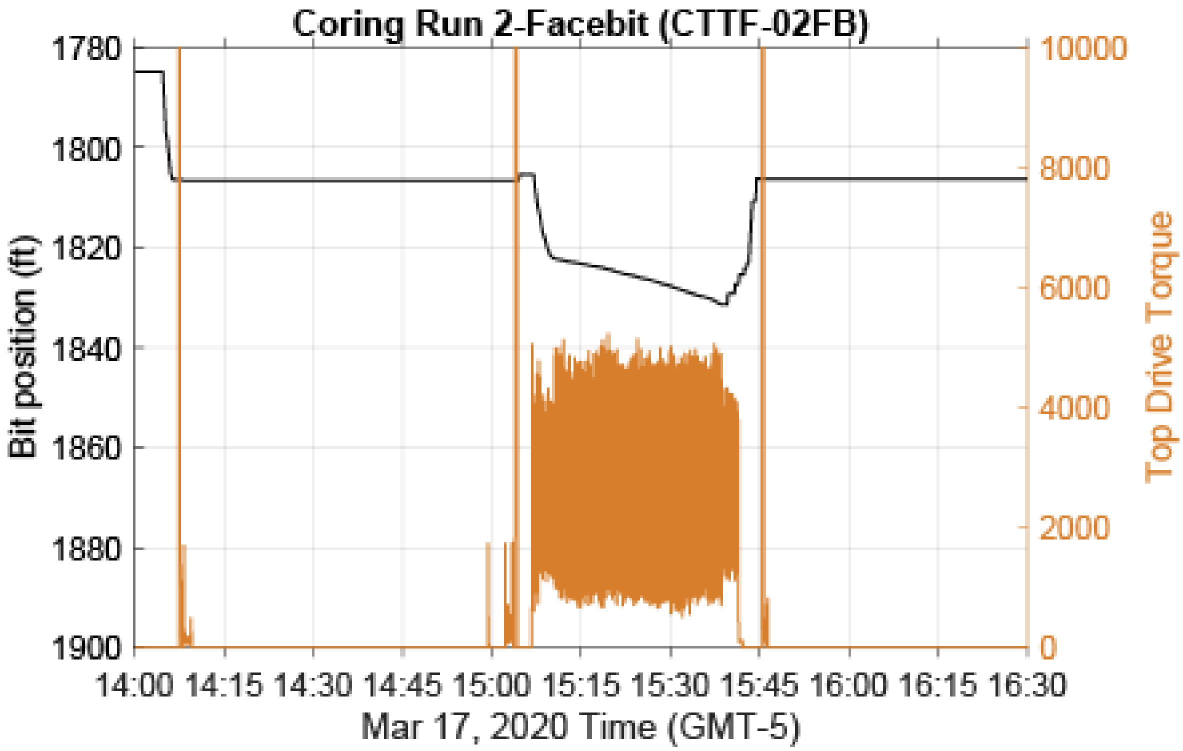


Figure B5. Bit position and top drive torque record for coring CTTF-02FB.

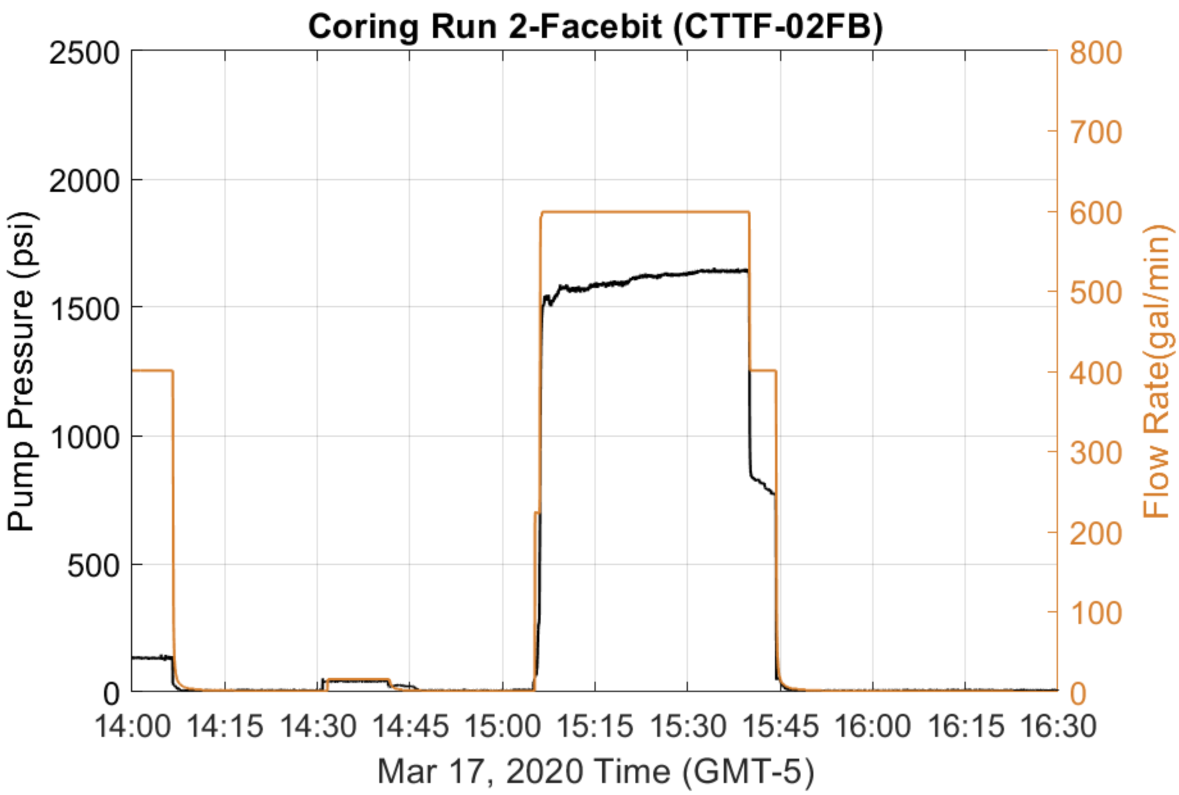


Figure B6. Rig pump pressure and flow rate record for coring CTTF-02FB.

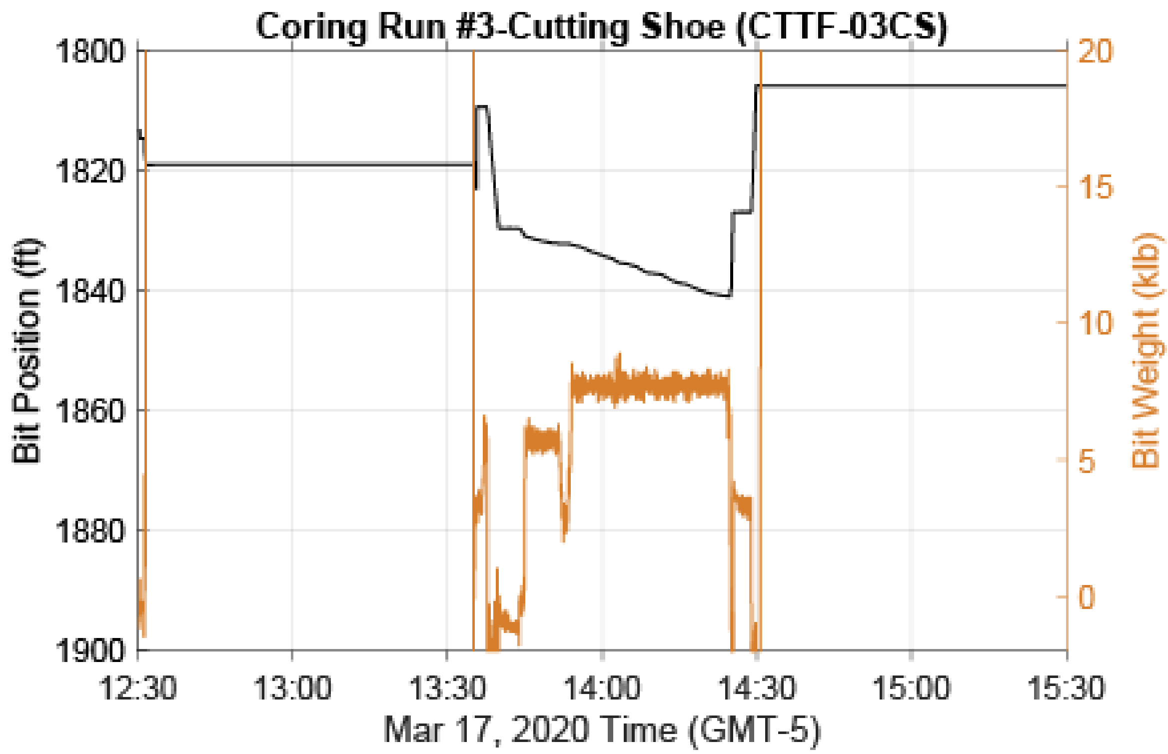


Figure B7. Bit position and bit weight record for coring CTTF-03CS.

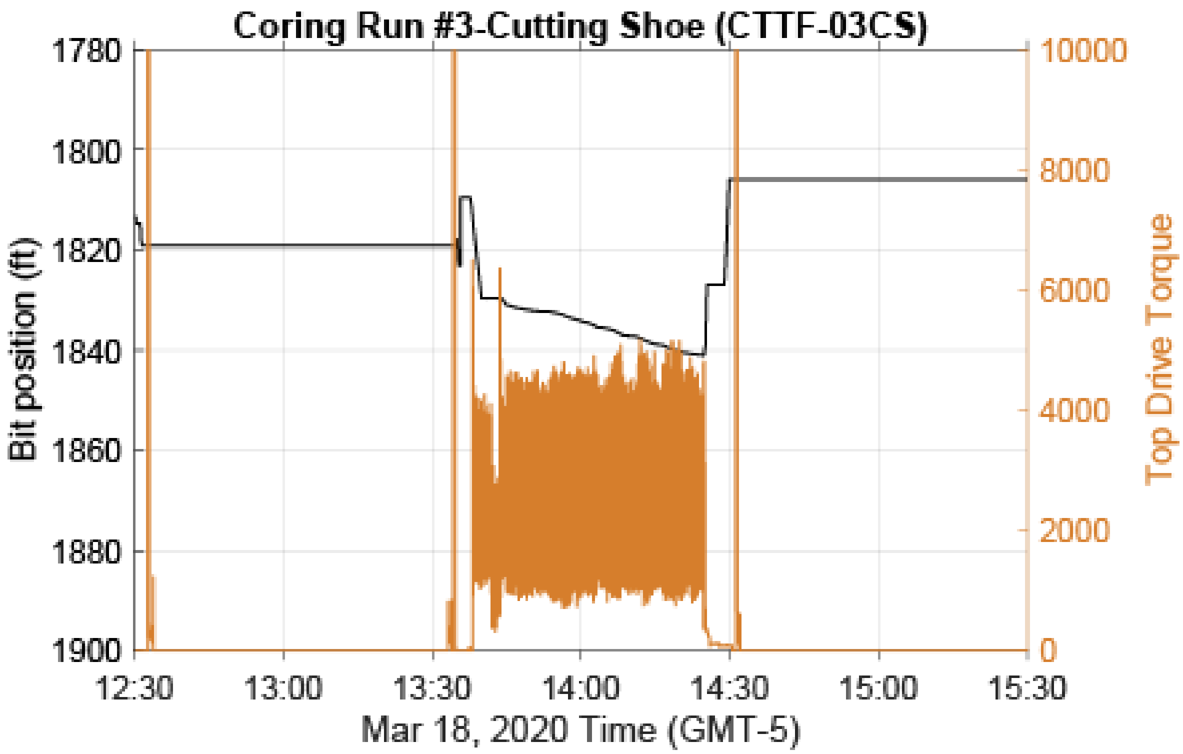


Figure B8. Bit position and top drive torque record for coring CTTF-03CS.

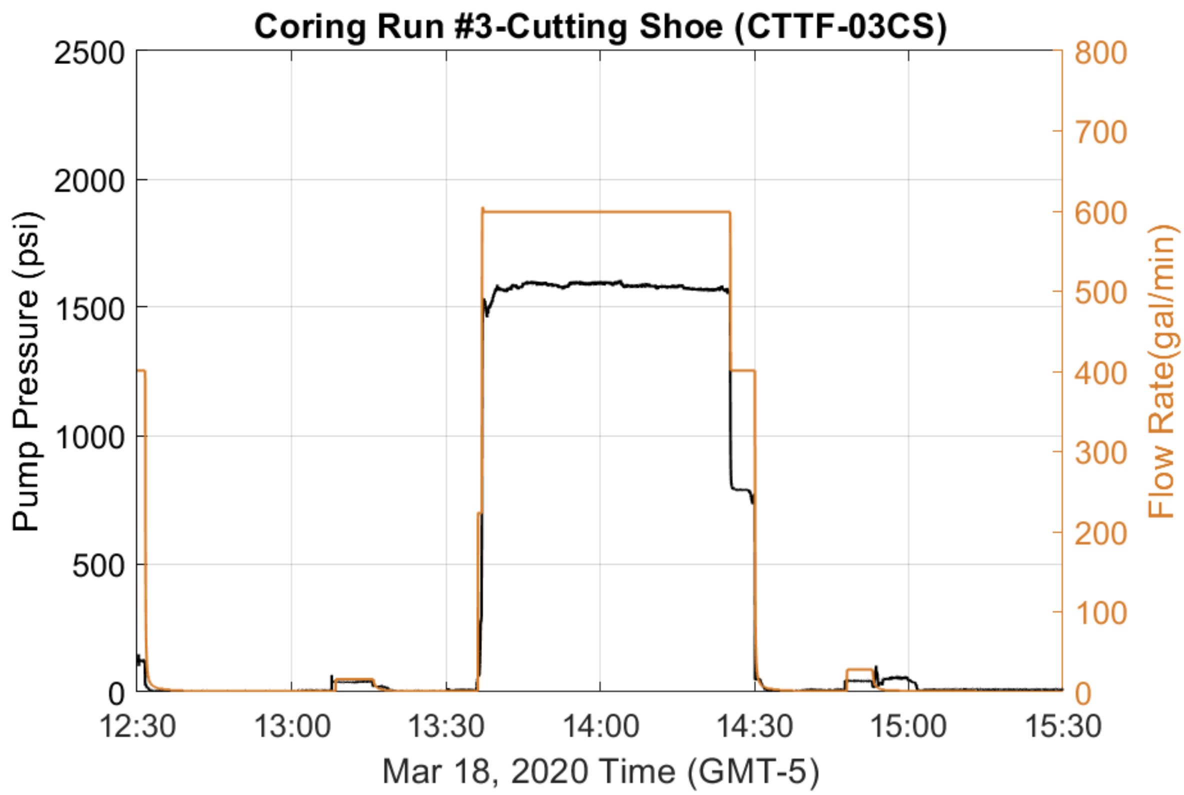


Figure B9. Rig pump pressure and flow rate record for coring CTTF-03CS.

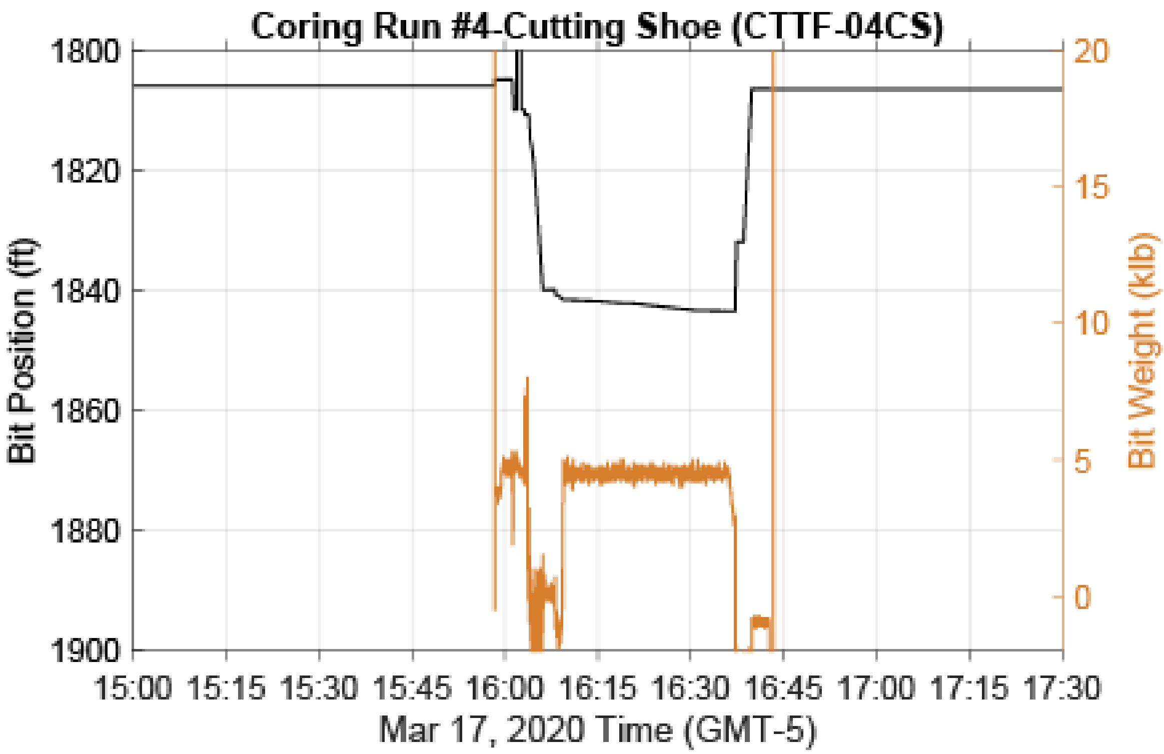


Figure B10. Bit position and bit weight record for coring CTTF-04CS.

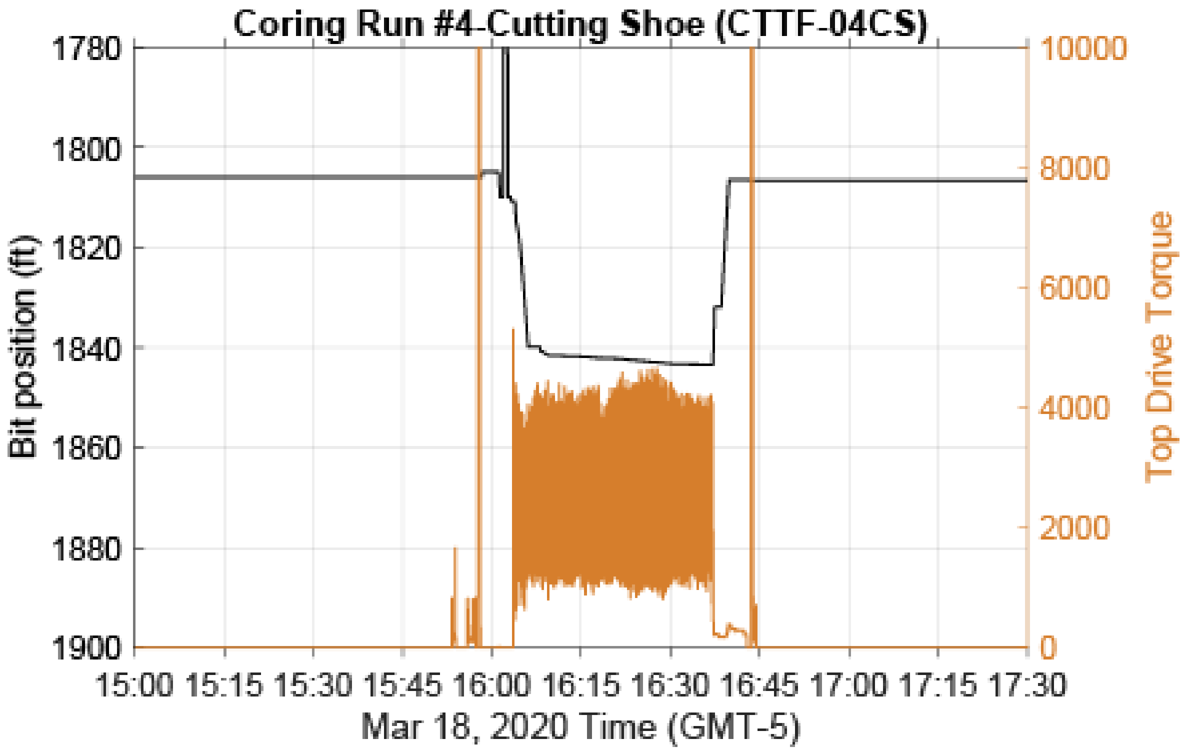


Figure B11. Bit position and top drive torque record for coring CTTF-04CS.

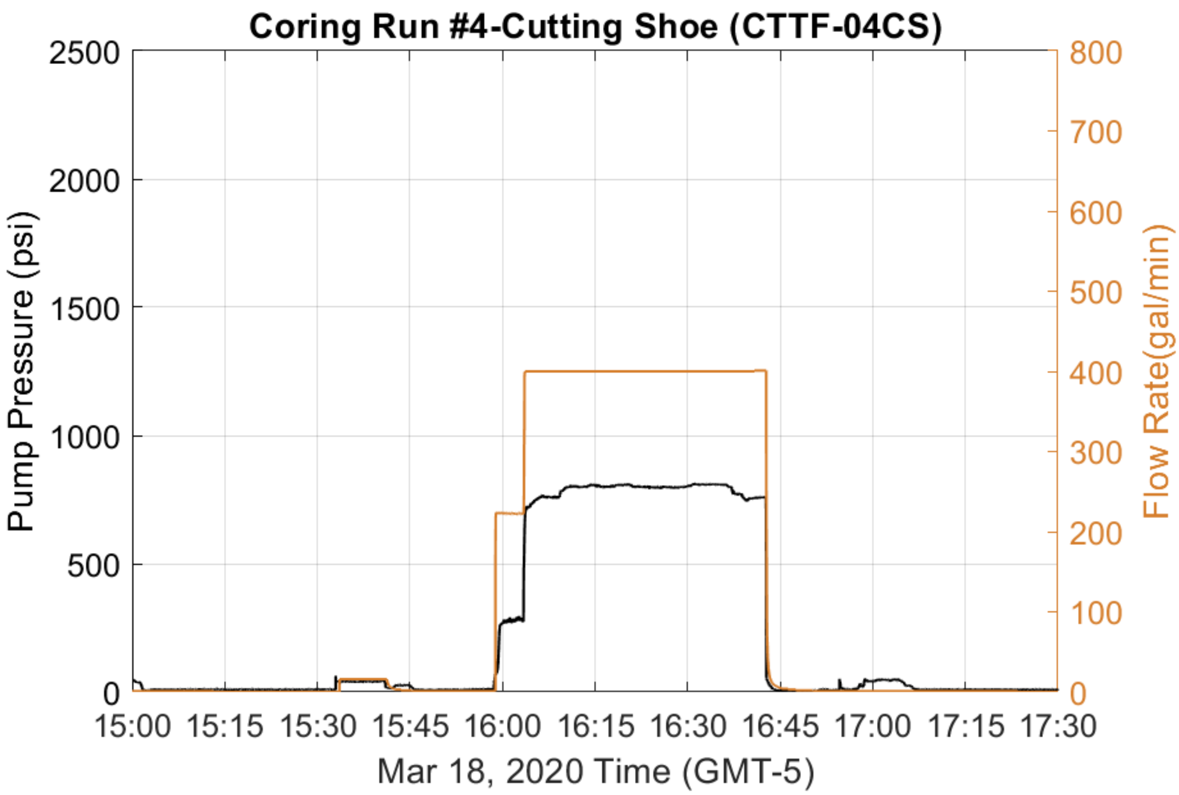


Figure B12. Rig pump pressure and flow rate record for coring CTTF-04CS.

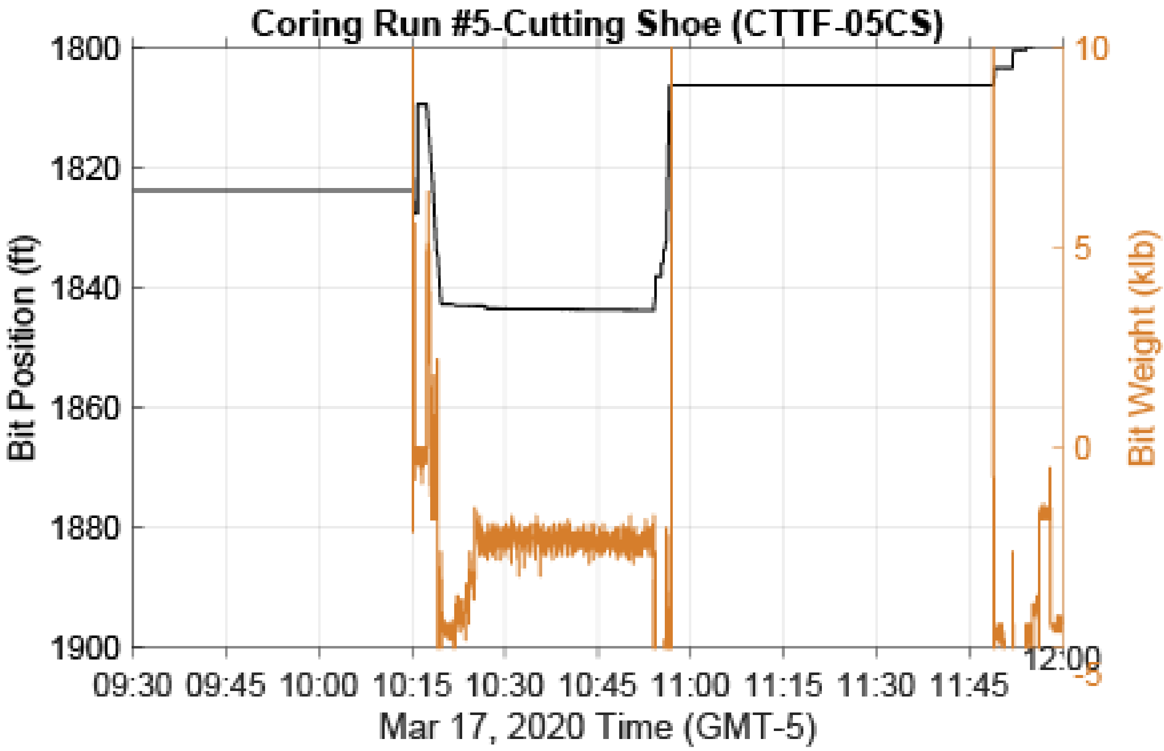


Figure B13. Bit position and bit weight record for coring CTTF-05CS.

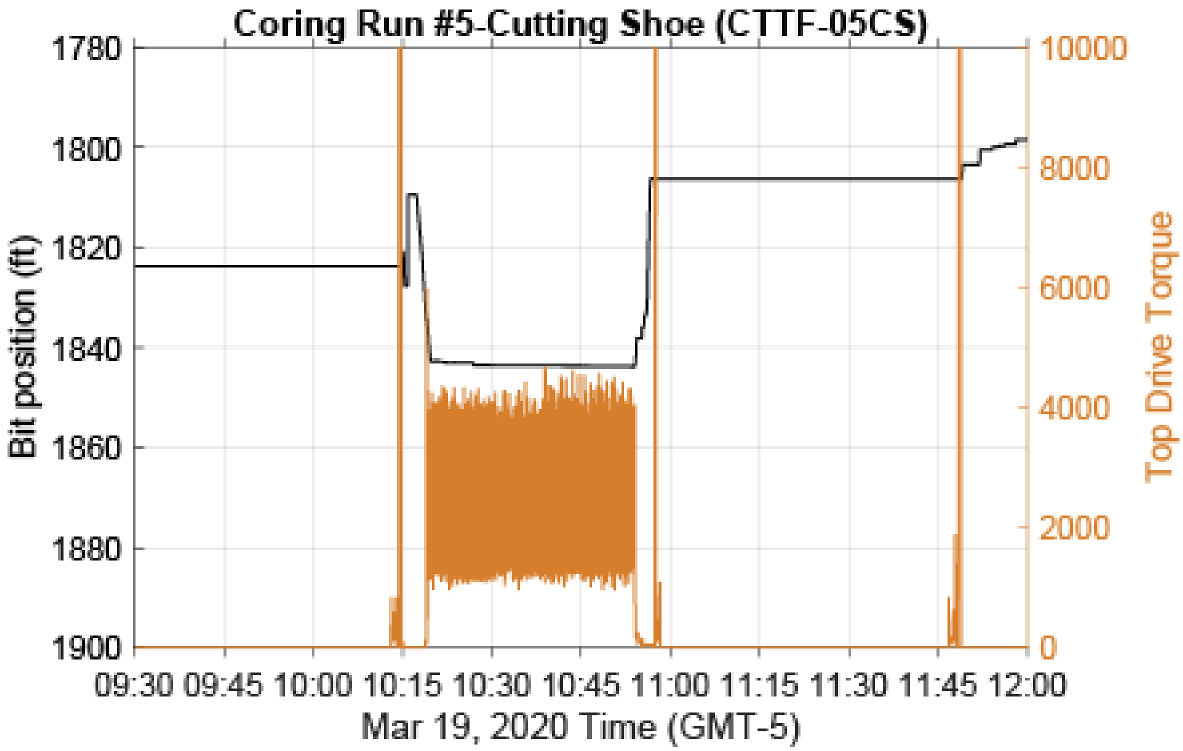


Figure B14. Bit position and top drive torque record for coring CTTF-05CS.

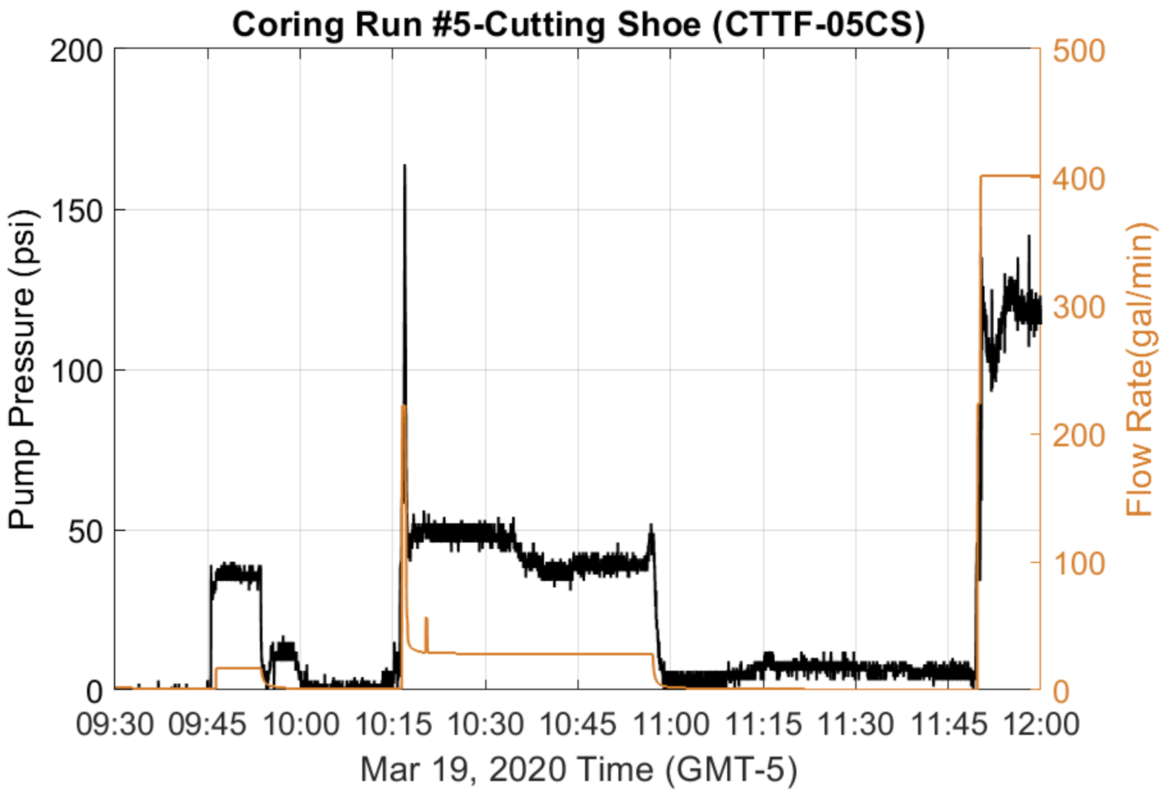


Figure B15. Rig pump pressure and flow rate record for coring CTTF-05CS.

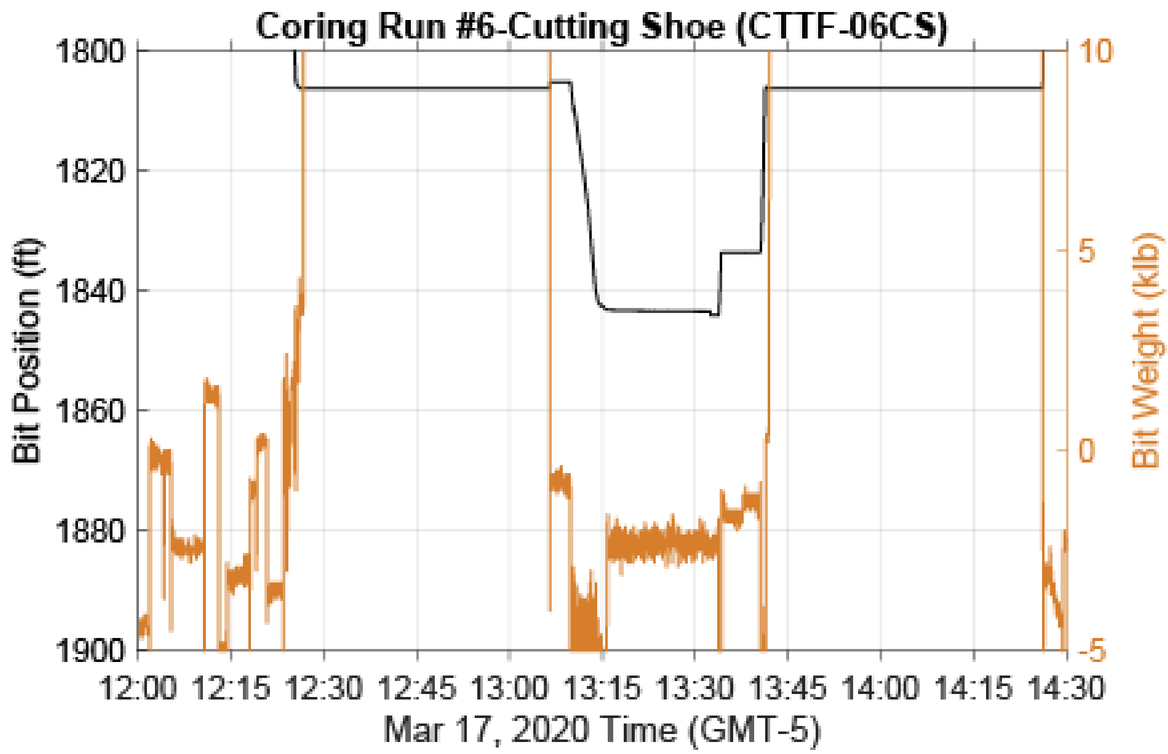


Figure B16. Bit position and bit weight record for coring CTTF-06CS.

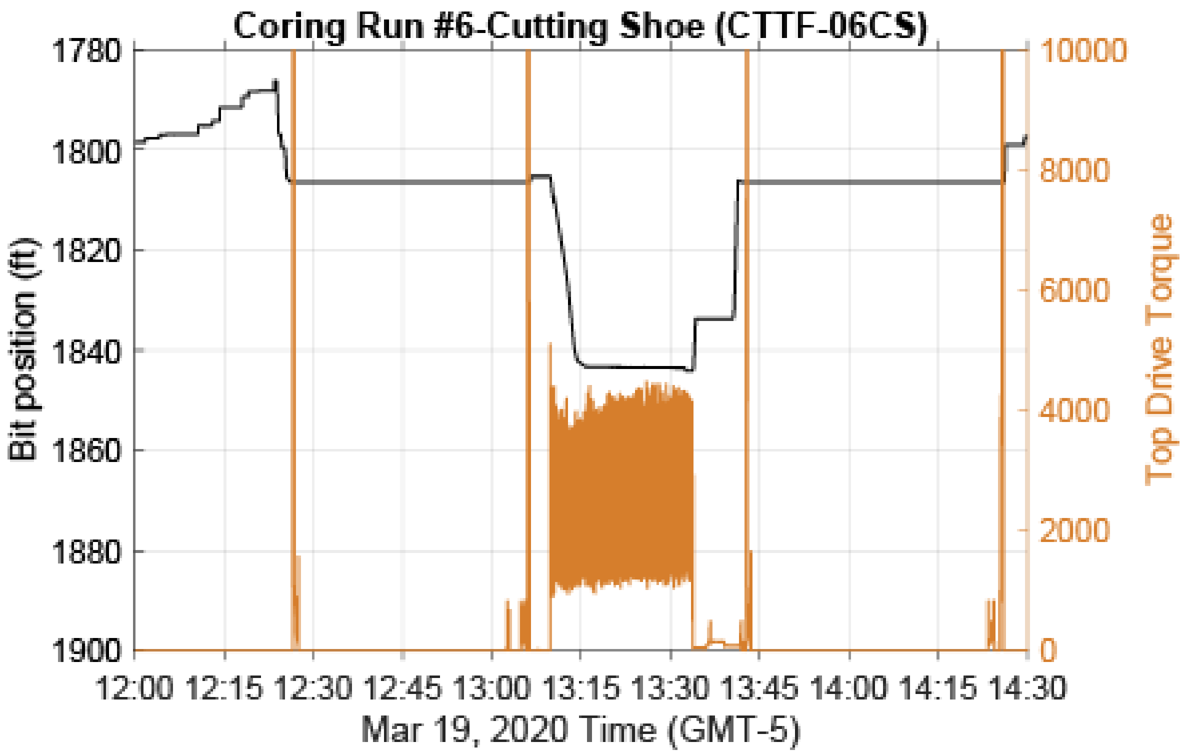


Figure B17. Bit position and top drive torque record for coring CTTF-06CS.

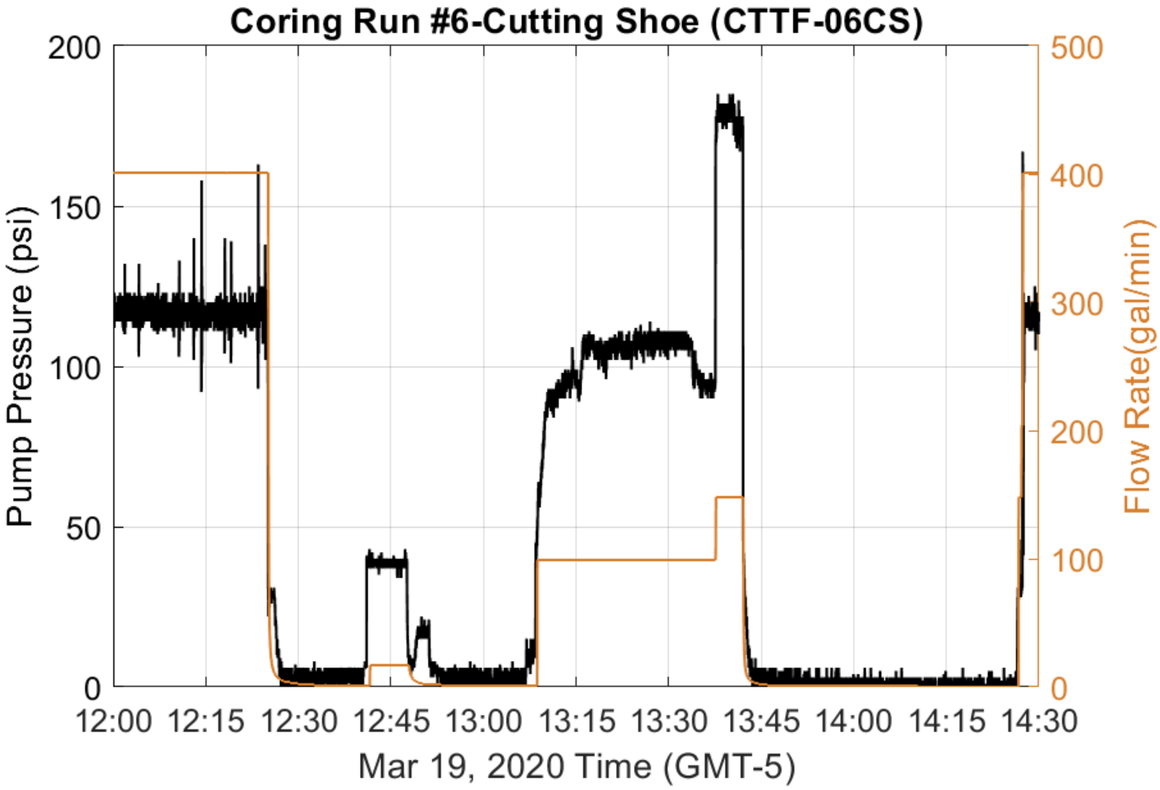


Figure B15. Rig pump pressure and flow rate record for coring CTTF-06CS.

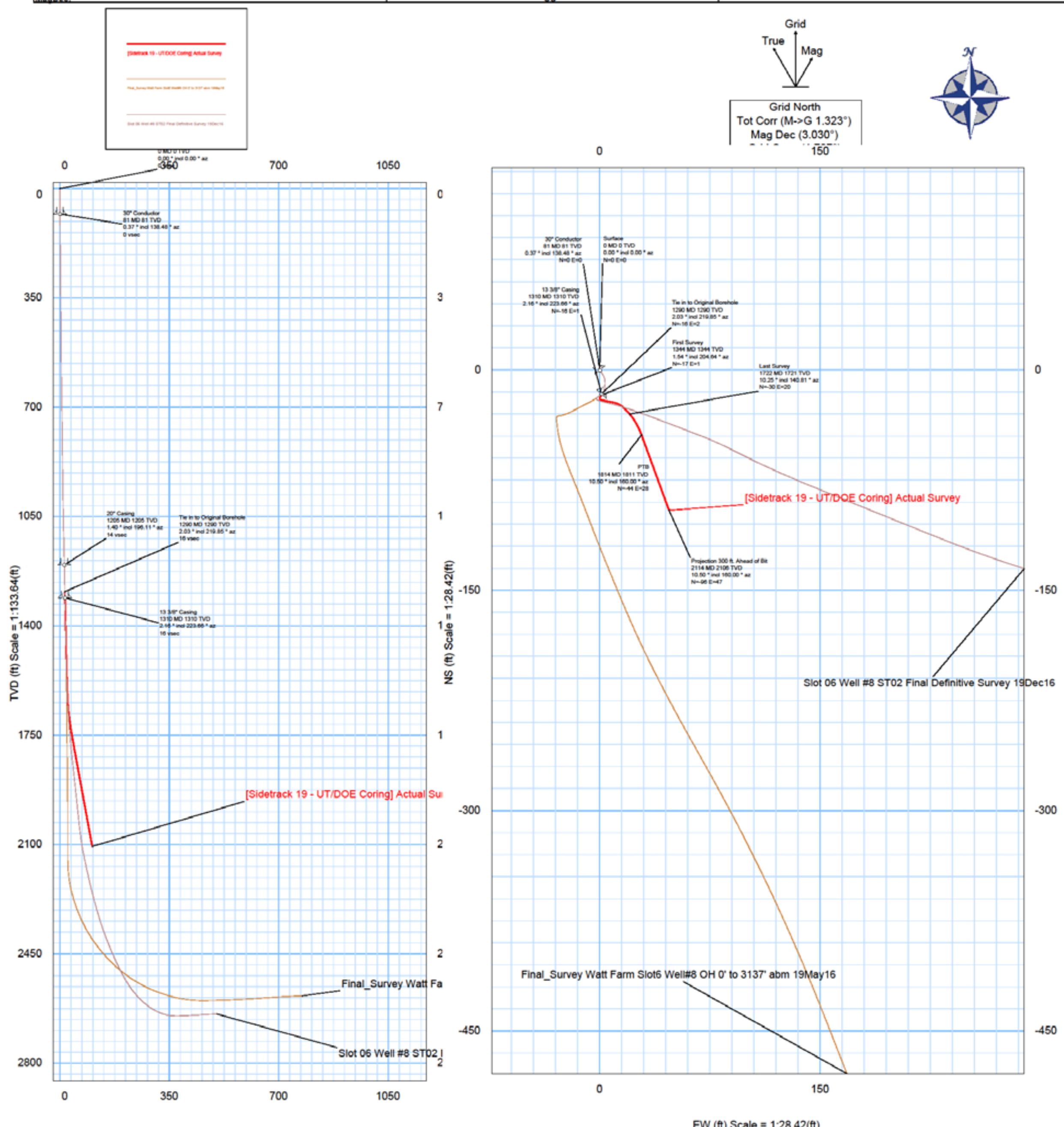
GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX C: Hole Location Information

CORING TOOL TEST

Borehole:	Well:	Field:	Structure:
Sidetrack 19 - UT/DOE Coring	Watt Farm Slot 06 Well #8	Milam County, Texas	SLB OFS Cameron Test Facility

Gravity & Magnetic Parameters	Surface Location NAD83 Texas State Plane, Central Zone, US Feet	Miscellaneous
Model: HDGM 2019 Dip: 59.487° Date: 09-Mar-2020	Lat: N 30 54 19.74 Northing: 10308530.9ft US Grid Conv: 1.7068°	Slot: Slot #6 TVD Ref: RKB(400ft above MSL)
MagDec: 3.03° FS: 47286.734nT Gravity FS: 998.683mgn (9.80665 Based)	Lon: W 97 1 10.37 Easting: 3335651.27ft US Scale Fact: 0.99988314	Plan: [Sidetrack 19 - UT/DOE Coring] Actual Survey



Critical Points								
Critical Point	MD	INCL	AZIM	TVD	VSEC	N(+)/S(-)	E(+)/W(-)	DLS
Marker MudLine	30.00	0.14	138.48	30.00	0.03	-0.03	0.02	0.46
Tie in to Original Borehole	1290.00	2.03	219.85	1289.86	15.82	-15.79	1.79	
First Survey	1344.00	1.54	204.64	1343.83	17.00	-17.18	0.87	1.25
Last Survey	1722.00	10.25	140.81	1720.54	33.51	-29.98	20.44	7.19
PTB	1814.00	10.50	160.00	1811.06	49.08	-44.20	28.48	3.75
Projection 300 ft. Ahead of Bit	2114.00	10.50	160.00	2106.04	103.18	-95.58	47.18	0.00

PART	Seq.	Survey Tool/ Survey Tool Code	Vendor/ Tool	Hole Size (in)	Casing Size (in)	Expected Max Incl (°)	MD From (ft)	MD To (ft)	Survey Frequency (ft)	EOU Size (Semi Major) (ft)	EOU Size (Semi Minor) (ft)	Comments/ Contingency
1	1	SLB_NSG+MSHOT-Depth Only		26	20		0	30	Act Stns	1.086	1.083	
1	2	SLB_NSG+MSHOT		26	20		30	1205	Act Stns	4.252	2.833	
1	3	NAL_NSG+MSHOT		17.5	13.625		1205	1290	Act Stns	4.058	2.434	
1	4	NAL_MWD_1.0_DEG		12.25	9.625		1290	1814	Act Stns	4.196	2.543	
1	5	NAL_MWD_1.0_DEG		12.25	9.625		1814	2114	1/98.425	4.495	3.856	
1	6	NAL_MWD_1.0_DEG		12.25	9.625		2114	2114	Act Stns	4.495	3.856	

GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX D: Core Photos

Appendix D: Core Photos

Figure 0-1 CTTF-01FB from core run 1 (face-bit).

Figure 0-2 CTTF-02FB from core run 2 (face-bit).

Figure 0-3 CTTF-03CS from core run 3 (cutting-shoe).

Figure 0-4 CTTF-04CS from core run 4 (cutting-shoe).

Figure 5 CTTF-04CS from core run 4 (cutting-shoe).

GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX E: Daily Reports

PCTB Land Test 2 Daily Report

Monday, 16 March 2020

PCTB Land Test Daily Report
Monday, 16 March 2020

1) The day began at 0700 with a safety briefing for all newly arrived personnel.
2) Mobilization of the coring service conex and coring tools was resumed and completed.
3) Picking up the drill pipe (singles) was initiated when it was discovered that the 5” elevator rented for the test was too small for the drill pipe. Although 5” drill pipe is being used it is configured for a 5-1/2” elevator so as not to have to change out elevators when running a tapered 5” and 5-1/2” drill string.
4) A rental 5-1/2” elevator was located and delivered to the rig.
5) While waiting for the delivery of the 5-1/2” elevator, the PCTB outer core barrel subassembly was assembled and the coring tools were spaced out.
6) A representative from the wireline company visited the site as a precursor to setting up wireline operations in the morning. All cross over subs required for the wireline packoff unit were located and test fitted.
7) Once the 5-1/2” elevator arrived, the drill collars were picked up and the BHA was assembled and hung off at the rig floor.
8) Picking up the 5” drill pipe (singles) resumed while tripping in the hole with the BHA.

Night Shift Operations Plan

1) The night shift will continue to pick up drill pipe (singles) while tripping in the hole, stopping when the bit reaches the casing shoe at ~1300 ft.
2) 7 stands of drill pipe (triples) will then be made up and racked back in the derrick ready to trip to TD and start coring at 0700 in the morning.
3) No additional drill should have to be picked up to complete the testing.

PCTB Land Test 2 Daily Report

Tuesday, 17 March 2020

OPERATIONAL RESULTS

0700: Daily briefing, safety for all newly arrived personnel and planned operations for the day.

0730: RIH w/pipe from casing shoe at ~1300 ft to TD and circulate.

0800: Rig up wireline.

1030: RIH with core barrel.

1100: Begin cutting core FB-1 @ ~1815.1 ft.

400 gpm

70 rpm

4200 WOB

775 pump pressure

1215: Stop coring @ 1821.7 ft.

RIH to recover core FB-1.

1300: Core FB-1 in service conex.

Pressure = ~2100 psi

Core length = ~5.5 ft

Cored interval = ~6.6 ft.

Note that the core catcher (wedge/spring) stuck to the top of the core and rode up inside the liner with the core.

1415: Pick up core barrel for core FB-2.

1500: Cutting core FB-2

5500 WOB

72 RPM

600 gpm

1590 pump pressure

1545: Stop coring @ 1831.5 ft

RIH w/WL to recover core FB-2

1645: Core FB-2 in service conex.

Ball closed

No retained pressure in autoclave. The autoclave held pressure when pressurized in the service conex prior to opening. The DST recorded a change in hydrostatic pressure as the tool was recovered indicating that the leak was present over the entire trip from TD to the rig floor.

Final reservoir pressure = 1615 psi

Reservoir fill pressure = 8000 psi

Night Shift Operations Plan

1) Pull out of hole to rig floor.

2) Prepare for switching to cutting shoe BHA in morning.

CORE RESULTS:

<u>Coring Test 1 (</u><u>core </u>**CTTF-1FB)**: 6.6 ft of formation were penetrated over 48 minutes. At 11:45, the rate of penetration slowed, it was interpreted that the bit was balling, and we ceased coring 11:52. The ball valve closed, and pressure recorded in the autoclave was 2100 psi.

70"(178 cm) of core was recovered in CTTF-1FB. Core recovery was 91%. The core was largely cylindrical with no marked variations in diameter. The core was predominantly composed of light gray indurated carbonate rich rock. Occasional layers of dark gray to charcoal fissile shale was found One ~15 cm section of almost pure shale was encountered. The core was cut into two sections: CTTF-1FB-1 and CTTF-1FB-2. The sections were photographed, labelled, put back in the core liner and preserved.

Figure 1: Core CTTF-1FB: 1.78 m of core were recovered composed of light grey resistant carbonate and more fissile charcoal colored shale.

<u>Coring Test 2 (</u><u>core </u>**CTTF-2FB)**: Coring advanced the bit from 1821.7-1831.4' MD from 15:00 to 15:34 with 600 gal/min circulation.

2.7 m of core (8.9 ft) of core were recovered resulting in a core recovery of 92%. The core was largely cylindrical with no marked variations in diameter. The core was predominantly composed of light gray indurated carbonate rich rock. Occasional layers of dark gray to charcoal fissile shale was found The core was cut into 3 sections: 1) CTTF-2FB-1: 0-0.90, 2) CTTF-2FB-2: 0.90-1.90 m, and 3)CTTF-2FB-3: 1.90-2.70 m.

Figure 2: Core CTTF-2FB: 2.7 m of core were recovered composed of light grey resistant carbonate and more fissile charcoal colored shale.

PRESSURE AND TEMPERATURE (DST) RESULTS:

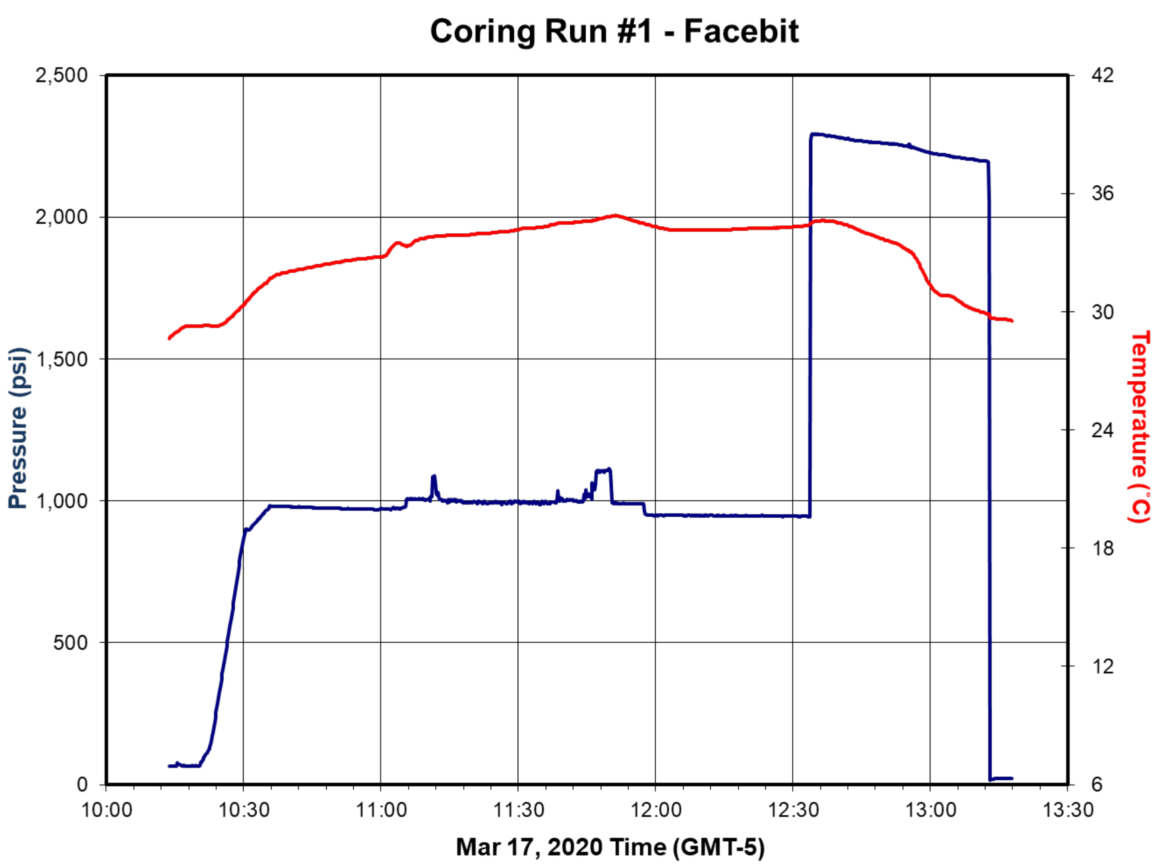


Figure 3: DST pressure and temperature record for **CTTF-1FB**. Boost pressure clearly recorded.

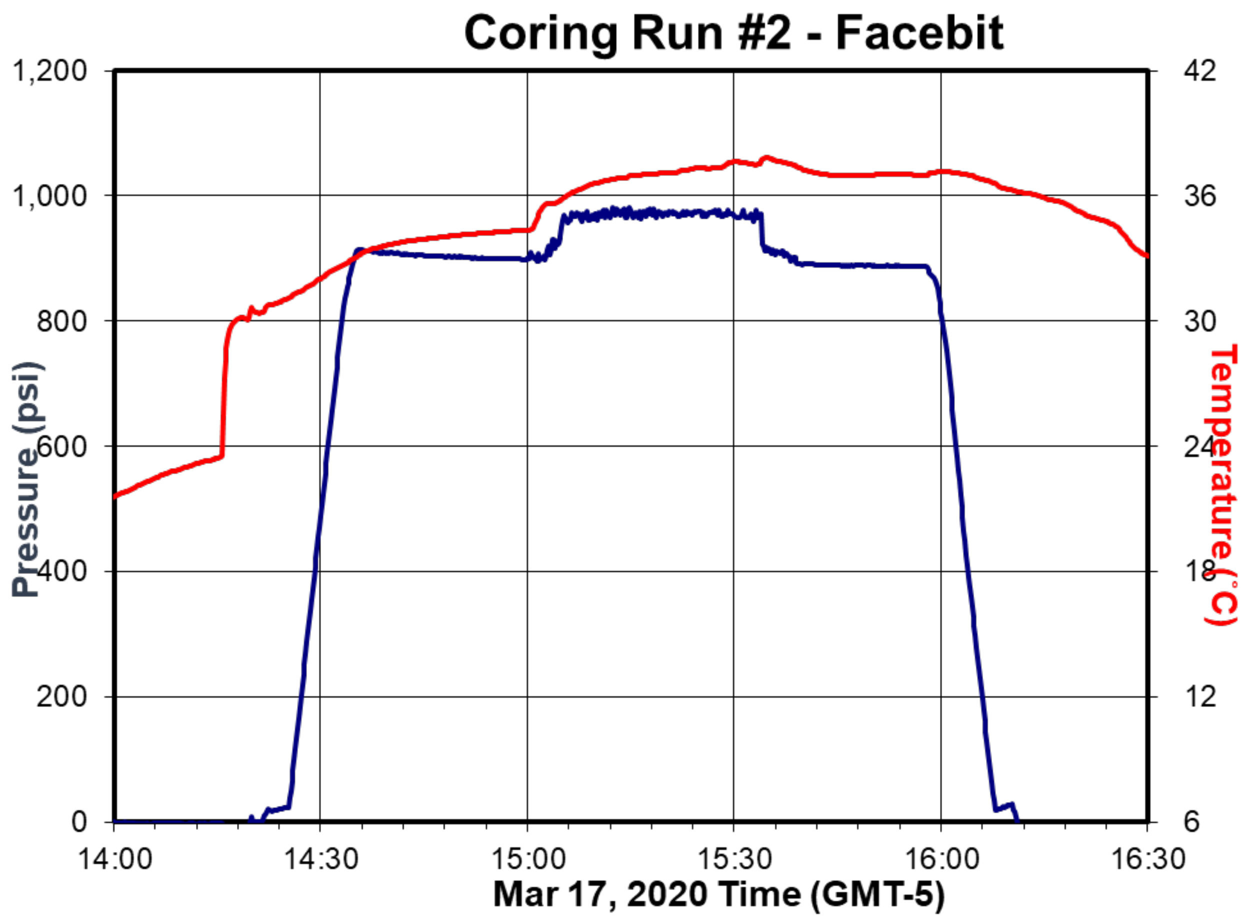


Figure 4: DST pressure and temperature record for **CTTF-2FB**. No boost pressure recorded.

PCTB Land Test 2 Daily Report

Wednesday, 18 March 2020

EXECUTIVE SUMMARY

Two cutting shoe pressure cores were taken. There was ~80% core recovery in both cases. However, in both cases, the ball valve jammed and did not seal. The working interpretation is that high flow rates (400 & 600 gpm) may have driven detritus between the seal carrier and housing, creating enough friction to prevent the ball valve from closing completely. In the next tests, we will reduce the flow rates and determine whether this improves the sealing.

OPERATIONAL RESULTS

0700: Daily briefing, safety for all newly arrived personnel and planned operations for the day.

0730: Make up PCTB-CS BHA. Waiting on assembled PCTB-CS for spacing out in BHA.

0930: Begin spacing out PCTB-CS.

1130: Spacing out complete, RIH w/bit.

1330: Begin cutting core 03CS at 1831.5 ft.

  5500 – 7500 klb WOB

  600 gpm

  70 rpm

  1600 psi

1430: Stop coring core 03CS at 1841 ft, circulate hole, rig up wireline to recover 03CS.

1515: Core 03CS in service conex. Ball jammed partially open.

  No pressure.

  ~7.5 ft of core.

1545: RIH w/04CS to cut 1/2 core.

1615: Begin cutting core 04CS.

  4500 klb WOB

  400 gpm

  70 rpm

  800 psi

1645: Stop cutting core 04CS at 1843.5 ft.

1730: Core 04CS at service conex. Ball valve jammed partially open.

No pressure.

~2 ft of core.

1800: Review test results to date.

Discussion: The ball valve jamming appears to be a result of detritus laden drilling mud migrating upward between the seal carrier and housing, creating enough friction to prevent the ball valve from closing completely. The problem may have been exasperated by the high flow rates used during the testing. The decision was made to employ lower flow rates in additional tests to see if that alleviates the problem.

Night Shift Operations Plan

1) Pull back to shoe.

2) Trip back to TD and circulate for 1 hour just prior to morning shift change.

CORE RESULTS:

Coring Test 3 *(*core CTTF-03CS): Coring advanced the bit from 1831.5 to 1841.0 ft. 9.5 ft of formation were penetrated over 50 minutes. The ball valve did not close, and pressure was not maintained in the autoclave.

114" (290 cm) of core was recovered in CTTF-03CS. Core recovery was 79%. The core was largely cylindrical with no marked variations in diameter. The core was predominantly composed of light gray indurated carbonate rich rock. Occasional layers of dark gray to charcoal fissile shale was found One ~15 cm section of almost pure shale was encountered. The core was cut into three sections: CTTF-03CS-1, CTTF-03CS-2, and CTTF-03CS-3. The sections were photographed, labelled, put back in the core liner and preserved. The core quality was perhaps more broken up than the previous face-bit cores.

Figure 1: Core CTTF-03CS-2: 2.30 m of core were recovered composed of light grey resistant carbonate and more fissile charcoal colored shale.

Coring Test 4 (core CTTF-04CS): Coring advanced the bit from 1841.0-1843.5' MD from 16:00 to 16:34 with 600 gal/min circulation. This core was cut shorter to test the concept that the core length was affecting the ability of ball valve to seal.

0.62 m of core (2.0 ft) of core were recovered resulting in a core recovery of 80%. The core was very good quality and was largely cylindrical with no marked variations in diameter. The core was predominantly composed of light gray indurated carbonate-rich rock. At the top of the core, few layers of dark gray to charcoal shale were found which transitioned to pure limestone. The core was left in one section: 1) CTTF-04CS-1 (0-0.62 m).

Figure 2: Core CTTF-04CS: 0.62 m of core were recovered composed of light grey resistant carbonate and charcoal colored shale.

PRESSURE AND TEMPERATURE (DST) RESULTS:

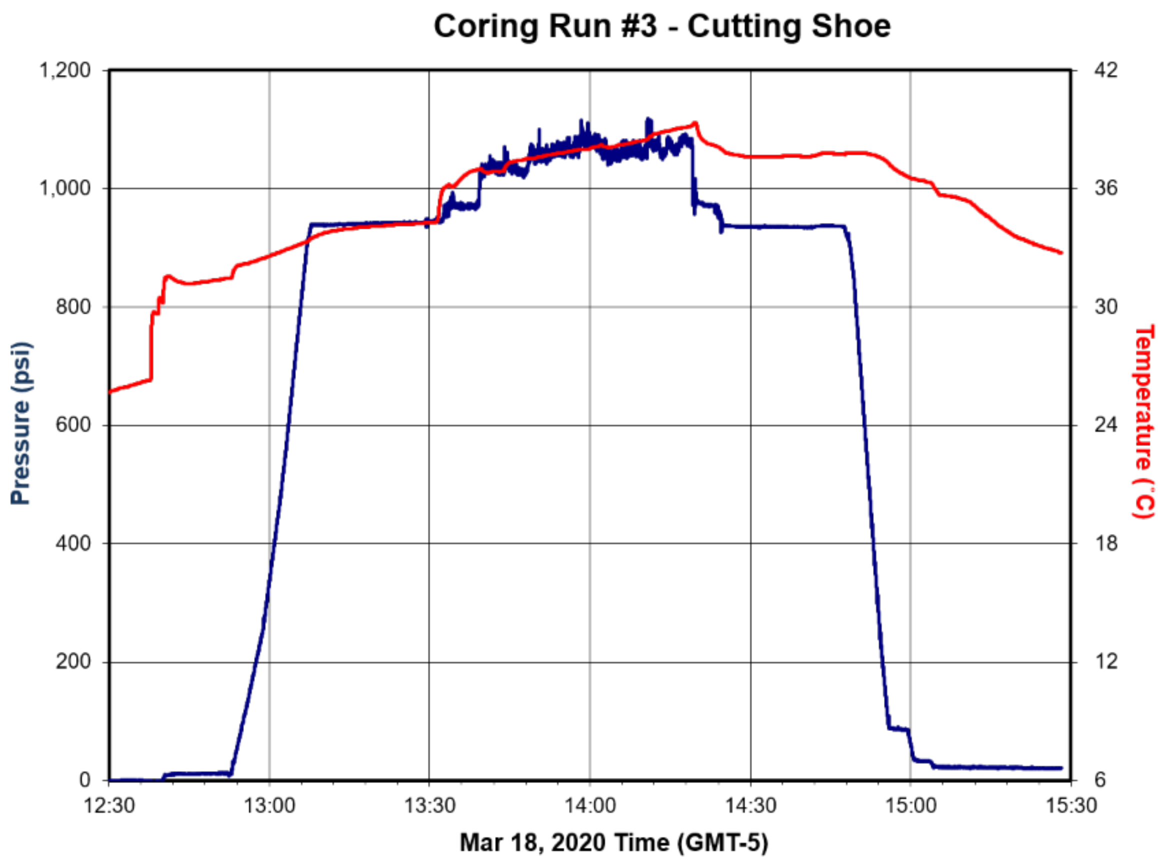


Figure 3: DST pressure and temperature record for **CTTF-03CS**.

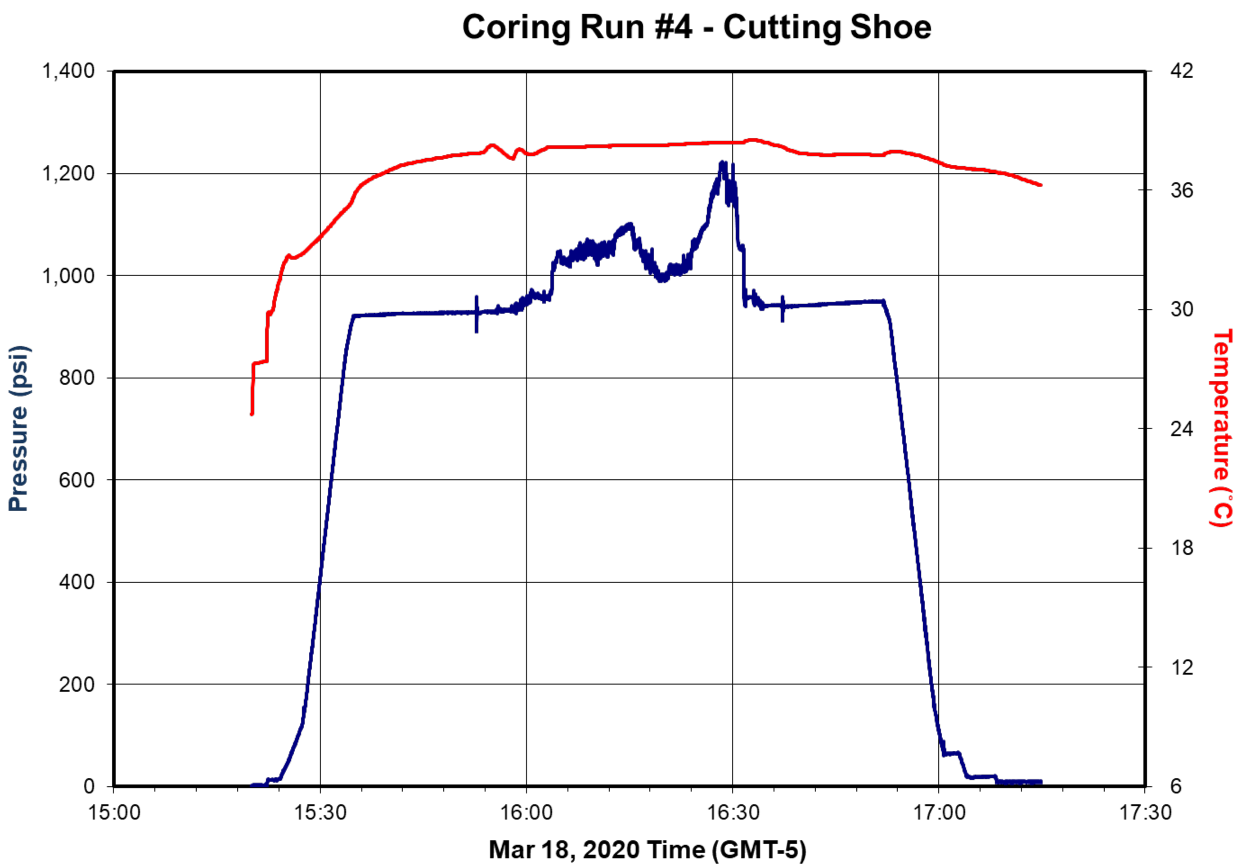


Figure 4: DST pressure and temperature record for **CTTF-04CS**.

PCTB Land Test 2 Daily Report

Thursday, 19 March 2020

EXECUTIVE SUMMARY

Two short cutting shoe pressure cores (e.g. 1 ft') were taken with high recovery. However, the ball valve was partially closed and thus did not seal in either run. The final deployment of the PCTB was to exercise it in the casing without coring (a 'water core'). The ball valve did not fully close. The Probe Deployment Tool (PDT) was then made up and run in the hole. When the tool was lowered on wireline, it unlatched at a depth of 348 ft. The PDT landed in the BHA and was then retrieved without incident. The PDT deployment was unsuccessful.

OPERATIONAL RESULTS

0700: Daily briefing, safety and planned operations for the day.

0730: RIH from shoe to TD and circulate in preparation for CS-3 [renamed CCTF-05CS].

Note, rig shut down due to lightning in the area preventing night crew from tripping to TD and circulating.

0800: Circulating hole.

0900: Pick up core CS-3 [CCTF-05CS].

1020: Begin cutting core CS-3 [CCTF-05CS] at 1843.5 ft.

1.0 WOB

30 gpm

70 rpm

50 psi

1100: Stop coring at 1843.8 ft.

1140: Core CS-3 [CCTF-05CS] at service conex. No pressure. It appears the ball was held partially open by either detritus or a short core stub. ~1 ft of core recovered. DST record shows an attempt to boost the autoclave pressure.

1245: RIH with core CS-4 [CCTF-06CS] at 1843.8 ft.

1315: Start cutting core CS-4 [CCTF-06CS] at 1843.8 ft.

1.0 WOB

100 gpm

70 rpm

100 psi

1335: Stop cutting CS-4 [CCTF-06CS] at 1844.2 ft.

1415: Core CS-4 [CCTF-06CS] at service conex. Ball did not fully close. No pressure.

1600: RIH with CS-5 [CCTF-07CS] Water Core bit at 1235 ft inside casing.

1645: CS-5 [CCTF-07CS] water core at service conex. Ball did not fully close. No pressure.

1815: RIH with Probe Deployment Tool (PDT) to 348 ft when weight was lost.

POOH with RPT only.

RIH with GS pulling tool.

Latch into PDT and recover. PDT stoked out when recovered.

2000: All tools laid out on cat walk. Shut down for the night.

Night Shift Operations Plan

1) POOH, lay out drill pipe.

Figure 1: Image of a partially closed ball valve.

Figure 2: The Probe Deployment Tool (PDT) after it is made up prior to running in the hole.

CORE RESULTS:

<u>Coring Test 5</u> (core **CTTF-05CS**): Coring advanced the bit from 1843.5 to 1843.8 ft. 0.3 ft of formation were penetrated over 45 minutes. The ball valve did not close, and pressure was not maintained in the autoclave.

7" (18 cm) of core was recovered in CTTF-05CS. The core was largely cylindrical with no marked variations in diameter. The core was predominantly composed of light gray indurated carbonate rich rock. One 4 cm layer of dark gray to charcoal fissile shale was found. The core was photographed, labelled, put back in the core liner and preserved. The core quality is very good.

Figure 3: Core CTTF-05CS-1: 0.18 m of core were recovered composed of light grey resistant carbonate and more fissile charcoal colored shale.

<u>Coring Test 6</u> (core **CTTF-06CS**): Coring advanced the bit from 1843.8 to 1844.2 ft. 9.5 ft over 20 minutes. No core was recovered.

<u>Coring Test 7</u>: No core was taken in this coring test. A 'Water Core' was taken at 1235 ft inside casing.

PDT & T2P RESULTS:

The Probe Deployment Tool (PDT) is a device designed to land into the BHA. Upon landing it unlatches the inner rod subassembly allowing the probe to be driven by either the weight of the rod, or pump pressure, into the formation. At that point, the probe is independent of the drill string, which compensates for any residual heave. We deployed the PDT with the BHA at 1235 ft inside casing. We began to build the tool at 17:00. We started to run the tool at 18:00. The tool was lost at 348 ft as recorded by a dramatic reduction in weight on the slickline. A large banging noise was heard which was interpreted to record the impact of the PDT when it rested in the BHA. The tool was quickly recovered with the GS pulling tool. When recovered, the tool was extended: the inner rod subassembly was run out from the outer barrel. Upon recovery, the very tip of the probe was snapped off (1cm), but there was no other apparent damage. No data were recorded by the probe tool.

PRESSURE AND TEMPERATURE (DST) RESULTS:

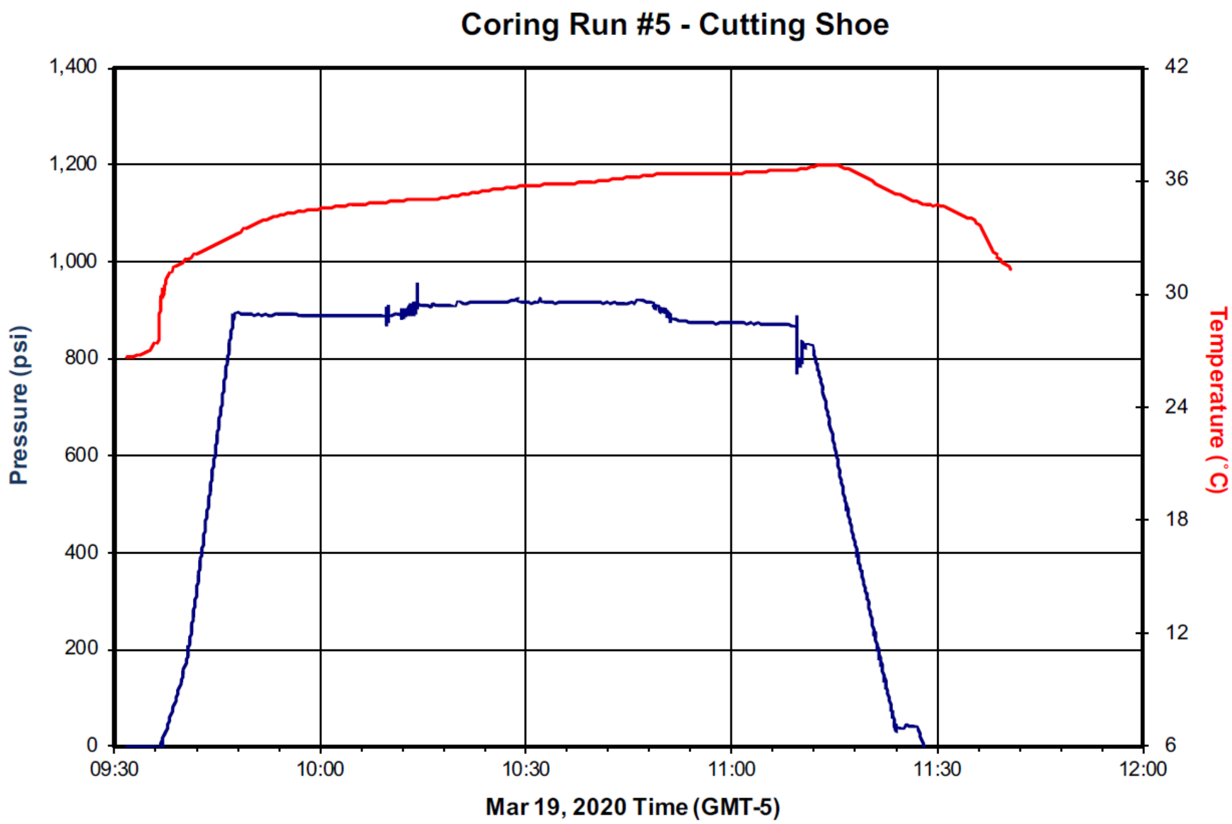


Figure 4: DST pressure and temperature record for **CTTF-05CS**.

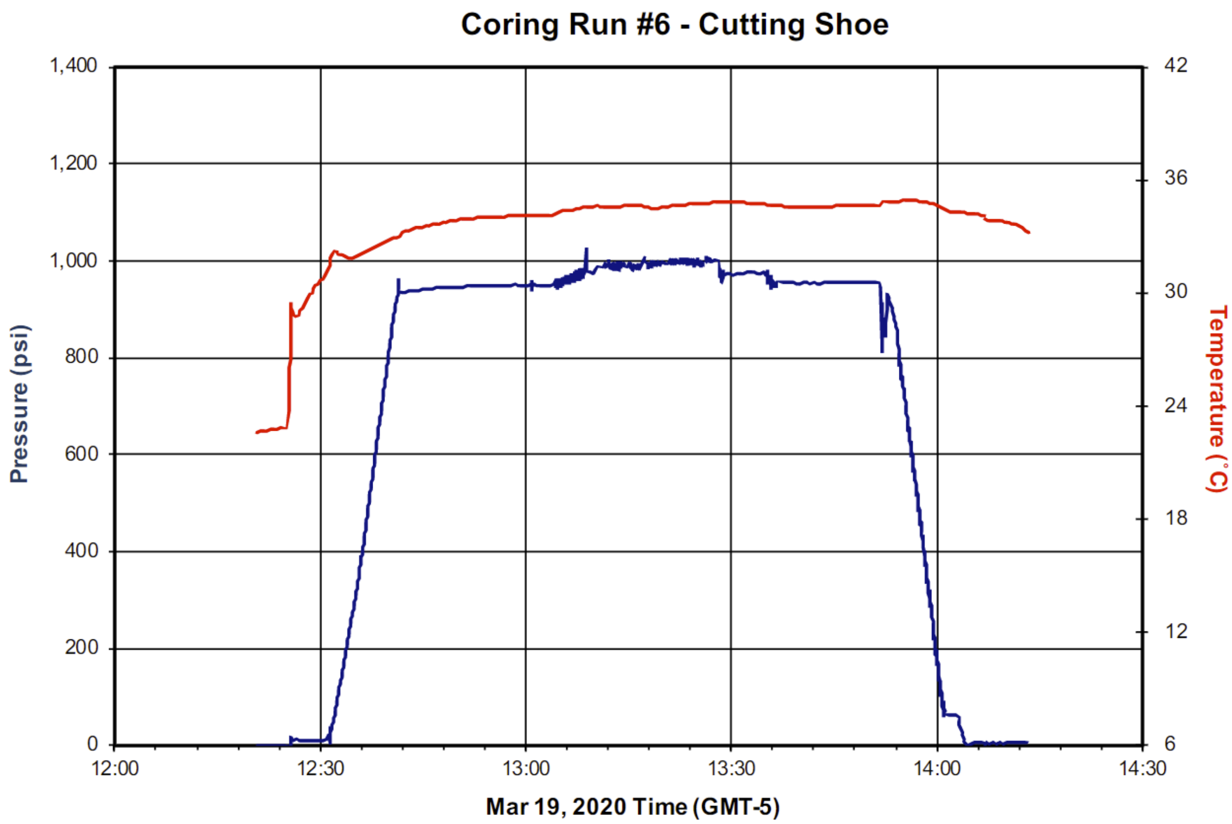


Figure 5: DST pressure and temperature record for **CTTF-06CS**.

Figure 6: DST pressure and temperature record for **CTTF-07CS**. (not yet available)

PCTB Land Test 2 Daily Report

Friday, 20 March 2020

0000: Lay out drill pipe in singles to pipe racks (night shift).

0700: Daily briefing, safety and planned operations for the day.

0730: Break down BHA and lay out to catwalk.

Disassemble PDT and RPT and place in shipping crate.

Disassemble PCTB coring tools and place in service conex.

1300: Load all drill collars and BHA subs into heavy tools conex.

Load PCTB outer core barrel subassembly in service conex.

1500: Load heavy tools conex on flatbed truck for shipment to GCI in Salt Lake City.

Load service conex on flatbed truck for shipment to GCI in Salt Lake City.

Load PDT/RPT crate on trailer for shipment to Pettigrew Engineering.

1600: All trucks depart CTTF.

Note: The drill pipe was loaded out and shipped from CTTF to Texflo on Monday, 23 March and from Texflo back to Tuboscope on Thursday, 26 March.

GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX F: IADC Report

Activity Log

Operator	Schlumberger / CTTF	Well	watts Slot 3
Contractor	Falcon Wireline	Rig #	Explorer

Date	From	To	Elapsed Time	Code No.	Details of Operation in Sequence and Remarks
2020-03-16	07:00	07:15	0.25	21	Safety meeting slot 6 GeoTek
2020-03-16	07:15	08:00	0.75	22	Start up rig, inspect equipment
2020-03-16	08:00	09:45	1.75	22	Swap out saver sub to6 5/8 reg connection, orientate temp hands to location.
2020-03-16	09:45	10:30	0.75	20	MOve pipe over and strap.
2020-03-16	10:30	11:00	0.50	22	Pick up 5" pipe for test group
2020-03-16	11:00	11:15	0.25	22	Elevators not fitting properly upset on the pipe is larger. Make call to get elevators out
2020-03-16	11:15	16:30	5.25	22	Wait on larger elevators, organize rig floor tool box and rig floor area,complete the stand in the rotary and rack back, double check makeup and breaking equipment. Make up BHA
2020-03-16	16:30	17:00	0.50	22	Offload elevators and continue working on BHA
2020-03-16	17:00	19:00	2.00	22	Pick up collars and drill pipe
2020-03-17	19:00	19:15	0.25	21	meeting slot 6 Geotek
2020-03-17	19:15	20:00	0.75	22	tally pipe, go over tally
2020-03-17	20:00	20:30	0.50	6	rack back 7 stds
2020-03-17	20:30	23:00	2.50	6	pick up pipe off the catwalk
2020-03-17	23:00	07:00	8.00	23	scrub and wash rig floor, oranize rig floor,Rig up 2" hose on Stand Pipe, pick up boards laying in the gravel area, pick up tools laying in the gravel area, gerenal house keeping
2020-03-17	07:00	07:15	0.25	21	Safety meeting GeoTek slot 6
2020-03-17	07:15	08:00	0.75	20	Build tools for coring
2020-03-17	08:00	08:30	0.50	6	TIH to 1815'
2020-03-17	08:30	09:15	0.75	5	Break circulation and circulate bottoms up
2020-03-17	09:15	10:30	1.25	1	Rig up wir line and running tools
2020-03-17	10:30	10:45	0.25	22	Set core tool in string, flow with 15gpm to set tool
2020-03-17	10:45	11:00	0.25	1	Rig down wire line
2020-03-17	11:00	12:00	1.00	4	Start core test with 400 gpm, 70 rpm, 6-8k wob, core F/1815' T/1821'

Activity Log

Operator	Schlumberger / CTTF	Well	watts Slot 3
Contractor	Falcon Wireline	Rig #	Explorer

Date	From	To	Elapsed Time	Code No.	Details of Operation in Sequence and Remarks
2020-03-17	12:00	13:00	1.00	22	Rack back stand and retrieve coring tool
2020-03-17	13:00	14:00	1.00	5	Pump sweep while test group readies next tool
2020-03-17	14:00	14:30	0.50	1	Rig up set tool
2020-03-17	14:30	15:00	0.50	22	Set tool in with wire line
2020-03-17	15:00	15:15	0.25	6	Rig down wire line and TIH to start core
2020-03-17	15:15	15:45	0.50	4	Start coring @ 1821' with 600 gpm, 70 rpm, stopped @ 1831'
2020-03-17	15:45	16:30	0.75	22	Rack back 1 stand amd retrieve coring tool
2020-03-17	16:30	18:00	1.50	5	Circulate and rebuild core tool
2020-03-17	18:00	19:00	1.00	6	POOH
2020-03-18	19:00	19:15	0.25	21	meeting slot 6 Geotek
2020-03-18	19:15	07:00	11.75	22	equipment inspection, lockout tagout mixing pump one, remove mixing centrifugal pump one, centrifugal is different size impeller, install two eight inch new butterfly valves to mixing line due to wash out, pressure up lines for leaks, wash mud house floor due to mud from removing centrifugal pump one, swap out 2" inch air line hose on rig floor that feed to derrick board, clean hand rails on stair towers, take out trash, gerenal house keeping
2020-03-18	07:00	07:15	0.25	21	Safety meeting GeoTek Slot 6
2020-03-18	07:15	10:45	3.50	20	Swap out bit , inter core assembly and adjust assembly
2020-03-18	10:45	11:30	0.75	6	TIH
2020-03-18	11:30	12:45	1.25	5	CONDITION MUD & CIRCULATE
2020-03-18	12:45	13:00	0.25	20	Rig up coring tool and wire line
2020-03-18	13:00	13:30	0.50	22	Run core tool in with wireline and set in bit.
2020-03-18	13:30	13:45	0.25	6	Latch core stand and begin to core
2020-03-18	13:45	14:30	0.75	4	Start coring @1831' core T/ 1841'
2020-03-18	14:30	15:15	0.75	6	Rack back stand and retrieve coring tool
2020-03-18	15:15	16:00	0.75	20	Swap coring tools and set new coring tool down hole
2020-03-18	16:00	16:45	0.75	4	Start coring @ 1841' @ 400gpm, 68 rpm, 6k on bit. Stop coring @

Activity Log

Operator	Schlumberger / CTTF	Well	watts Slot 3
Contractor	Falcon Wireline	Rig #	Explorer

Date	From	To	Elapsed Time	Code No.	Details of Operation in Sequence and Remarks
					1843.50'
2020-03-18	16:45	17:30	0.75	22	Retrieve coring tool and rig down wire line
2020-03-18	17:30	17:45	0.25	6	POOH to shoe
2020-03-18	17:45	19:00	1.25	22	Organize rig floor, housekeeping
2020-03-19	19:00	19:15	0.25	21	meeting
2020-03-19	19:15	03:45	8.50	22	equipment inspection, clean and organize tool box on rig floor, swap damage pressure washer hose, clean and organize and pressure wash rig floor, pressure wash stair tower, put togehter centrifugal pump back together to casing, place centrifugal in place for welder to get measurements, put damage centrifugal on pallet ready for ship out for repairs, swap pressure sensor on stand pipe, scrub and clean restroom due to bad odor, gerenal house keeping
2020-03-19	03:45	04:15	0.50	22	Adverse Weather (Lightning 3.7 Miles)
2020-03-19	04:15	05:45	1.50	22	General House Keeping
2020-03-19	05:45	06:15	0.50	22	Adverse Weather (Lightning 4.4 Miles)
2020-03-19	07:00	07:15	0.25	21	Safety meeting GeoTek slot 6
2020-03-19	07:15	07:45	0.50	22	Start up rig , inspect equipment
2020-03-19	07:45	08:00	0.25	6	TRIPSTIH
2020-03-19	08:00	09:30	1.50	5	CONDITION MUD & CIRCULATE
2020-03-19	09:30	09:45	0.25	20	Rig up coring tools and wire line
2020-03-19	09:45	10:15	0.50	22	Set coring tools down hole
2020-03-19	10:15	10:45	0.50	4	CORINGStart coring @ 1845' with 30gpm, 2k on bit, 70 rpm, cored less than 1/2 a foot
2020-03-19	10:45	11:45	1.00	6	Rack back a stand and retrieve coring tool
2020-03-19	11:45	12:30	0.75	5	CONDITION MUD & CIRCULATE, pump sweep
2020-03-19	12:30	13:30	1.00	4	Start test @ 1843' with 68rpm, 3k on bit, 100gpm
2020-03-19	13:30	14:30	1.00	6	Rack back stand and rig up wire line and retrieve tool
2020-03-19	14:30	15:00	0.50	5	CONDITION MUD & CIRCULATE

Activity Log

Operator	Schlumberger / CTTF	Well	watts Slot 3
Contractor	Falcon Wireline	Rig #	Explorer

Date	From	To	Elapsed Time	Code No.	Details of Operation in Sequence and Remarks
2020-03-19	15:00	15:15	0.25	6	POOH to shoe
2020-03-19	15:15	16:15	1.00	20	Run core tool down hole with wire line to set
2020-03-19	16:15	16:30	0.25	20	Retrieve tool
2020-03-19	16:30	16:45	0.25	1	Rig down core tool and P/U new test tool
2020-03-19	16:45	18:00	1.25	22	Preping for next run
2020-03-19	18:00	18:15	0.25	22	Pick up last tool for testing
2020-03-19	18:15	18:30	0.25	22	Insert running tool in pipe, running tool came unlatch at 348'
2020-03-19	18:30	18:45	0.25	22	Pick up over shot for fishing tool out of pipe, run tool in and latch tool
2020-03-19	18:45	19:00	0.25	22	Overshot is at surface fishing attemp was successful, lay down tools

GOM2 PRESSURE CORING TOOL WITH BALL VALVE (PCTB) LAND TEST 2020 REPORT

APPENDIX G: Geotek report

PRESSURE CORING TOOL WITH BALL VALVE (PCTB)

2020 FIELD TEST

GEOTEK CORING INC.

DOCUMENT NO.

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ISSUE	REPORT STATUS	PREPARED	APPROVED	DATE
1	Released	MM/MS/AB	JR/PS	04/20/20

TABLE OF CONTENTS

1 2020 PCTB 4 FIELD TESTING

1.1 PREVIOUS TESTING SUMMARY

1.1.1 *2020 PRE-GOM3 PRESSURE ACTUATION TESTING SUMMARY*

In January 2020, the Geotek Test Facility at SLC was used to test several modifications to the PCTB4, including:

- low-friction coatings for moving latch parts
- an updated single trigger mechanism
- a lower-force IT plug shear pin
- new lip seals for the flow diverter
- a higher-volume pressure section.

The purpose of this testing is to vet the modifications, as noted above, made to the final PCTB4 specification. Additionally, the parts were assembled in random sets to ensure compatibility and interchangeability amongst the assemblies, as well as be interchangeable with both *Upper Assemblies*. It had been previously postulated that drilling mud might cause problems with the correct operation of the tool. Consequently half of the tests were conducted with clean water as in previous tests with the other half using viscous drilling mud.

2 2020 FIELD TEST GOALS & PURPOSE

Testing at the Cameron Test & Training Facility was carried out with the intent of proving the functionality of the modified PCTB4 in a drilling environment.

Testing would be performed with the following variables not available during the previous testing at SLC:

- travel up and down the drill pipe
- coring in a rock formation (and producing the associated cuttings)
- using filtered and recirculated drilling fluid.

3 TEST RESULTS

3.1 TESTING RUN DATA

TEST	SET (PSI)	FILL (PSI)	BOTTOM HOLE DEPTH (FT)	BOTTOM HOLE PRESSURE (PSI)	PCTB SEAL PRESSURE (PSI)	CORE RECOVERY (FT)	CORE RECOVERY (%)
1FB	1856	8060	1822	980	2128	5.5	82
2FB	1821	8034	1832	985	0	9.0	90
3CS	1807	7920	1841	990	0	7.5	75
4CS	1802	7955	1843	991	0	2.0	80
5CS	1863	8163	1844	991	0	0.8	100
6CS	1786	7995	1844	991	0	0.3	83
7CS	1895	7914	1180	639	0	N/A	N/A

Table 1. CTTF Testing Summary

3.1.1 *1FB*

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1815.0 ft. to 1821.7 ft., using 6000 lbs. weight on bit and circulating drilling fluid at 400 gpm. This produced a rate of penetration of approximately 9 ft. per hour. The tool was pulled from the hole at 2100 lbs. and unlatched smoothly.

The tool appeared normal in all regards and was taken to the service van for pressure check. The pressure transducer read 2128 psi, showing full pressure capture plus boost to within 15% of set pressure.

The sample was removed from the tool and was found to be a rock core 5.5 ft. in length.

Result: Successful test

Failure mode: None

Corrective action: None

Figure 1. Core recovered during coring run 1FB.

3.1.2 *2FB*

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1822.0 ft. to 1832.2 ft., using 6000 lbs. weight on bit and circulating drilling fluid at 600 gpm. Rate of penetration increased to approximately 21 ft. per hour. The tool was pulled from the hole at 2050 lbs. and unlatched smoothly.

At the surface the autoclave did not appear to be pressurized, which was confirmed by a pressure transducer reading equal to atmosphere. A complete post-run analysis was performed on the tool to determine the mode of failure. The autoclave and pressure section were pressure tested to 3000 psi in their in-situ state. No leaks were observed at any point in this process. Next the tool was disassembled and checked for damage and incorrectly assembled parts. All was found to be in order. The ball valve was isolated and its articulation checked. The ball was found to be extremely stiff to open, suggesting increased friction between the seal carrier and the ball valve housing.

Recovered core was 9.0 ft. in length.

Result: Unsuccessful test

Failure mode: Inconclusive

Corrective action: None

Figure 2. Core recovered during coring run 2FB.

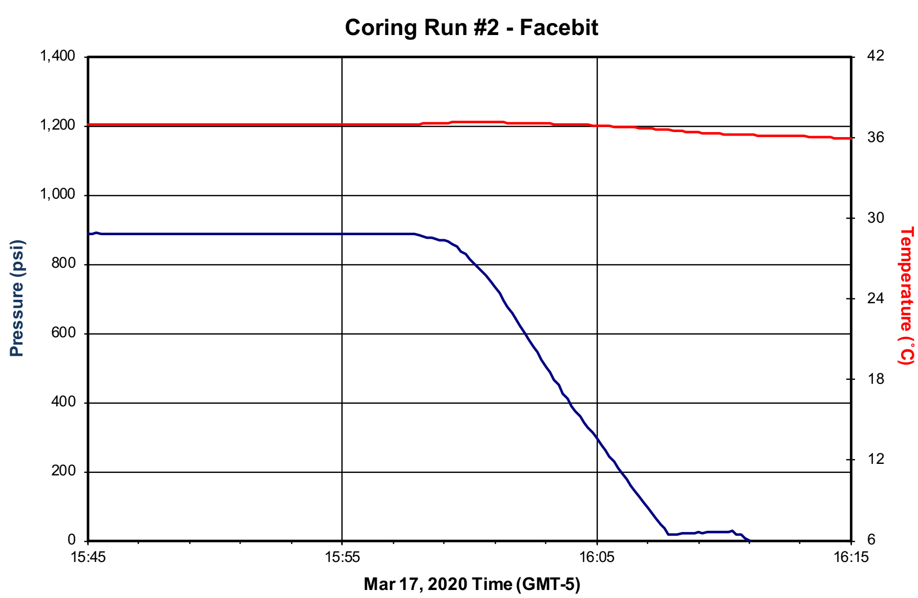

Figure 3. DST record from 2FB blown up around the period of core retrieval. Note that there is no indication of boost.

3.1.3 *3CS*

Prior to core 3CS the BHA was pulled to the surface, reconfigured, and spaced out for the cutting shoe assembly at the request of the client.

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1831.0 ft. to 1841.0 ft., using 8000 lbs. weight on bit and circulating drilling fluid at 600 gpm. Using this combination, rate of penetration decreased to approximately 15 ft. per hour. The tool was pulled from the hole at 2050 lbs. and unlatched smoothly.

When pulled to the surface, the tool was not pressurized and the ball valve was in a half-closed position. Detailed post-run analysis showed no failure mode apart from a stiff ball valve.

Recovered core was 7.5 ft. in length.

Result: Unsuccessful test

Failure mode: Incomplete ball closure

Corrective action: Triple-check ball valve assembly procedures

Figure 4. Core recovered during coring run 3CS.

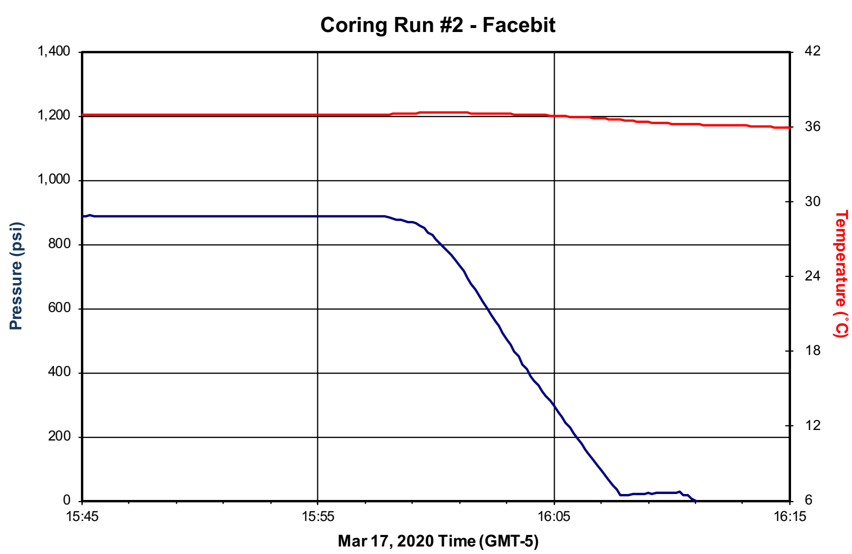

Figure 5. DST record from 3CS blown up around the period of core retrieval. Note that there is no indication of boost.

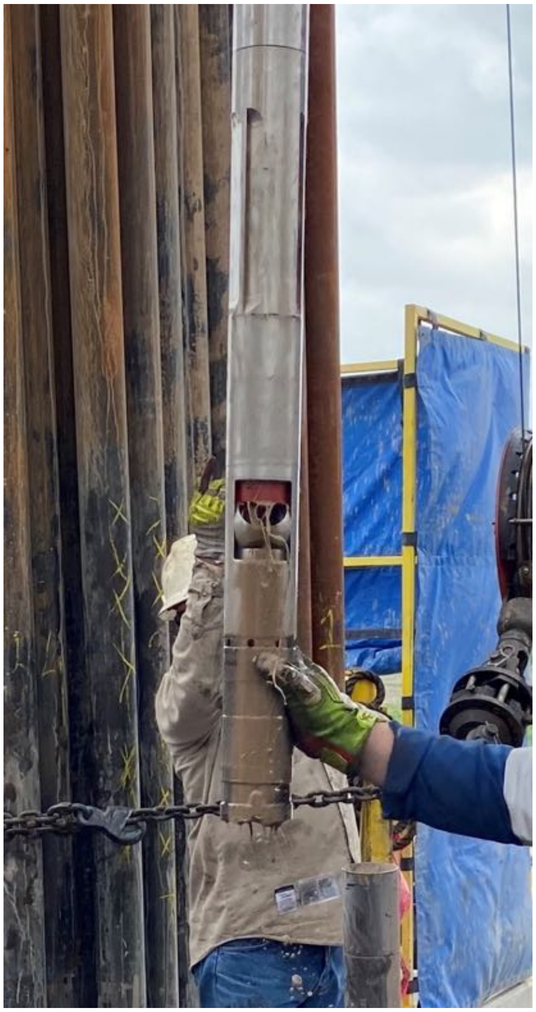

Figure 6. Seal carrier (red part), ball valve and ball follower (below the ball valve) after coring run 3CS.

3.1.4 ***4CS***

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1841.0 ft. to 1843.5 ft., using 6000 lbs. weight on bit and circulating drilling fluid at 400 gpm. Rate of penetration decreased to approximately 6 ft. per hour. The tool was pulled from the hole at 2050 lbs. and unlatched smoothly.

At the surface the ball was again observed to be only partially closed. In post-run analysis the seal carrier was found to be stiff and difficult to move, with significant amounts of fine grit present in the annulus between seal carrier and ball valve housing.

Recovered core was 2.0 ft. in length.

Result: Unsuccessful test

Failure mode: Incomplete ball closure

Corrective action: Use lower drilling fluid flow rate to lessen forcing of fine particles into ball valve assembly

Figure 7. Core recovered during coring run 4CS.

Figure 8. Seal carrier (red part), ball valve and ball follower after coring run 4CS. On recovery to the coring van (L) and after hammering to move the ball and sleeve (R). Note the material above the 'tide' mark on the seal carrier and the streaks close to the edge of the ball housing.

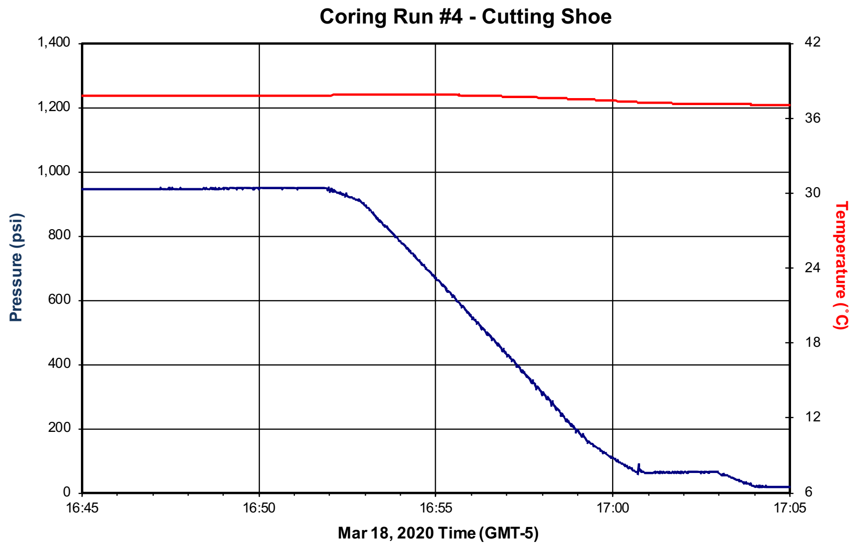

Figure 9. DST record from 4CS blown up around the period of core retrieval. Note that there is no indication of boost.

3.1.5 *5CS*

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1843.5 ft. to 1843.8 ft., using 3000 lbs. weight on bit and circulating drilling fluid at 30 gpm. This combination of weight on bit and flow rate is a close comparison to drilling parameters used offshore when drilling in hydrate-bearing sediments. As expected, these parameters yielded a decreased rate of penetration of approximately 1 ft. per hour. The tool was pulled from the hole at 2150 lbs. and unlatched smoothly.

The tool arrived at the surface without pressure. The ball valve appeared closed but closer observation showed that it was slightly cocked, leaving an obvious leak path. Post-run analysis found the same stiffness in the ball valve observed in prior tests. Fine grit was again observed on the surface of the seal carrier.

Recovered core was 0.8 ft. in length. A compact plug of consolidated cuttings was found in the core catcher.

Result: Unsuccessful test

Failure mode: Incomplete ball closure

Corrective action: Increase drilling fluid flow rate

Figure 10. Core recovered during coring run 5CS.

Figure 11. Seal carrier (red part), ball valve and ball follower after coring run 5CS. The ball is in the closed position and was most likely jostled into this position during handling at or from the rig floor.

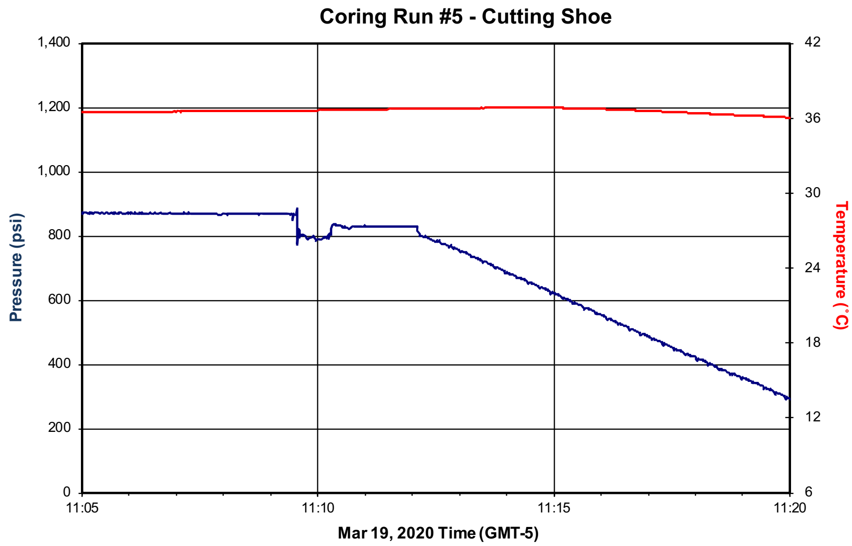

Figure 12. DST record from 5CS blown up around the period of core retrieval. Note the unusual pressure record around the start of core retrieval.

3.1.6 *6CS*

The tool was run into the hole and latched into the BHA without incident. Drilling proceeded from a depth of 1843.80 ft. to 1844.16 ft., using 3000 lbs. weight on bit and circulating drilling fluid at 100 gpm. Rate of penetration stayed steady at approximately 1 ft. per hour. The tool was pulled from the hole at 2210 lbs. and unlatched smoothly.

At the surface, the ball was again observed to be partially open. In post-run analysis the ball valve mechanism was again found to be stiff with grit present.

Recovered core was 0.3 ft. in length.

Result: Unsuccessful test

Failure mode: Incomplete ball closure

Corrective action: Test actuation without drilling or circulating fluid

Figure 13. Ball valve, seal carrier (red part) and ball follower after Core Run 6CS. Note that the ball was moveable by hand suggesting that the seal carrier or spring was jammed above it. Note the coarse-grained looking material after the seal carrier has been moved down.

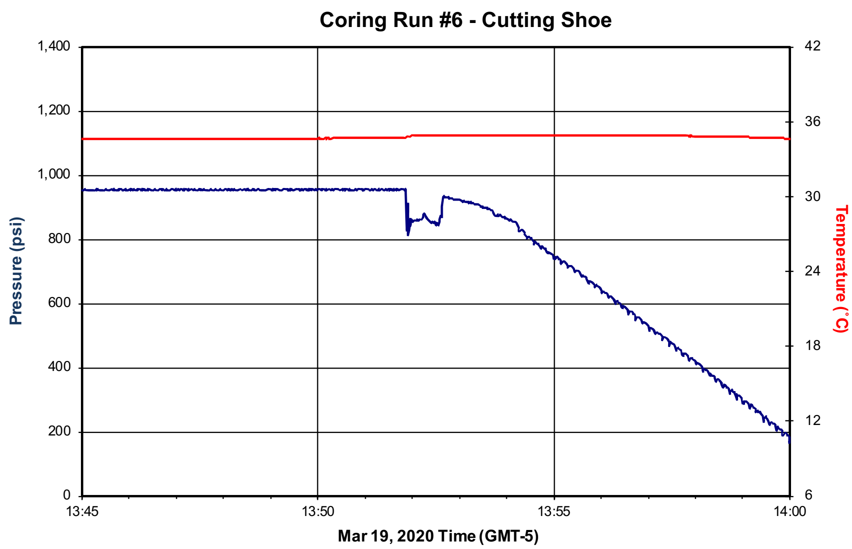

Figure 14. DST record from 6CS blown up around the period of core retrieval. Note the unusual pressure record around the start of core retrieval.

3.1.7 *7CS (WATER CORE)*

Prior to 7CS the BHA was pulled up to the bottom of the cased portion of the hole (1200 ft. depth). The tool was run into the hole and latched into the BHA without incident. The wireline running tool was switched for the wireline pulling tool and the coring tool was retrieved. The tool was pulled from the BHA at 2050 lbs. and unlatched smoothly.

At the surface the tool was observed to be unpressurized, although the ball did appear to be fully closed. The tool was taken to the service van and pressure tested in in-situ condition. The autoclave and pressure section were tested to 1800 psi (boost pressure) without leaks. Pressurizing the tool took many times longer than normal, indicating that the tool was empty when the ball closed. This suggests that the ball was open while the tool was pulled up hole, draining the contents before the ball closed at some point before reaching the surface.

Result: Unsuccessful test

Failure mode: Presumed incomplete ball closure

Corrective action: None; end of field test

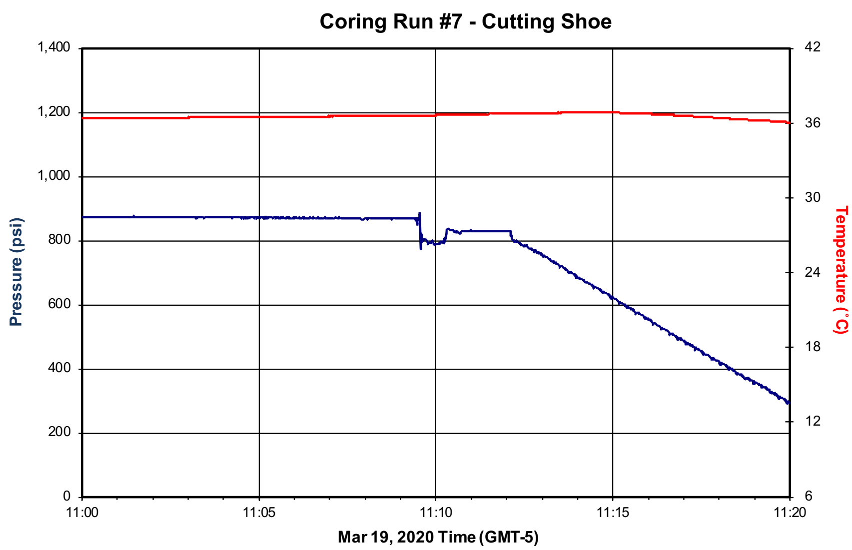

Figure 15. DST record from 7CS blown up around the period of core retrieval. Note the unusual pressure record around the start of core retrieval.

4 FAILURE MODE FINDINGS

4.1 OBSERVED FINDINGS

The failure of so many tests at CTTF has highlighted the fragility of the ball valve sealing mechanism in real-world usage of the PCTB as in many cases the tool was recovered to the rig floor with the ball closed. Because the ball valve can be 'rattled' closed during the wireline trip to the surface it is postulated that all failures at CTTF were the result of a not fully closed ball valve. Analyses of the ball valve assemblies were made during disassembly in the coring van and the results are reported below.

A sample of mud was taken from the CTTF mud tanks for analysis and the results are also reported below.

4.1.1 *BALL VALVE STICTION*

Prior to every coring run, ball valve assemblies were fully cleaned and rebuilt with new seals and lubricant. Additionally, each assembly was test fired a minimum of three times before each run to ensure that they were correctly built and fully functional.

After every run, ball valve assemblies were carefully removed from the autoclave assembly and assessed for function. In every case, technicians observed a severe stickiness which hampered the smooth opening and closing of the ball valve. In several cases, the seal carrier would not move to its downward (closed) position even without counterpressure from the ball. In one case, the seal carrier remained resistant to upward movement even with the ball valve spring removed.

This amount of stiction most closely resembles that seen in previous offshore operations when sandy formations have been encountered downhole, introducing large amounts of fine particulates into the very small annulus between seal carrier and ball valve housing.

4.1.2 *MUD PROPERTIES*

The mud used at CTTF during the coring operation was mixed to a nominal weight of 10.2 lb/g and a measured funnel viscosity of 48 sec/quart. The mud mix (total volume of 700 bbls) included:

- Barite – 320 bags
- Tannathin – 10 bags
- New Phalt – 10 bags
- New Gel – 4 bags
- Caustic Soda – 2 bags

A sample of mud was taken from the top of one of the mud tanks at CTTF for analysis. The results show that the mud had a density of 1.205 g/cc (10.06 lb/g) and contained 0.24 % by weight of solids in the 63-125 μm size fraction.

As this sample was taken from the top of one of the tanks the amount of fine sand sized material measured may not be representative as a result of settling in the tank.

4.1.3 *MUD USAGE*

The mud was used for the drilling of the hole below the casing set point (1,308 ft) to the first coring point at 1,822 ft, an advance of circa 500 ft, using the CTTF roller cone bit (typically producing cuttings 1/4” to 3/8” in size). During the drill to depth and the coring process the drilling mud was recirculated via shakers and filters to remove particles greater than 110 μm in size.

Figure 16. Mud sample from CTTF (L) and the coarse-grained material sieved from the mud (R).

4.2 RECORDED FINDINGS

4.2.1 *DATA STORAGE TAG ANALYSIS*

DST data (see Appendix 2) bolsters the conclusion that in every failed run, pressure was lost in a catastrophic manner rather than a slow leak.

5 CTTF TESTING DISCUSSION

The testing at CTTF highlighted problems with sealing of the tool at the bottom end – the ball valve. In particular the failure of the ball to close fully once actuated by the single trigger mechanism that controls the sealing of the PCTB and the firing of the pressure section to provide a pressure boost.

The analysis of the failures together with examination of the parts in the ball valve assembly highlights the likelihood that jamming of the mechanism is occurring. This jamming could be occurring with the upper seal carrier or the lower ball follower and their associated springs.

Using this hypothesis and the analysis of the mud used at CTTF a series of tests were designed to assess the susceptibility of the ball valve assembly to ‘grit’ (sand sized particles specifically) jamming the mechanism. These tests and the results from them are described below in Section 6.

6 SALT LAKE CITY BALL VALVE ASSEMBLY TESTING

A range of tests were conducted with different arrangements, firstly to set a baseline for ball valve closure timings, then to produce a positive failure and finally to more closely mimic to conditions at CTTF to produce failure again and allow more analysis.

The tests were all conducted so that the closure of the ball valve could be visually monitored. To assist with the post test analysis a high-speed camera for slow motion capture was used to record the ball valve actuation inside a water filled fixture.

The testing comprised the following groups of tests:

- Tests in air (dry fire testing)
- Tests in water
- Tests in polymer drilling fluid
- Coarse sand testing
- Blast media (Aluminum Oxide, 53-125 μm) tests
- Blast media in water tests

6.1 BALL VALVE DRY FIRE TESTING

The first set of testing is a dry fire of the isolated ball valve assembly using the collet release sleeve. By dry firing in air, the least viscous medium in this testing set, we are able to achieve baseline data for the quickest ball valve actuation. Figure 17 shows the dry fire setup of the isolated ball valve assembly.

Figure 17. Isolated ball valve assembly for dry firing.

The results of the dry fire data were recorded by filming the ball valve in slow motion at 240 fps. The frames from the entire actuation are then counted using a video editing software. The results are shown in the Table 2 below.

TEST #	TOTAL FRAMES TO FIRE	FRAMERATE	TIME TO FIRE (s)
1	6	240	0.025
2	7	240	0.029
3	7	240	0.029
4	7	240	0.029
Average	7	240	0.028

Table 2. The four tests yield consistent results showing an average of 6.75 frames, or 0.028 seconds, to fully actuate the ball.

6.2 BALL VALVE WATER TESTING

A fixture was constructed out of a clear acrylic tube to house the ball valve assembly during actuation. The acrylic has a 4.75” ID, to closely simulate the bore size of the BHA. The fixture is shown in Figure 18 with a ball valve assembly inside and full of water.

Figure 18. Acrylic test fixture

The ball valve was tested five times in tap water to compare baseline data in liquid. The results are documented in the Table 3 below showing a firing time of 1.64 more than in air.

TEST #	TOTAL FRAMES TO FIRE	FRAMERATE	TIME TO FIRE (s)
1	12	240	0.05
2	11	240	0.046
3	11	240	0.046
4	11	240	0.046
5	10	240	0.042
Average	11	240	0.046

Table 3. Firing the ball in water slowed the actuation down by an average of 4.25 frames, or 0.018 seconds. All of the actuations were smooth and consistent.

6.3 DRILLING FLUID POLYMER TESTING

In order to increase the viscosity of the fluid, Insta-Vis™ Drilling Fluid Polymer was mixed with water to create three different test fluids. Each fluid viscosity was measured with a timed ball drop test and calculated knowing the size, density of the ball, and density of the fluid. Three different viscosity fluids were mixed and the ball valve assembly was fired once in all three of the fluids. The three test results are listed in the Table 4 below showing only small increases in firing time compared with water (x1.2).

TEST #	TOTAL FRAMES TO FIRE	FRAMERATE	TIME TO FIRE (s)	FLUID VISCOSITY (Pa.s)
1	13	240	0.054	2.14
2	14	240	0.058	4.78
3	13	240	0.054	10.94

Table 4. The increased viscosity of the fluid proved to not slow the ball valve down in any meaningful way.

6.4 INTRODUCED GRIT TESTING

6.4.2 *#149 μm SIZE SAND*

The first test with introduced grit included about 2 lbs of #100 mesh sand (149 μm particle size) mixed into a drill mud solution. The same sand was also applied to the ball valve assembly seal carrier, ball, and ball follower; with fluid film (a lanolin based grease) as a sticking agent, before deploying into the test fixture. Figure 19 below shows the ball valve before deployment.

Figure 19. Ball valve covered with #100 mesh sand

The ball valve actuated fully and the #100 sand created no discernable issues during the test.

6.4.3 *53-125 µm ALUMINUM OXIDE BLAST MEDIA*

The next grit testing uses 53-125 µm Aluminum Oxide to investigate whether this small grain size would create a failure during actuation. This material was picked based on the CTTF mud particle sizes extracted from a sample. Introducing Aluminum Oxide to the ball valve assembly began producing failures. Six various tests were performed with the Aluminum Oxide blast media and all of the data was captured with slow motion videos.

Each header below includes the name of the recorded video followed by the test parameters, results, and observations. Videos are available on request.

- Al2_O3_1

The seal carrier, ball, ball follower, and housing extension flow ports are coated with fluid film and Aluminum Oxide is applied to the surface. The assembly pre-deployment is shown below in Figure 20.

Figure 20. Ball valve assembly with applied Aluminum Oxide

The ball valve was actuated in the test fixture filled with water and failed. The ball valve closes halfway before jamming.

- Al2_O3_2

The ball follower is coated with fluid film and Aluminum Oxide is applied to the surface. The tool was actuated in water and failed. The ball valve is jammed and closes approximately 5% of the stroke.

- Al2_O3_3

4 grams of Aluminum Oxide were measured and poured into the flow ports of the ball valve housing extension. The ball was actuated in water and failed. The ball valve closes approximately 25% of the stroke.

- Al2_O3_4

4 grams of Aluminum Oxide were measured and applied to the carrier and ball follower. The ball was actuated in water and failed. The ball valve closes approximately 10% of the stroke.

- Al2_O3_5

The assembly was lightly pressure washed and no more grit was added to the tool. The ball valve was actuated in water and failed. The ball valve closes approximately 10% of the stroke.

- Al2_O3_6

The ball valve assembly was fully disassembled, pressure washed, and rebuilt. No grit was applied to the assembly. A clear drilling fluid mixture was made to closely simulate CTTF mud specifications with the following parameters (see section 4.1.2):

  - Viscosity of 48 s/quart (determined from CTTF mud report)
  - 0.24% Aluminum Oxide by weight added to drilling fluid

The tool was then actuated and failed. The ball valve closed at approximately 90% of the stroke.

6.4.4 *ALUMINUM OXIDE AND WATER TESTING*

In order to further validate the test failures, three ball valve assemblies were tested 26 times in the same conditions.

PCTB Assemblies #1 and #2 were assembled with upgraded xylan coated parts; including the seal carrier, ball valve spring, and spring collet. Assembly #3 was assembled as the older revision ball valve, with no xylan coated parts.

In order to achieve consistent data, a test procedure was developed and performed systematically for all 26 tests. The procedure included the following steps:

- Fully disassemble all ball valve assembly components
- Pressure wash each individual component until grit free
- Reassemble ball valve assembly with all seals and lubrication as used in the field
- Dry fire ball valve in vice with release sleeve, reset ball valve and reset sleeve
- Place ball valve assembly into the acrylic test fixture
- Mix 2.5 gallons of water with 0.05 lbs of Aluminum Oxide powder (0.25% by weight)
- Pour solution into the test fixture to fill in and around the assembly
- Let solution settle for 15 seconds
- Fire ball valve by removing release sleeve
- Remove tool and wash out fixture in preparation for next test

Each test was filmed in slow motion at 240 fps. The results of this set of testing is shown in the Tables below.

All videos are available on request.

The naming convention for the videos denotes A#, for assembly number, G# for grit test number, Pass for sealed after actuation (>95% closed), and Fail for leaking.*

ASSEMBLY #	VIDEO NAME	APPROX. % BALL CLOSURE	SEALED (Y/N)	FRAME COUNT	ACTUATION TIME (S)
1	A1_G1_Fail	75	N	14	0.058
1	A1_G2_Pass	95	Y	12	0.050
1	A1_G3_Fail	80	N	19	0.079
1	A1_G4_Fail	90	N	14	0.058
1	A1_G5_Fail	25	N	16	0.067
1	A1_G6_Fail	80	N	17	0.071
1	A1_G7_Fail	80	N	14	0.058
1	A1_G8_Fail	80	N	23	0.096
1	A1_G9_Fail	80	N	24	0.100

Table 5. Assembly #1 water and grit test results

Assembly #1 failed to fully fire and seal 8/9 times. After each failure, the ball valve was removed from the test fixture and evaluated by putting downward pressure on the ball follower. On 6/8 failures, pushing on the ball follower would reduce the jamming and help the ball finish the stroke. The seal carrier would remain in contact with the ball and continue its downward motion. During these tests, a noticeable amount of grit was built up around the ball follower causing the resistance of downward motion.

On 2/8 of the failures, when the ball follower was pushed down the seal carrier remained jammed. The carrier would then finish it's stroke and seal after a small delay.

ASSEMBLY #	VIDEO NAME	APPROX. % BALL CLOSURE	SEALED (Y/N)	FRAME COUNT	ACTUATION TIME (S)
2	A2_G1_Pass	100	Y	11	0.046
2	A2_G2_Pass	100	Y	21	0.088
2	A2_G3_Fail	25	N	16	0.067
2	A2_G4_Pass	100	Y	14	0.058
2	A2_G5_Pass	100	Y	16	0.067
2	A2_G6_Pass	95	Y	17	0.071
2	A2_G7_Pass	100	Y	15	0.063
2	A2_G8_Pass	100	Y	15	0.063
2	A2_G9_Fail	85	N	28	0.117
2	A2_G10_Pass	100	Y	14	0.058

Table 6. Assembly #2 water and grit test results

Assembly #2 failed to fully fire and seal on 2/10 tests. Pressure was applied to the ball follower on both failures and the seal carrier would remain unjammed throughout the length of the remaining stroke.

Although assembly #2 fired and sealed on 8/10 tests, the timing of the successful tests was slower than the baseline average. The successful assembly #2 tests took an average 15.375 frames, or 0.064 seconds to close. This is 28% slower than the baseline water fire data average of 11 frames, or 0.046 seconds.

ASSEMBLY #	VIDEO NAME	APPROX. % BALL CLOSURE	SEALED (Y/N)	FRAME COUNT	ACTUATION TIME (S)
3	A3_G1_Pass	100	Y	15	0.063
3	A3_G2_Fail	5	N	N/A	N/A
3	A3_G3_Fail	80	N	16	0.067
3	A3_G4_Fail	5	N	N/A	N/A
3	A3_G5_Fail	25	N	15	0.063
3	A3_G6_Fail	5	N	N/A	N/A
3	A3_G7_Fail	50	N	17	0.071

Table 7. Assembly #3 water and grit test results

Assembly #3 failed at the highest rate of 6/7 tests. This assembly included no xylan coated parts and consistently jammed at an earlier state in the ball valve stroke than both assembly #1 and assembly #2. On three of the assembly #3 tests, the ball valve jams immediately and no useful timing data could be collected. On all of the failures the seal carrier was not jammed when the ball follower was pressed down and the stroke would complete.

6.5 SLC TESTING DISCUSSION

Overall, each of the three ball valve assemblies tested in water and a 53-125 µm grit solution failed to a lesser or greater degree. The fine grit particles successfully jammed the sliding surfaces inside the ball valve assemblies and created partial actuations. Frame by frame timing data on the successful firing tests shows that grit in the system slows down the actuation when compared to the baseline water-only testing performed.

It is clear from the SLC set of tests that there is significant potential for both the seal carrier and the ball follower to become jammed with fine grained sand sized particles in the 53-125 μm size range.

7 CONCLUSION

The PCTB tool cored much more effectively with both the face bit and cutting shoe configuration than in the testing conducted at CTTF in 2015 as demonstrated by the recovery percentages (see Section 3.13.1) and the observed rates of penetration for the cores collected. This improvement in coring efficiency is a result of changes in the flow path through and around the tool that was implemented in 2016 with the flow diverter modification. The flow diverter allows the use of higher flow rates without the risk of the core liner collapsing. Flow rates used during this round of testing were up to 600 gpm whereas previously no more than 200 gpm could be used without collapsing the core liner.

The changes made more recently to a single trigger mechanism, for the sealing and pressure boosting of the tool, worked successfully and removed any doubts about the timings of the engagement of the upper seals, the actuation of the ball valve closure and the firing of the pressure boost. With the resultant confidence in the timing of the tool operation and the failed tests at CTTF the focus for the reliability of the pressure seal has clearly moved to the ball valve closure and the subsequent testing in Salt Lake City.

The effect of the increase in volume of the pressure section were not observed as the circumstances under which the effect might have been seem did not occur. When the boost was seen in run 1FB (see Section 3.1.1) the pressure section functioned correctly.

The follow up testing in Salt Lake City has clearly demonstrated the susceptibility to jamming of the ball valve mechanism by fine grained sand sized particles (in the range 53-125 μm diameter). This size of particles is commonly found in dry mud (and maybe cuttings) and hence robust mitigation mechanisms (design/procedures) are required. The tolerancing of the parts in this sub-assembly needs to be closely assessed and appropriate measures designed into the sub-assembly to robustly defend against the ingress of grit which can clearly jam either or both the seal carrier and the ball follower.

8 NEXT STEPS

To mitigate the problems of the grit particles jamming the ball valve mechanism the following work should be conducted:

- a tolerance study of the existing parts to assess the differences between the success rates of the different assemblies tested
- a design review of the seal carrier with particularly attention on the access of grit to the sliding surfaces and the requirement for the displacement of fluid during actuation
- a design review of the ball follower to remove the possibility of grit getting to the sliding surfaces
- Further detailed testing of new components

APPENDICES

1 APPENDIX 1: RUN SHEETS

1.1 1FB

GEOTEK CORING Inc
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REVISION NO.: 0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-17	**CORE:**	1FB
TOOL ASSEMBLY TEAM:		Burrows, Mimitz, Minarich, Selman	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,825.00 ft	**BOTTOM HOLE PRESSURE:**	809 psi
DST SERIAL NUMBERS: **LINER LENGTH ADJUSTER:**	C9476	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST		**AUTOCLAVE PRESSURE TEST**			
LINER/IT PLUG LENGTH (156.75")	YES	To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.			
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,856 psi				
RESERVOIR PRESSURE:	8,060 psi				
SUPPLY VALVE OPEN	YES				
FILL VALVE CLOSED/PORT PLUGGED	YES	**TEST 1**			
SET VALVE CLOSED/PORT PLUGGED	YES	**DATE:**	2020-03-17	**INITIAL:**	2,768 psi
DRAIN VALVE CLOSED/PORT PLUGGED	YES	**START TIME:**	08:21	**START:**	2,747 psi
SHUTOFF VALVE OPEN	YES			**END:**	2,740 psi
SAMPLE PORT CLOSED/PORT PLUGGED	YES	**TEST 2 (IF REQUIRED)**			
IT PLUG SHEAR PIN INSTALLED	YES	**DATE:**		**INITIAL:**	
		START TIME:		**START:**	
				END:	
TOOL READY FOR RIG FLOOR	**DATE:** 2020-03-17 **TIME:** 07:54	**TOOL SENT TO RIG FLOOR**		**DATE:** 2020-03-17	**TIME:** 09:50
NOTES:					

CORING RUN

DATE:		2020-03-17	**TOOL DEPLOYMENT TIME:**		09:20
START DEPTH:	1,815.00 ft	**END DEPTH:** 1,821.69 ft	**ANTICIPATED RECOVERY:**		6.69 ft
CORING START TIME:		11:05	**CORING END TIME:**		11:52

FLOW RATES		**DRILL PARAMETERS**			**WIRELINE PULLOUT**	
RUNNING IN:	15 gpm					
CORING:	400 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**	**WEIGHT (MAX):**	2,100.0 lbs
PULLING:	0 gpm	6,000 lbs	70 rpm	9 ft/hr	**SPEED:**	100 ft/min
P.O.O.H.:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A	TIME OUT:	N/A

		TIME ON DECK:	13:00
TOTAL TIME IN HOLE:	3:40	**TOTAL TIME CORING:**	0:47
NOTES:			

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR	**DATE:** 2020-03-17 **TIME:** 13:05	**TRANSDUCER PRESSURE:**	2,128 psi
		TOTAL CORE RECOVERY:	5.50 ft
		RECOVERY PERCENTAGE:	82%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES:	Competent rock core

1.2 2FB

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REVISION NO.: 0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-17	**CORE:**	2FB
TOOL ASSEMBLY TEAM:		Burrows, Minarich, Selman	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,822.00 ft	**BOTTOM HOLE PRESSURE:**	808 psi
DST SERIAL NUMBERS:	**LINER LENGTH ADJUSTER:** 9481	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,821 psi
RESERVOIR PRESSURE:	8,034 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-17	**INITIAL:**	2,997 psi
START TIME:	11:11	**START:**	2,246 psi
		END:	2,923 psi
TEST 2 (IF REQUIRED)			
DATE:		**INITIAL:**	
START TIME:		**START:**	
		END:	

TOOL READY FOR RIG FLOOR	**DATE:** 2020-03-17	**TIME:** 12:45	**TOOL SENT TO RIG FLOOR**	**DATE:** 2020-03-17	**TIME:** 14:05
NOTES:					

CORING RUN

DATE:		2020-03-17	**TOOL DEPLOYMENT TIME:**		14:12
START DEPTH: 1,822.20 ft	**END DEPTH:**	1,832.20 ft	**ANTICIPATED RECOVERY:**		10.00 ft
CORING START TIME:		15:05	**CORING END TIME:**		15:33

FLOW RATES		**DRILL PARAMETERS**			**WIRELINE PULLOUT**	
RUNNING IN:	15 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**	**WEIGHT (MAX):**	2,050.0 lbs
CORING:	600 gpm	6,000 lbs	70 rpm	21 ft/hr	**SPEED:**	100 ft/min
PULLING:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A	TIME OUT:	N/A
P.O.O.H.:	0 gpm					

		TIME ON DECK:	16:10
TOTAL TIME IN HOLE:	1:58	**TOTAL TIME CORING:**	0:28
NOTES:			

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR	**DATE:** 2020-03-17 **TIME:** 16:40	**TRANSDUCER PRESSURE:**	0 psi
		TOTAL CORE RECOVERY:	9.00 ft
		RECOVERY PERCENTAGE:	90%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES:	Unknown mode of failure. Pressure tested autoclave and pressure section, no findings. Ball was extremely stiff on disassembly and some gouges were noted, which did not seem to impact the seal.

1.3 3CS

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REVISION NO.:	0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-18	CORE:	3CS
TOOL ASSEMBLY TEAM:		Burrows, Minarich, Selman	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,832.00 ft	BOTTOM HOLE PRESSURE:	812 psi
DST SERIAL NUMBERS:	LINER LENGTH ADJUSTER: C9484	RABBIT:	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,807 psi
RESERVOIR PRESSURE:	7,920 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-18	INITIAL:	2,955 psi
START TIME:	08:35	START:	2,935 psi
		END:	2,926 psi
TEST 2 (IF REQUIRED)			
DATE:	2020-03-18	INITIAL:	3,012 psi
START TIME:	10:55	START:	2,993 psi
		END:	2,967 psi

TOOL READY FOR RIG FLOOR	DATE: 2020-03-18	TIME: 12:00	TOOL SENT TO RIG FLOOR	DATE: 2020-03-18	TIME: 12:45

NOTES: Used tool for space-out after first pressure test; re-assembled and tested prior to coring run.

CORING RUN

DATE:	2020-03-18	TOOL DEPLOYMENT TIME:	12:52
START DEPTH: 1,831.00 ft	END DEPTH: 1,841.00 ft	ANTICIPATED RECOVERY:	10.00 ft
CORING START TIME:	13:39	CORING END TIME:	14:19

FLOW RATES		DRILL PARAMETERS			WIRELINE PULLOUT	
RUNNING IN:	15 gpm					
CORING:	600 gpm	W.O.B.:	R.P.M.:	R.O.P.:	WEIGHT (MAX):	2,050.0 lbs
PULLING:	0 gpm	8,000 lbs	70	15 ft/hr	SPEED:	100 ft/min
P.O.O.H.:	0 gpm	COLD SHUCK:	TIME IN:	N/A	TIME OUT:	N/A

		TIME ON DECK:	15:00
TOTAL TIME IN HOLE:	2:08	TOTAL TIME CORING:	0:40
NOTES:			

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR	DATE: 2020-03-18 TIME: 15:15	TRANSDUCER PRESSURE:	0 psi
		TOTAL CORE RECOVERY:	7.50 ft
		RECOVERY PERCENTAGE:	75%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES: Ball valve partly open.

1.4 4CS

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REVISION NO.: 0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-18	**CORE:**	4CS
TOOL ASSEMBLY TEAM:		Burrows, Minarich	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,841.00 ft	**BOTTOM HOLE PRESSURE:**	816 psi
DST SERIAL NUMBERS: **LINER LENGTH ADJUSTER:**	9492	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,802 psi
RESERVOIR PRESSURE:	7,955 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-18	**INITIAL:**	3,175 psi
START TIME:	14:25	**START:**	3,157 psi
		END:	3,148 psi
TEST 2 (IF REQUIRED)			
DATE:		**INITIAL:**	
START TIME:		**START:**	
		END:	

TOOL READY FOR RIG FLOOR	**DATE:** 2020-03-18	**TIME:** 14:55	**TOOL SENT TO RIG FLOOR**	**DATE:** 2020-03-18	**TIME:** 15:00
NOTES:					

CORING RUN

DATE:	2020-03-18	**TOOL DEPLOYMENT TIME:**	15:20
START DEPTH: 1,841.00 ft	**END DEPTH:** 1,843.50 ft	**ANTICIPATED RECOVERY:**	2.50 ft
CORING START TIME:	16:03	**CORING END TIME:**	16:30

FLOW RATES							
RUNNING IN:	15 gpm	**DRILL PARAMETERS**			**WIRELINE PULLOUT**	
CORING:	400 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**	**WEIGHT (MAX):**	2,050.0 lbs
PULLING:	0 gpm	6,000 lbs	68	6 ft/hr	**SPEED:**	100 ft/min
P.O.O.H.:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A	TIME OUT:	N/A

		TIME ON DECK:	17:10
TOTAL TIME IN HOLE:	1:50	**TOTAL TIME CORING:**	0:27
NOTES:			

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR	**DATE:** 2020-03-18 **TIME:** 17:35	**TRANSDUCER PRESSURE:**	0 psi
		TOTAL CORE RECOVERY:	2.00 ft
		RECOVERY PERCENTAGE:	80%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES:

1.5 5CS

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CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-19	**CORE:**	5CS
TOOL ASSEMBLY TEAM:	Burrows, Minarich, Selman		
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,844.00 ft	**BOTTOM HOLE PRESSURE:**	818 psi
DST SERIAL NUMBERS: **LINER LENGTH ADJUSTER:**	C9476	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,863 psi
RESERVOIR PRESSURE:	8,163 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES
TOOL READY FOR RIG FLOOR — **DATE:**	2020-03-19
TIME:	09:05

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-19	**INITIAL:**	2,990 psi
START TIME:	08:36	**START:**	2,973 psi
		END:	2,954 psi
TEST 2 (IF REQUIRED)			
DATE:		**INITIAL:**	
START TIME:		**START:**	
		END:	
TOOL SENT TO RIG FLOOR		**DATE:**	2020-03-19
		TIME:	09:10

NOTES:

CORING RUN

DATE:	2020-03-19	**TOOL DEPLOYMENT TIME:**	09:20
START DEPTH: 1,843.50 ft	**END DEPTH:** 1,843.80 ft	**ANTICIPATED RECOVERY:**	0.30 ft
CORING START TIME:	10:18	**CORING END TIME:**	10:48

FLOW RATES		DRILL PARAMETERS			WIRELINE PULLOUT	
RUNNING IN:	15 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**	**WEIGHT (MAX):**	2,150.0 lbs
CORING:	30 gpm	3,000 lbs	70	1 ft/hr	**SPEED:**	100 ft/min
PULLING:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A	TIME OUT:	N/A
P.O.O.H.:	0 gpm					

		TIME ON DECK:	11:30
TOTAL TIME IN HOLE:	2:10	**TOTAL TIME CORING:**	0:30
NOTES:	Ball closed, cuttings visible in ball		

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR — **DATE:**	2020-03-19	**TRANSDUCER PRESSURE:**	0 psi
TIME:	12:00		
		TOTAL CORE RECOVERY:	0.80 ft
		RECOVERY PERCENTAGE:	267%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES:

1.6 6CS

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REVISION NO.: 0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-19	**CORE:**	6CS
TOOL ASSEMBLY TEAM:		Burrows, Minarich, Selman	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,844.00 ft	**BOTTOM HOLE PRESSURE:**	818 psi
DST SERIAL NUMBERS: **LINER LENGTH ADJUSTER:**	C9492	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,786 psi
RESERVOIR PRESSURE:	7,995 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-19	**INITIAL:**	3,162 psi
START TIME:	11:24	**START:**	3,159 psi
		END:	3,135 psi
TEST 2 (IF REQUIRED)			
DATE:		**INITIAL:**	
START TIME:		**START:**	
		END:	

TOOL READY FOR RIG FLOOR	**DATE:** 2020-03-19	**TIME:** 12:05	**TOOL SENT TO RIG FLOOR**	**DATE:** 2020-03-19	**TIME:** 12:10
NOTES:					

CORING RUN

DATE:	2020-03-19	**TOOL DEPLOYMENT TIME:**	12:25
START DEPTH: 1,843.80 ft	**END DEPTH:** 1,844.16 ft	**ANTICIPATED RECOVERY:**	0.36 ft
CORING START TIME:	13:10	**CORING END TIME:**	13:28

FLOW RATES		**DRILL PARAMETERS**			**WIRELINE PULLOUT**	
RUNNING IN:	15 gpm					
CORING:	100 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**	**WEIGHT (MAX):**	2,210.0 lbs
PULLING:	0 gpm	3,000 lbs	68	1 ft/hr	**SPEED:**	100 ft/min
P.O.O.H.:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A	TIME OUT:	N/A

		TIME ON DECK:	14:05
TOTAL TIME IN HOLE:	1:40	**TOTAL TIME CORING:**	0:18
NOTES:	Ball cocked open		

CORE TRANSFER & RECOVERY

RECEIVED FROM RIG FLOOR	**DATE:** 2020-03-19 **TIME:** 14:30	**TRANSDUCER PRESSURE:**	0 psi
		TOTAL CORE RECOVERY:	0.30 ft
		RECOVERY PERCENTAGE:	83%
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

NOTES:	

1.7 7CS (WATER CORE)

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FROM BOREHOLE TO LABORATORY
GEOTEK CORING INC.

REVISION NO.: 0

CORING RUN REPORT
CAMERON TEST FACILITY 2020

DATE:	2020-03-19	**CORE:**	7CS
TOOL ASSEMBLY TEAM:		Burrows, Minarich, Selman	
BOTTOM CORE DEPTH (BELOW RIG FLOOR):	1,200.00 ft	**BOTTOM HOLE PRESSURE:**	532 psi
DST SERIAL NUMBERS: **LINER LENGTH ADJUSTER:**	C9476	**RABBIT:**	N/A
NOTES:			

TOOL ASSEMBLY

BUILD CHECKLIST	
LINER/IT PLUG LENGTH (156.75")	YES
SET PRESSURE (CONFIRM WITH 3 TESTS):	1,895 psi
RESERVOIR PRESSURE:	7,914 psi
SUPPLY VALVE OPEN	YES
FILL VALVE CLOSED/PORT PLUGGED	YES
SET VALVE CLOSED/PORT PLUGGED	YES
DRAIN VALVE CLOSED/PORT PLUGGED	YES
SHUTOFF VALVE OPEN	YES
SAMPLE PORT CLOSED/PORT PLUGGED	YES
IT PLUG SHEAR PIN INSTALLED	YES

AUTOCLAVE PRESSURE TEST

To test, pressurize assembled autoclave to 3000 psi (+/- 100 psi). Record this *INITIAL* pressure below. Wait five minutes to allow for acclimitization. During this time inspect for gross leakage of water or significant pressure drop. If leaks or pressure loss are observed, rectify and retest. At five minutes, record *START* pressure. Wait 10 minutes, then observe and record *END* pressure. If pressure loss >60 psi is observed, the test is considered a failure and should be repeated.

TEST 1			
DATE:	2020-03-19	**INITIAL:**	3,018 psi
START TIME:	15:58	**START:**	2,995 psi
		END:	2,949 psi
TEST 2 (IF REQUIRED)			
DATE:		**INITIAL:**	
START TIME:		**START:**	
		END:	

TOOL READY FOR RIG FLOOR	**DATE:** 2020-03-19	**TIME:** 15:30	**TOOL SENT TO RIG FLOOR**	**DATE:** 2020-03-19	**TIME:** 15:31
NOTES:					

CORING RUN

DATE:	2020-03-19	**TOOL DEPLOYMENT TIME:**	16:20
START DEPTH: 1,204.00 ft	**END DEPTH:** 1,204.00 ft	**ANTICIPATED RECOVERY:**	0.00 ft
CORING START TIME:	N/A	**CORING END TIME:**	N/A

FLOW RATES			**DRILL PARAMETERS**			**WIRELINE PULLOUT**	
RUNNING IN:	0 gpm						
CORING:	0 gpm	**W.O.B.:**	**R.P.M.:**	**R.O.P.:**		**WEIGHT (MAX):**	N/A
PULLING:	0 gpm	0 lbs	0	0 ft/hr		**SPEED:**	N/A
P.O.O.H.:	0 gpm	**COLD SHUCK:**	TIME IN:	N/A		TIME OUT:	N/A

		TIME ON DECK:	16:45
TOTAL TIME IN HOLE:	0:25	**TOTAL TIME CORING:**	N/A
NOTES:	Water core to test functionality of tool.		

CORE TRANSFER & RECOVERY

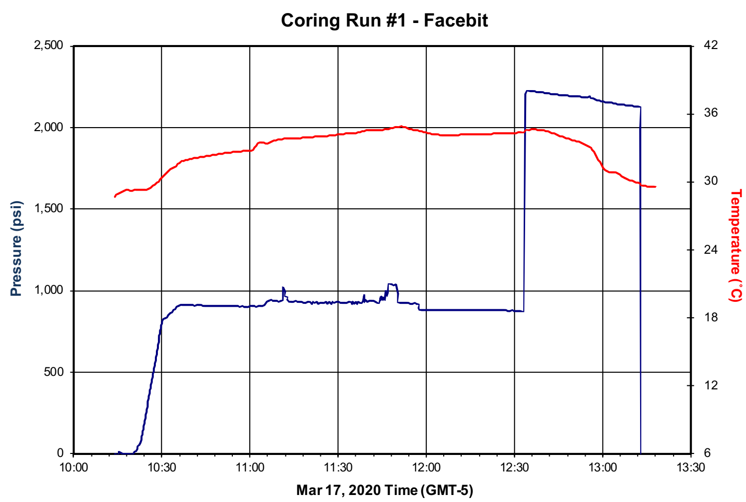
RECEIVED FROM RIG FLOOR	**DATE:** 2020-03-19 **TIME:** 17:08	**TRANSDUCER PRESSURE:**	0 psi
		TOTAL CORE RECOVERY:	N/A
		RECOVERY PERCENTAGE:	N/A
NOTES:			

POST-CORING TOOL ANALYSIS & REBUILD

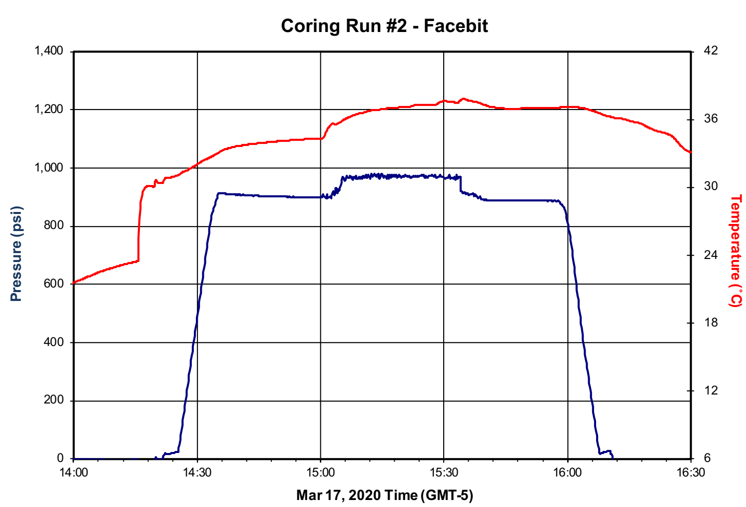
NOTES:	Tool came to surface with ball fired, sleeve valve fired, no pressure and no contents. Pressure tested autoclave and pressure section post-run and found no leaks, but autoclave seemed to be full of air.

2 APPENDIX 2: DST DATA PLOTS

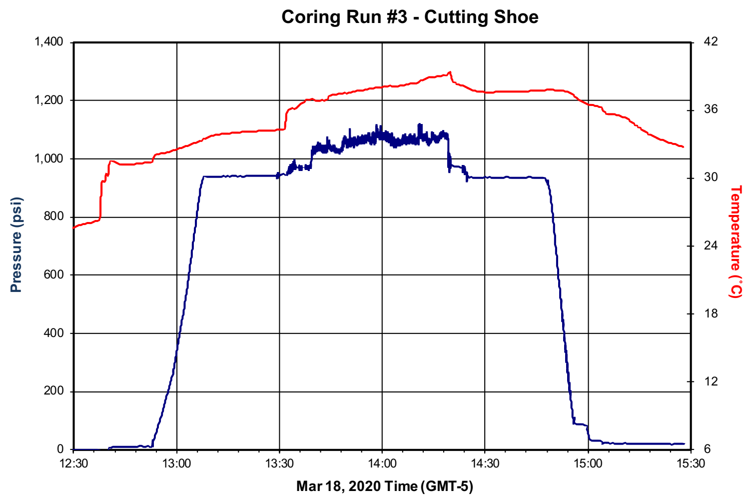
2.1 1FB



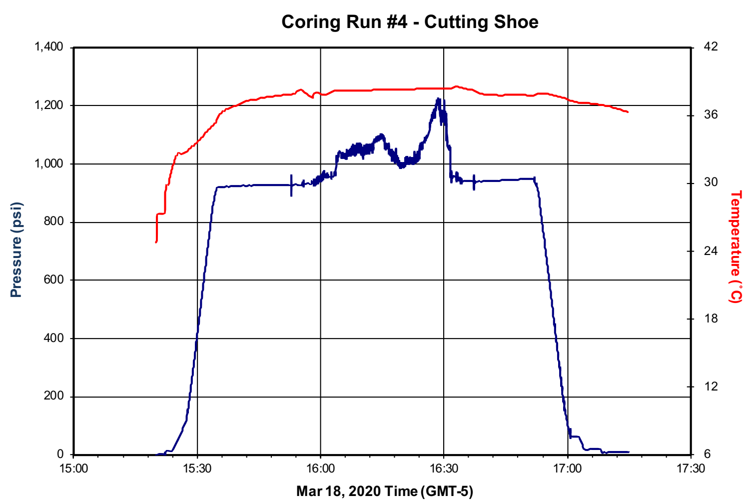
2.2 2FB



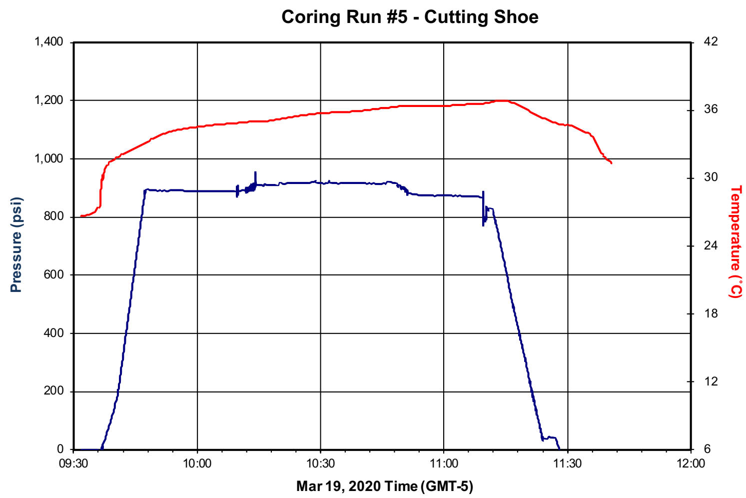
2.3 3CS


Coring Run #3 - Cutting Shoe
Pressure (psi)
Temperature (°C)
1,400
1,200
1,000
800
600
400
200
0
42
36
30
24
18
12
6
12:30
13:00
13:30
14:00
14:30
15:00
15:30
Mar 18, 2020 Time (GMT-5)

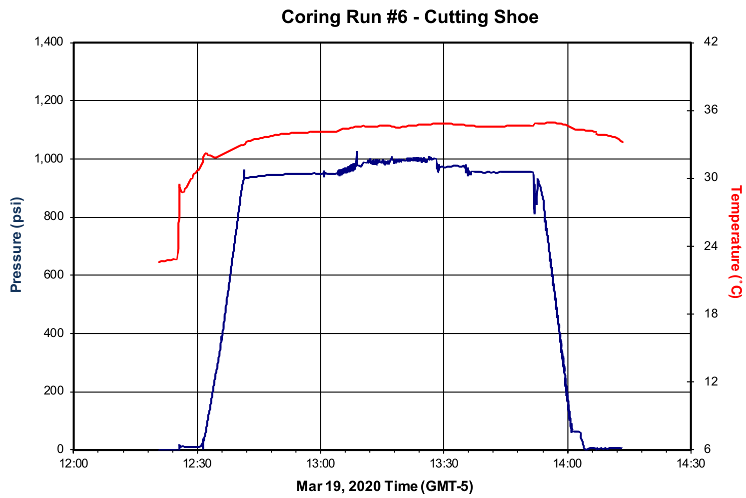
2.4 4CS


Coring Run #4 - Cutting Shoe
Pressure (psi)
Temperature (°C)
1,400
1,200
1,000
800
600
400
200
0
42
36
30
24
18
12
6
15:00
15:30
16:00
16:30
17:00
17:30
Mar 18, 2020 Time (GMT-5)

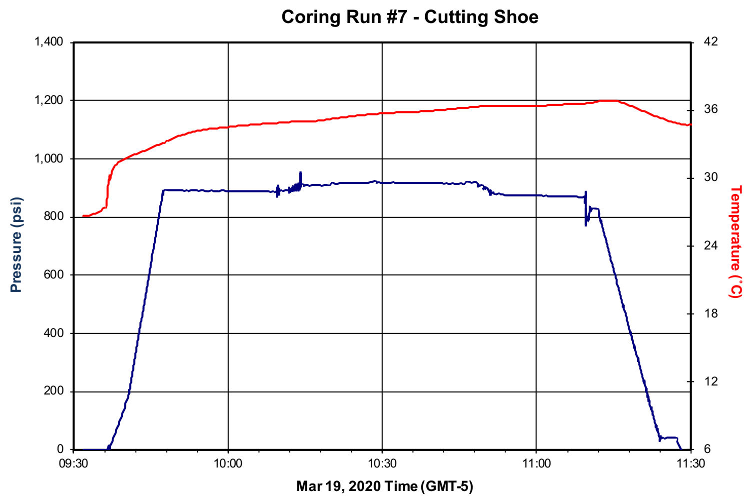
2.5 5CS


Coring Run #5 - Cutting Shoe
Pressure (psi)
Temperature (°C)
Mar 19, 2020 Time (GMT-5)
1,400
1,200
1,000
800
600
400
200
0
42
36
30
24
18
12
6
09:30
10:00
10:30
11:00
11:30
12:00

2.6 6CS


Coring Run #6 - Cutting Shoe
Pressure (psi)
Temperature (°C)
Mar 19, 2020 Time (GMT-5)
1,400
1,200
1,000
800
600
400
200
0
42
36
30
24
18
12
6
12:00
12:30
13:00
13:30
14:00
14:30

2.7 7CS


Coring Run #7 - Cutting Shoe
Pressure (psi)
Temperature (˚C)
Mar 19, 2020 Time (GMT-5)
0
200
400
600
800
1,000
1,200
1,400
6
12
18
24
30
36
42
09:30
10:00
10:30
11:00
11:30