Summary of Drilling Activities: Well 16A(78)-32

Operator: ..... Utah FORGE – U.S. Department of Energy

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Date:..... March 2021

Table of Contents

I. Acknowledgements

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We thank the many stakeholders who support this project, including Smithfield Foods Inc, Utah School and Institutional Trust Lands Administration, Beaver County, the City of Milford, the Utah Governor's Office of Energy Development, and the Utah Congressional Delegation.

Special thanks to Scout Drilling Technologies for providing the BHA detail tables, to NOV ReedHycalog for insightful analysis and to Fred Dupriest and Sam Noynaert with Texas A&M University for providing technical support and the MSE plots contained in this report.

II. Well Overview

Well 16A(78)-32 was spud on October 30, 2020. The rig was released on January 12, 2021. The days versus depth chronology for this well is shown in Figure 1.

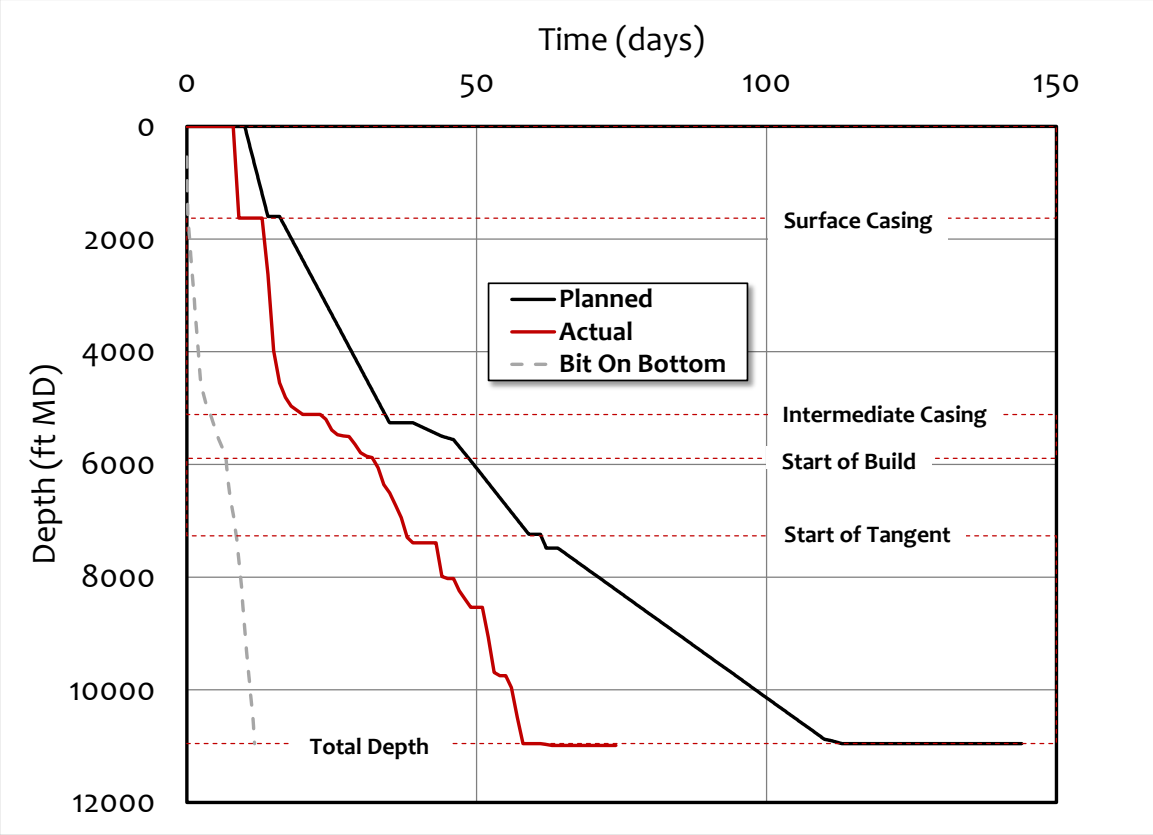

Figure 1. Days vs. Depth for Well 16A(78)-32.

Surface and total depth coordinates for Well 16A(78)-32 are provided in Tables 1 and 2, respectively.

Table 1. Surface Coordinates

Latitude	38° 30' 14.447 N
Longitude	112° 53' 47.066 W
Northing	13,987,645.20 ft
Easting	1,097,896.92 ft
Ground level elevation	5,414.00 ft
Rotary table elevation	30.00 ft
Vertical section azimuth plan	105.00°

Table 2. Total Depth Coordinates

Item	Plan	Actual

TVD from rotary table elevation	8,557.79 ft	8,560.61 ft
Northing	1,032.02 ft	-1,047.44 ft
Easting	3,851.55 ft	3,936.54 ft
Well Plan Azimuth	3,987.42 ft	4,073.51 ft
Measured Depth	10,938.00 ft	10,987.00 ft

II.1 Directional Profile

Directional trajectory plots are shown in Figure 2 and Figure 3.

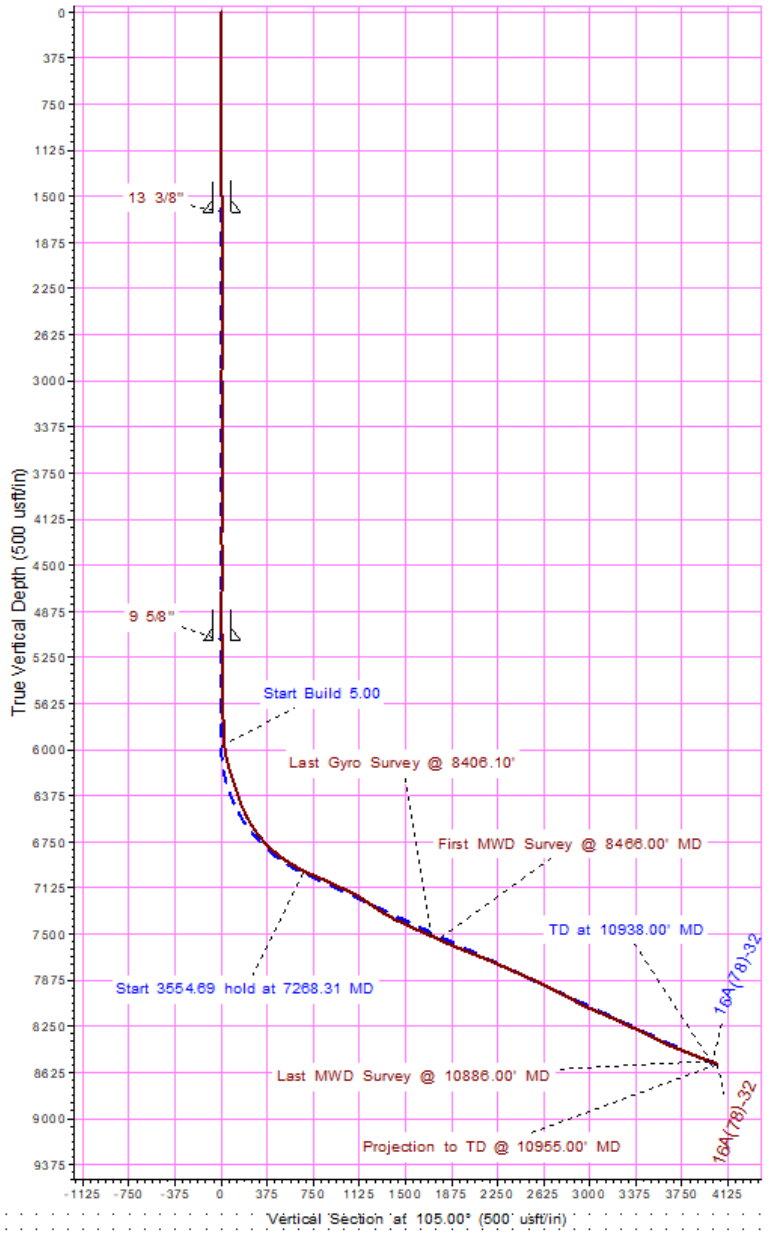

Figure 2. Directional profile (approximate elevation view).

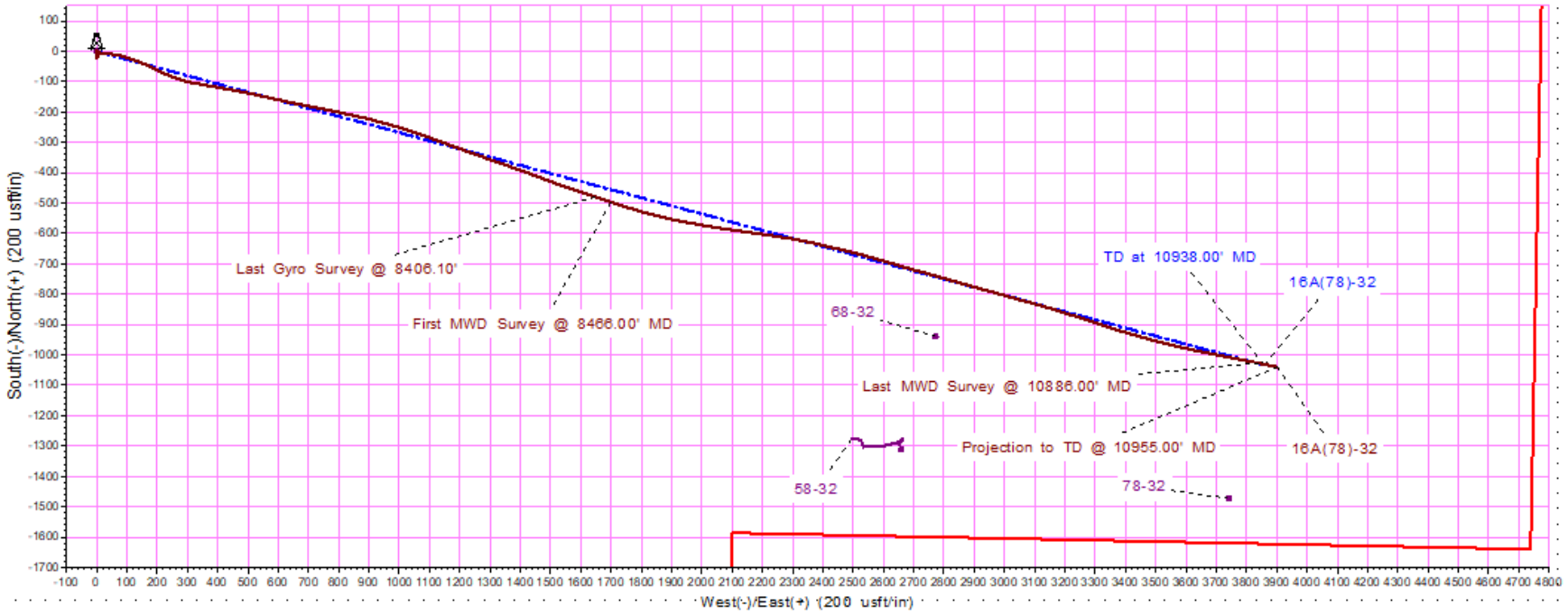

Figure 3. Plan view of trajectory at TD before coring

III. Drilling Operations Surface Section

III.1 Drilling BHA 01: 17.5-inch hole from 28' to 1,629' MD

BHA 01 is shown in Table 3. A 17.5 bit drilled from 28' to 1,629' MD. The surface section was drilled in 12 hours with an average ROP of 134 fph (Figures 4 and 5). Verticality was maintained along the section. When pulled to the surface, an inspection of the mud motor and Vertical Scout RRS showed that all equipment was in good shape. The bit came out in excellent condition. It was rated as green (0,1 grading). When pulled to surface, there was clay-like material attached to some of the tools. When inclination began to increase, the rotational speed was decreased from 75 rpm to 35-40 rpm, and the flow rate was reduced from 800 gpm to 700 gpm, allowing the tool to correct the inclination within 0.5 deg/100 ft. Mild bit balling was encountered, as shown in Figure 6.

Surface casing (13 3/8" x 68 ppf, L80, BTC) was run to a depth of 1,629 ft MD and then cemented to surface. When bumping the plug, the floats failed.

Table 3. BHA 01: 17.5-inch hole from 28' to 1,629' MD

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	TKC76 Bit	NOV	A275580	17 1/2		2	2	7 5/8 REG
2	14" Vertical Scout RSS	Scout	SDI-1400-VS08-002	14		21.11	23.11	7 5/8 REG
3	7 5/8 Reg Pin X 6 5/8 Reg Pin X-Over	Scout	SDI-950-XO-010	9 1/2	2 3/4	2.15	25.26	7 5/8 REG
4	9 5/8" Scout 7/8 5.9 stg Straight Fixed 17 3/8" Stab	Scout	TDI-OSA-962-01-	9 5/8		41.08	66.34	6 5/8 REG
5	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	79.86	6 5/8 REG
6	17 3/8" Steel Stabalizer	Stabildrill	SD24282	8 3/8	2 7/8	7.96	87.82	6 5/8 REG
7	8" NMDC	Stabildrill	SD55421	8 1/4	3 1/4	29.52	117.34	6 5/8 REG
8	8" Hang off Sub	Scout	SDI-825-OSTM-008	8 1/4	3 1/4	5.09	122.43	6 5/8 REG
9	4 Stands of 8" DC					378	500.43	6 5/8 REG
10	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	111111	8	2 3/4	2.8	503.23	4 1/2 IF
11	3 Stands of HWDP						503.23	4 1/2 IF

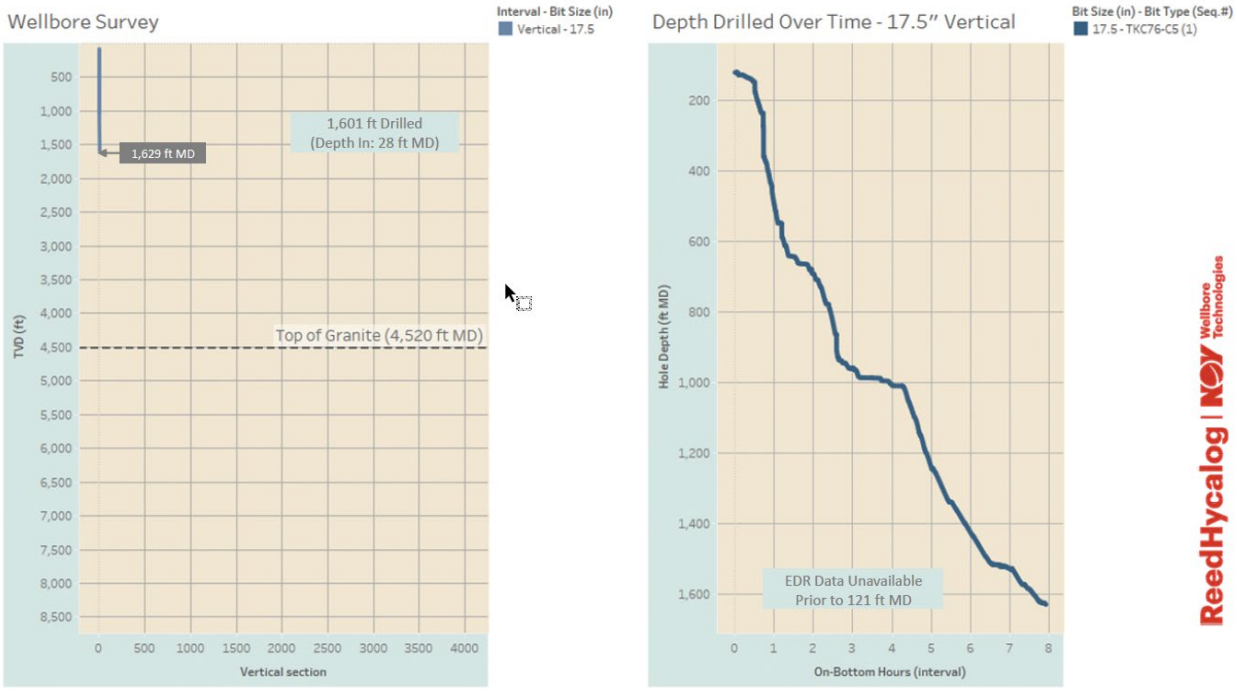

Figure 4. On bottom time for drilling the surface hole.

Figure 5. Bit photographs after pulling.

Figure 1. Evidence of bit balling

Lessons Learned

- Mild bit balling affected the ability of the VRTSS to stay on course.
- Have products on location to eliminate bit balling. Even better, control this with HSI.
- During cementing, the plug bumped; the floats did not hold. Failure of the float equipment in the surface and the intermediate hole suggests a re-evaluation of all float equipment. The RFP should also have had transportation included (oversight when bidding).
- The rig pumps could not pump more than 800 gpm due to maximum pressure limitations of the pump liners. Higher rates (900 gpm) would have been desirable.

Recommendations

- Rig pump capable of pumping 900 gpm.
- Increase HSI[1] by reducing the bit nozzle size (TFA[2]) to improve hole cleaning and reduce bit balling issues.

IV. Drilling Operations Vertical Section for Intermediate Casing

12-1/4" hole was drilled from the surface shoe to a depth of 5113 feet. Intermediate casing was run and cemented. Figure 7 shows the depth drilled versus time on bottom.

[1] HSI indicates Hydraulic Horsepower per square inch.
[2] Total Flow Area (TFA) is summation of nozzle areas through which fluid can pass in a bit.

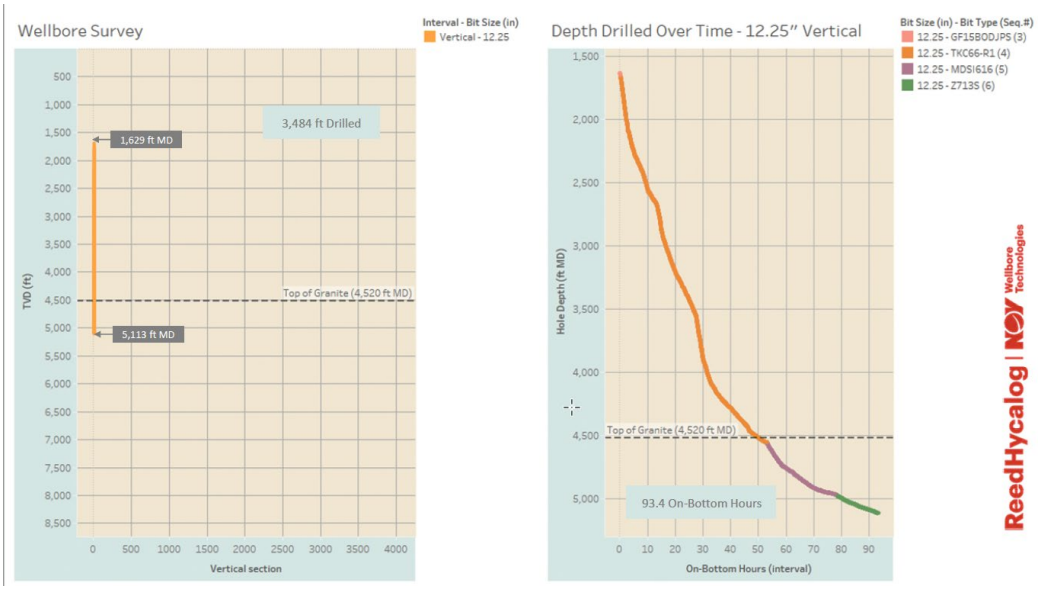

Figure 7. Intermediate casing was set at 5113 ft.

IV.1 Drilling BHA 02: 1,605' to 1,629'

BHA 02 is described in Table 4. . An attempt was made to drill the surface casing floats with the VRSS (Figure 8) and a PDC bit. The bit used is shown in Figure 9. After little progress, it was decided to POOH and pick up a tricone bit for drilling the shoe track.

Figure 8. Scout Vertical Rotary Steerable System.

Table 4. BHA 02 1,605' to 1,605' (Failed to drill plug)

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	NOV 12 1/4 TKC 66	NOV	E266453	12 1/4		2	2	6 5/8 REG
2	9 5/8" Vertical Scout RSS	Scout	SDI-962-VS08-016	9 5/8		20.79	22.79	6 5/8 REG
3	6 5/8 Reg Pin X 6 5/8 Reg Pin X-Over	Scout	SDI-800-XO-047	8 1/16	2 3/4	2.19	24.98	6 5/8 REG
4	9 5/8" Scout 7/8 5.9 stg Straight Fixed 12 1/8" Stab	Scout	TDI-OSA-962-01-	8 1/8		41.11	66.09	6 5/8 REG
5	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	79.61	6 5/8 REG
6	12 1/8" Steel Stabalizer	Stabildrill	SD29018	8 1/16	2 3/4	4.97	84.58	6 5/8 REG
7	8" NMDC	Stabildrill	SD55421	8 1/4	3 1/4	29.52	114.1	6 5/8 REG
8	8" Hang off Sub	Scout	SDI-825-OSTM-008	8 1/4	3 1/4	5.09	119.19	6 5/8 REG
9	4 Stands of 8" DC					366.49	485.68	6 5/8 REG
10	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	Rig	8	2 3/4	2.8	488.48	4 1/2 IF
11	3 Stands of HWDP					276.35	764.83	4 1/2 IF

Figure 9. NOV TKC 66. Notice the highlighted damage inside the red circle.

IV.2 Drilling BHA 03: 1,605' to 1,644'

BHA 03 (Table 5) was the same assembly as BHA 02 except for the VRSS and the bit. The procedure was to tag the casing floats at 1,605' and drill out the floats and cement. Drilling proceeded with 15 feet of new hole from 1,629' to 1,644', after which an FIT

was performed at 9.5 ppg.

Table 5. BHA 03 1,605' to 1,644'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	12.25" GF15BODJPS Smith Rock Bit	Smith	RK6139	12 1/4		1.1	1.1	6 5/8 REG
2	9 5/8" Scout 7/8 5.9 stg Straight Fixed 12 1/8" Stab	Scout	TDI-OSA-962-01-	8 1/8		41.11	42.21	6 5/8 REG
3	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	55.73	6 5/8 REG
4	4 Stands of 8" DC					366.49	422.22	6 5/8 REG
5	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	Rig	8	2 3/4	2.8	425.02	4 1/2 IF
6	3 Stands of HWDP					276.35	701.37	4 1/2 IF

Lessons Learned

- BHA 02 unsuccessfully attempted to drill out the shoe track with the VRSS and PDC bit. On pulling, the bit had two chipped cutters, as shown in Figure 9. The lesson is to drill the float equipment with a conventional BHA or confirm float equipment is PDC drillable.

Recommendations

- Drill the casing float equipment with a tri-cone bit to prevent PDC cutter damage (see Figure 9).
- The Smith 12 -1/4" tri-cone bit is stored in the Conex trailer on the 16A pad.

IV.3 Drilling BHA 04: 1,644' to 4,552'

BHA 04 (Table 6 and Figures 10 and 11) drilled from 1,644' to 4,552'. This BHA drilled just past the approximate top of the granite. It performed adequately, drilling 2,908 ft with an average ROP of 49 fph. The BHA was pulled because of low ROP. Verticality was maintained along the run with the rotary steerable system. At surface, the tools were noted to be undamaged and functional: the motor drained adequately, the motor stabilizer was 1/16" under gauge.

Lessons Learned

- The rig pumps could only deliver 800 gpm due to pressure limitations of the liners and the electrical connections permitting only two of the three pumps to run simultaneously.
- Maintain adequate mud products on location to prevent bit balling. Improved HSI is the real solution.

- The motor used to drill this section was a 9 5/ 8” 7/8 5.9 stage rev/gal 0.155. Pick up a faster motor; for example, run a 9 5/8” 7/8 5.7 stage rev/gal 0.242.
- More WOB and a higher speed motor appeared desirable for higher ROP.
- Control drill to maintain desired inclination.
- Monitor MSE for any trend changes(Figure 12).

Table 6. BHA 04, 1,644' to 4,552'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	NOV 12 1/4 TKC 66	NOV	E266453	12 1/4		2	2	6 5/8 REG
2	9 5/8" Vertical Scout RSS	Scout	SDI-962-VS08-027	9 5/8		20.65	22.65	6 5/8 REG
3	6 5/8 Reg Pin X 6 5/8 Reg Pin X-Over	Scout	SDI-800-XO-046	8	2 3/4	2.16	24.81	6 5/8 REG
4	9 5/8" Scout 7/8 5.9 stg Straight Fixed 12 1/8" Stab	Scout	TDI-OSA-962-01-	8 1/8		41.11	65.92	6 5/8 REG
5	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	79.44	6 5/8 REG
6	12 1/8" Steel Stabalizer	Stabildrill	SD29018	8 1/16	2 3/4	4.97	84.41	6 5/8 REG
7	8" NMDC	Stabildrill	SD55421	8 1/4	3 1/4	29.52	113.93	6 5/8 REG
8	8" Hang off Sub	Scout	SDI-825-OSTM-008	8 1/4	3 1/4	5.09	119.02	6 5/8 REG
9	4 Stands of 8" DC					366.49	485.51	6 5/8 REG
10	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	Rig	8	2 3/4	2.8	488.31	4 1/2 IF
11	3 Stands of HWDP					276.35	764.66	4 1/2 IF

Figure 10. Rerun from BHA 02. Views of each blade are shown in Figure 11. This is a ReedHycalog TKC 66R1. It drilled 2908 feet in 59.58 hours at 48.8 ft/hr.

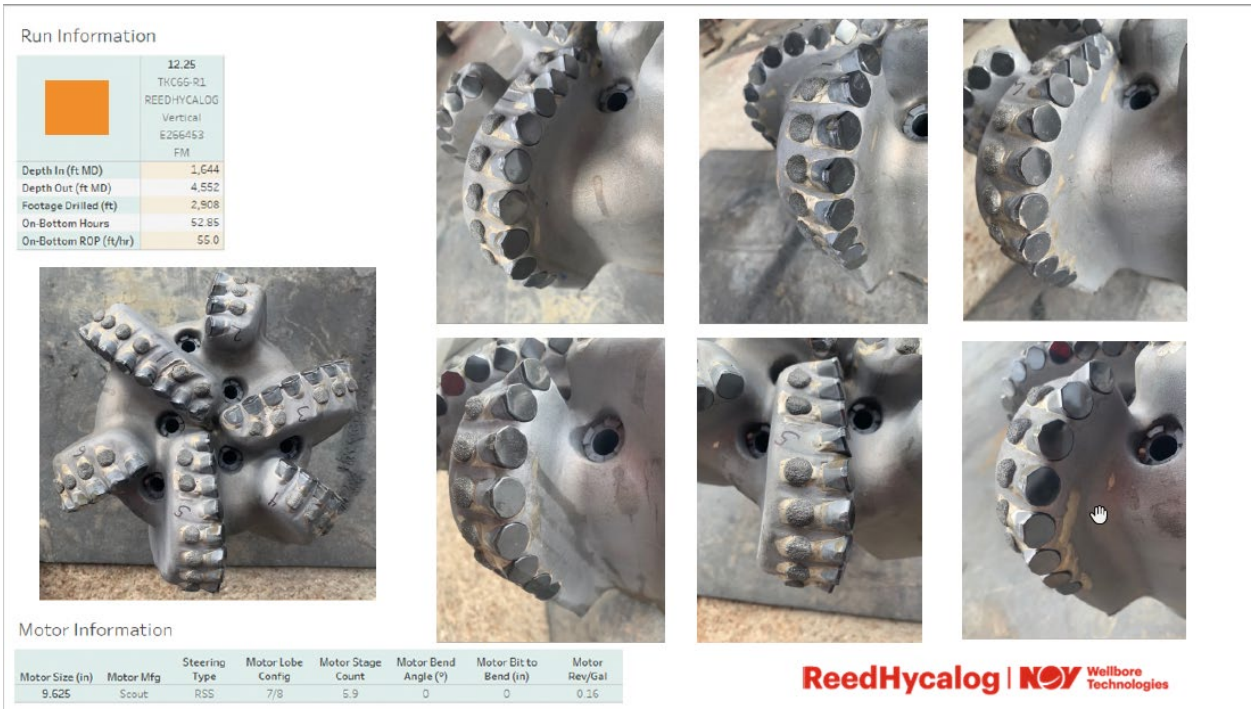

Figure 11. NOV Reed TKC66R1 bit that drilled from 1,644' to 4,552'. The bit performed adequately and this was an appropriate bit selection for this drilling section. The attributes were six blades, 16 mm cutters, impact resistors, ION 3D Cutters and a matrix body (erosion/abrasion present).

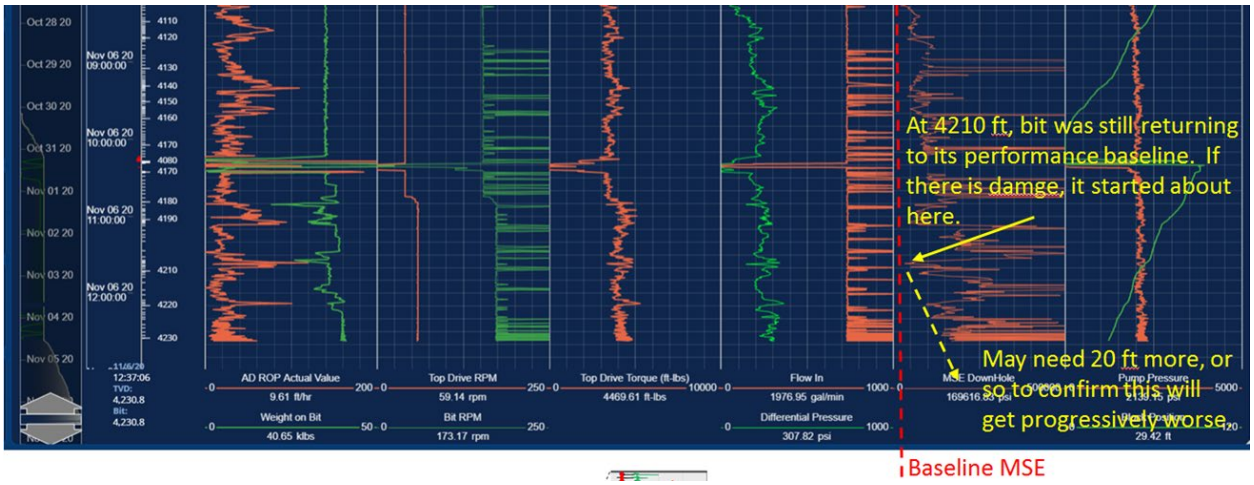

Figure 12. Monitoring MSE was particularly valuable. This shows diagnosis of bit failure (after the fact). The real value is in real-time evaluation and the increasing MSE was why the bit was pulled.

IV.4 Drilling BHA 05: 4,552' to 4,964'

BHA 05 (Table 7 and Figure 13) was pulled due to general and progressively lower ROP caused by severe bit damage. The Vertical Scout RSS, motor, and MWD were all

undamaged when inspected at the surface. Verticality was kept without issue. Footage drilled was 412 feet with an average ROP of 14 fph. A step test for weight on bit was performed - ranging from 20K to 50K lb- to optimize drilling using MSE. The WOB was limited to 45,000 lb.

Table 7. BHA 05 (4552 to 4964 ft MD)

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	12.25 Smith MDSi616	Smith	JM7398	12 1/4		2	2	6 5/8 REG
2	9 5/8" Vertical Scout RSS	Scout	SDI-962-VS08-027	9 5/8		20.65	22.65	6 5/8 REG
3	6 5/8 Reg Pin X 6 5/8 Reg Pin X-Over	Scout	SDI-800-XO-046	8	2 3/4	2.16	24.81	6 5/8 REG
4	9 5/8" Scout 7/8 5.9 stg Straight Fixed 12 1/8" Stab	Scout	OSA-962-01-006	8		41.12	65.93	6 5/8 REG
5	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	79.45	6 5/8 REG
6	12 1/8" Steel Stabalizer	Stabildrill	SD25600	8 3/8	2 3/4	5.8	85.25	6 5/8 REG
7	8" NMDC	Stabildrill	SD55421	8 1/4	3 1/4	29.52	114.77	6 5/8 REG
8	8" Hang off Sub	Scout	SDI-825-OSTM-008	8 1/4	3 1/4	5.09	119.86	6 5/8 REG
9	4 Stands of 8" DC					366.49	486.35	6 5/8 REG
10	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	Rig	8	2 3/4	2.8	489.15	4 1/2 IF
11	3 Stands of HWDP					276.35	765.5	4 1/2 IF

Lessons Learned

- The rig pumps could only pump 800 gpm due to pressure limitations of the liners.
- The motor used to drill this section was a 9 5/8" 7/8 5.9 stage rev/gal 0.155. Pick up a faster motor – for example, run a 9 5/8" motor 7/8 5.7 stage rev/gal 0.242. The higher speed motor has proven to provide improved ROP.
- The WOB was controlled utilizing MSE and limited to 45Klb, monitoring shock and vibe, and trying to avoid stick slip.
- **Use 13 mm cutters in the granite.**

Figure 13. Smith MDiS616. This bit drilled from 4,552 to 4964 ft MD. The apparent initial failure mode sequence could have been micro-chipping and spalling. The failure may have been compounded by potential axial vibration. This bit run, like most others in the granite, (refer to Figure 14), showed high initial ROP and a relatively rapid drop thereafter. Rhyolitic layer in Well 58-32 suggests higher compressive strength near the top of the granite. Two rhyolites were encountered in well 16A(78)-32.

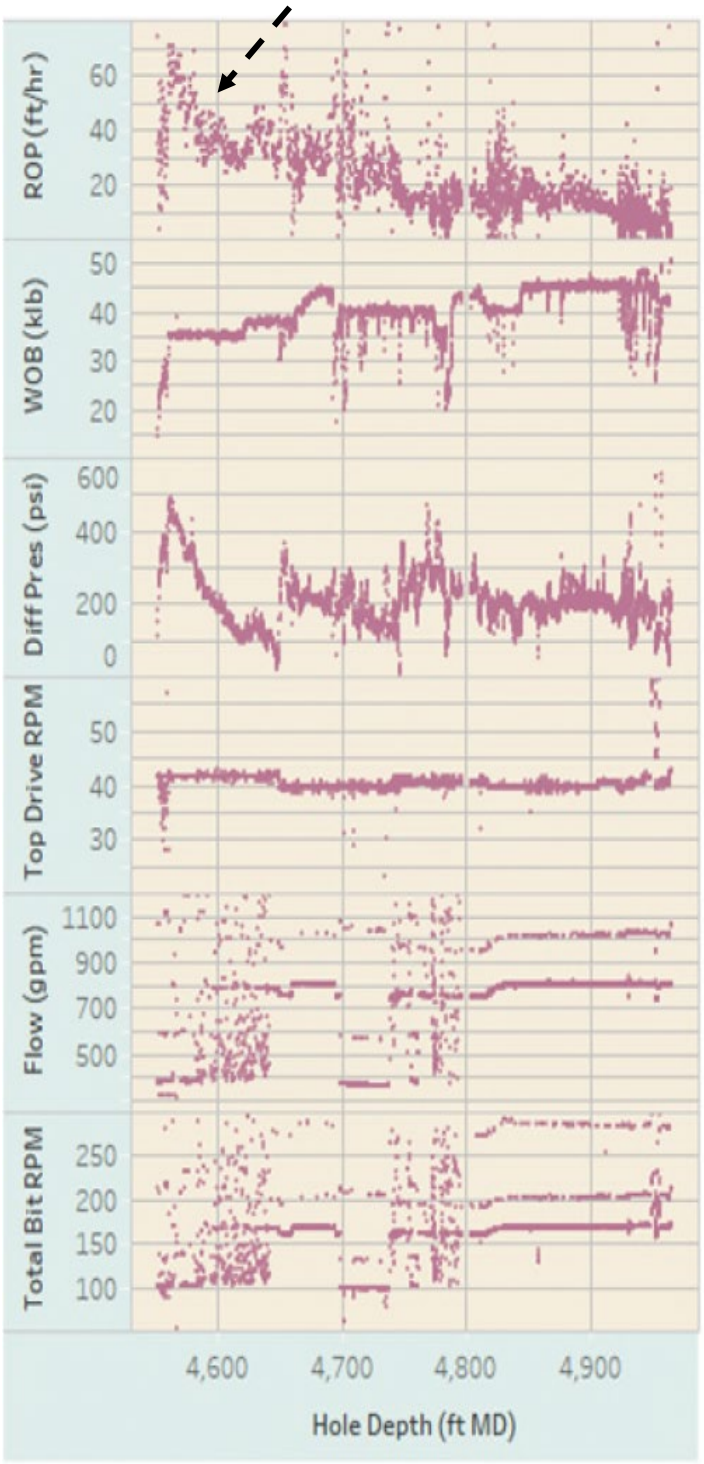

Figure 14. Performance during drilling from 4,552 to 4964 ft MD using BHA05. The arrow highlights a characteristic feature for many of the bits and the BHAs in all sections of this well – high initial rate followed by stabilized lower or decreasing ROP.

IV.5 Drilling BHA 06: 4,964' to 5,113'

BHA 06 (Table 8 and Figure 15) drilled 149 feet with an average ROP of 9 fph. It was pulled because of poor performance and the casing point was called. At the surface, both stabilizers and the bit had clay-like material attached, which could explain the very slow ROP.

Table 8. BHA 06 Drilled from 4,964 to 5,113 feet

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Z713S Smith 2x18's 4x20' 1x16	Smith	JP4755	12 1/4		2	2	6 5/8 REG
2	9 5/8" Vertical Scout RSS	Scout	SDI-962-VS08-027	9 5/8		20.65	22.65	6 5/8 REG
3	6 5/8 Reg Pin X 6 5/8 Reg Pin X-Over	Scout	SDI-800-XO-046	8	2 3/4	2.16	24.81	6 5/8 REG
4	HT 9 5/8" Scout 7/8 5.9 stg Straight Fixed 12 1/8" Stab	Scout	OSA-962-01-031C	9 5/8		41.18	65.99	6 5/8 REG
5	8" Shock Sub	NOV	160-80692	8 3/8	2 3/4	13.52	79.51	6 5/8 REG
6	12 1/8" Steel Stabalizer	Stabildrill	SD25600	8 3/8	2 3/4	5.8	85.31	6 5/8 REG
7	8" NMDC	Stabildrill	SD55421	8 1/4	3 1/4	29.52	114.83	6 5/8 REG
8	8" Hang off Sub	Scout	SDI-825-OSTM-008	8 1/4	3 1/4	5.09	119.92	6 5/8 REG
9	4 Stands of 8" DC					366.49	486.41	6 5/8 REG
10	6 5/8 Reg Pin X 4 1/2IF Box X-Over	Rig	Rig	8	2 3/4	2.8	489.21	4 1/2 IF
11	3 Stands of HWDP					276.35	765.56	4 1/2 IF

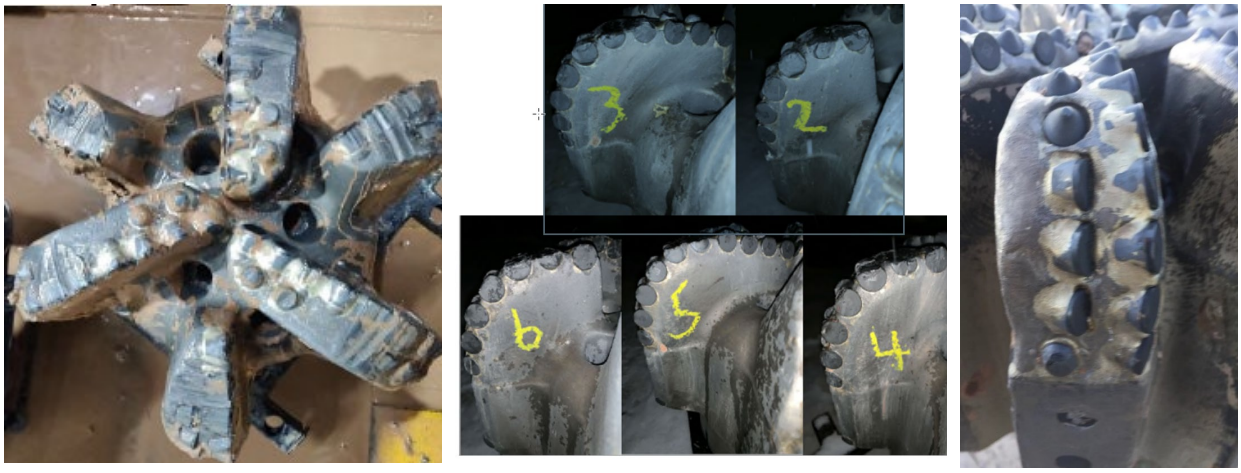

Figure 15. Smith Z713 Smith Z713. This bit drilled from 4,964' to 5,113'.Conical cutting elements were used in the primary cutting structure (cone). The conical cutting elements may have restricted the depth-of-cut. Although this bit had good dull condition, there was degraded ROP. Some of this may be related to weight transfer from the VRSS.

Lessons Learned and Recommendations

- The rig pumps – as configured - could only pump 800 gpm due to pressure limitations of the liners.
- Bit balling was experienced. Mud additives should be available on site in the event that bit balling is diagnosed.
- The motor used to drill this section was a 9 5/8" Scout, 7/8 5.9 stage rev/gal 0.155. A recommendation is to run a 9 5/8" motor 7/8 5.7 stage rev/gal 0.242.
- The shearing cutting elements proved to be more effective.
- Use 13 mm cutters in the granite.
- The WOB could go to 55K lb_f.
- The WOB and other drilling parameters must be "controlled" with MSE, monitoring shock and vibe, and trying to avoid or control stick slip and whirl.

IV.6 BHA 07: Gyro BHA

The procedure for acquiring the gyro data was as follows: tripped in the hole to 5,113', cooled hole prior to dropping survey tool, tripped out of the hole with survey tool acquiring surveys.

IV.7 Casing Point – 9 5/8" 40 ppf HCL80 to 5,110'

The intermediate hole reached TD at 5,113 ft . Verticality was maintained. 9-5/8", 40 ppf, HCL 80 casing was run to a depth of 5,113 ft. Bottom was confirmed at 5,113' and the string was picked up to 5,110 ft MD before cementing. The casing was cemented successfully. However, the plug was not bumped, and the floats did not hold. There were similar issues for the surface casing.

Recommendations

- Increase the HSI by reducing the TFA to improve hole cleaning and help to reduce bit balling issues. Figure 16 shows two examples of the consequences of bit balling.
- Any of the cutter structures shown in Figure 17 can be fine-tuned to successfully drill the granite. Any one of the bit companies - Schlumberger Smith, NOV Reed-Hycalog, and Ulterra can provide the bits with an appropriate cutter pattern.
- Drill the intermediate hole to top of granite with 5 blade or 6 blade PDC, 16 mm cutters. The bit should be jetted for 1.4 to 1.3 HSI. The preferred mud motor would have a fixed 1.50 bit to bend and a 9 5/8" 7/8 5.7 stage, 0.242 rev/gal.
- Drill the granite with fixed 1.25 bit to bend motor and a 9 5/8" 7/8 5.7 stage, 0.242 rev/gal. The TFA range should be within .98 to .85. The preferred cutter size is 13 mm and the cutters should be 1 mm to 1.5 mm off tip. The HSI has no discernable effect in the granite. Confirm with the vendor that the maximum weight on bit is 45,000 to 50,000 lb_f.

Figure 16. Two examples of clay-like material attached to the BHA and impeding ROP.

Figure 17. Generic bit configurations that were better performers. In the granite, 13 mm cutters were more effective. As time went on, more cutter refinements evolved.

V. Vertical Portion of 8-3/4" Production Hole

The depth chronology is shown in Figure 18.

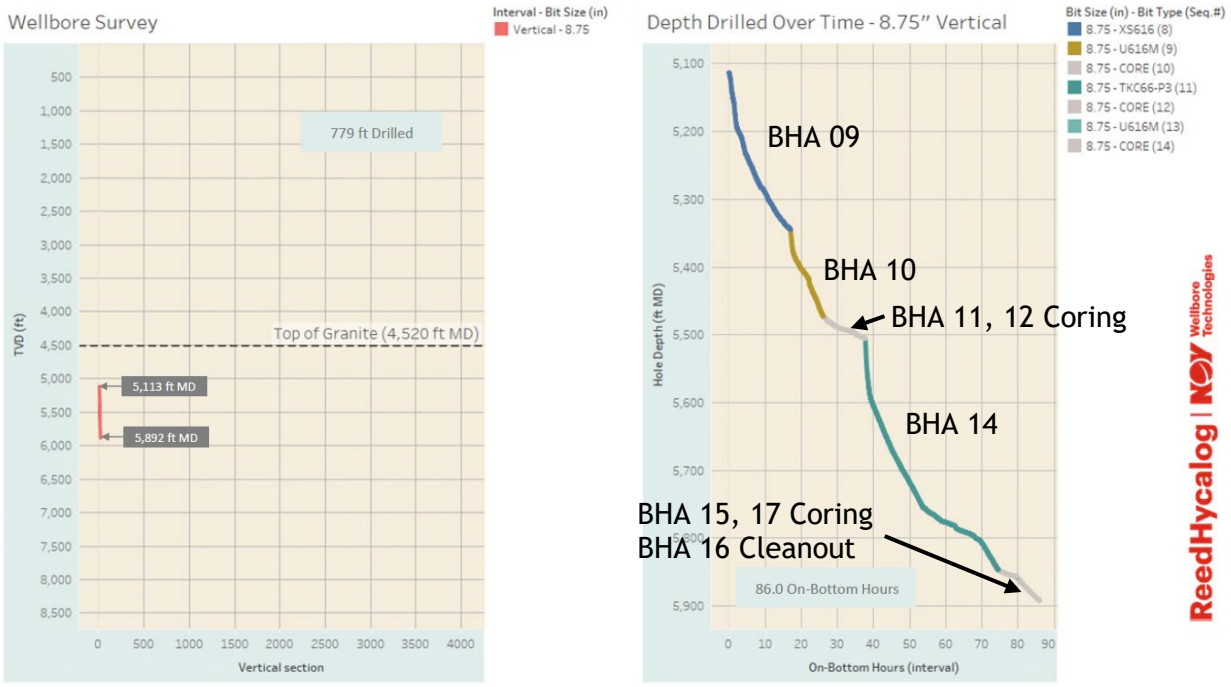

Figure 18. Depth chronology for the vertical part of the 8-3/4-inch hole.

V.1 Drilling BHA 09: 5,113' to 5,345'

After drilling out the shoe with a mill tooth bit (BHA 08, as shown in Figure 19), BHA 09 was run in the hole (PDC bit, Table 9, and Figure 20) and the rig drilled 232 ft with an ROP of 13 fph. After the first 15 ft below the shoe, an FIT was performed at 9.6 ppg EMW. Verticality was maintained without any issues. At the surface, all tools appeared to be functional. The bit was generally in good shape with only one chipped cutter on the shoulder area, but it was just a slow ROP bit for this formation.

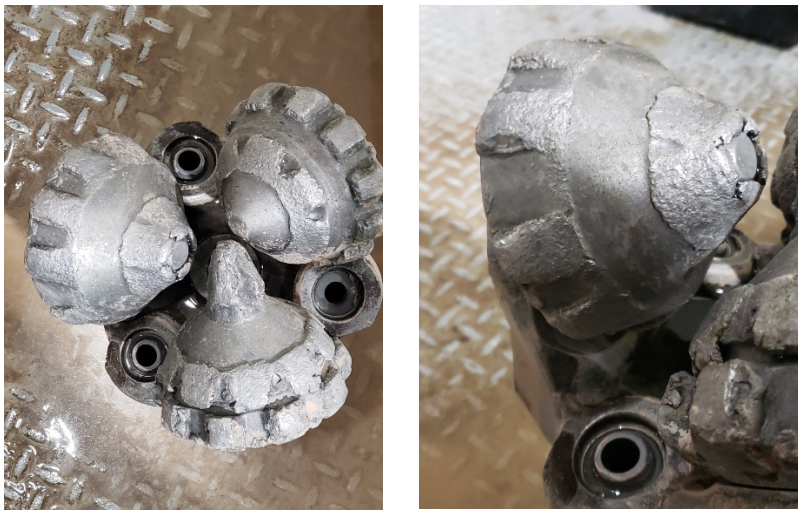

Figure 19. Mill tooth bit (before and after the run).

Table 9. BHA 09 (5,113' to 5,345')

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	XS 616 Smith Bits	Smith	JV2705	8 3/4		0.85	0.85	4 1/2 REG
2	712 Vertical Scout RSS	Scout	712-VS08-011	7 1/8		19.6	20.45	4 1/2 IF
3	6 1/2 Scout 7/8 3.0 Straight Fixed 8 15/16 Stab Pin	Scout	650-05-433	6 1/2		28.48	48.93	4 1/2 IF
4	6 1/2" Shock Sub NOV	NOV	147-0009	6 3/4	2 1/4	10.81	59.74	4 1/2 IF
5	6 3/4 Stabil Drill NM Stabilizer	Stabil	SD 610501	6 3/4		6.87	66.61	4 1/2 IF
6	6 1/2" Scout UBHO	Scout	650-UBHO-083	6 1/2	2 3/4	3.11	69.72	4 1/2 IF
7	6 3/4 NMDC	Stabil Drill	SD 55831	6 3/4		30.35	100.07	4 1/2 IF
8	7 Stands of DC's		Rig	6 1/2	3	644.15	744.22	4 1/2 IF
9	3 Stands of HWDP					276.35	1020.57	4 1/2 IF

Figure 20. Smith XS 616. This bit, as with all others showed a characteristic rapid ROP-drop in the first 100 feet or so that was drilled. The run showed the inefficiency of 16 mm cutters. Schlumberger Smith's maximum allowable weight on bit was 45,000 lb_f and, at the time, it is felt that one needs at least 50,000 lb_f to engage all the cutters and prevent bit whirl. The VRSS was having difficulties holding angle and therefore a lower weight on bit was mandated.

Lessons Learned

- The motor used to drill this section was a 9 5/8" Scout, 7/8 5.9 stage rev/gal 0.155. A recommendation would be running a 9 5/8" 7/8 5.7 stage rev/gal 0.242.
- For the Schlumberger Smith XS 616, the maximum allowable weight on bit was 45,000 lb_f and it is anticipated that one would need at least 50,000 lb_f to engage all of the cutters.
- The WOB ranged from 35,000 lb_f to 45,000 lb_f and this may well have been a major cause of chipping.
- The VRSS had difficulties holding angle and had to use lower weights.
- MSE, shock and vibe, and stick slick were all indicators of low bit performance

or other dysfunction. Figure 21 shows dysfunction starting at 5311 ft. Figure 22 documents an rpm step test for ROP optimization.

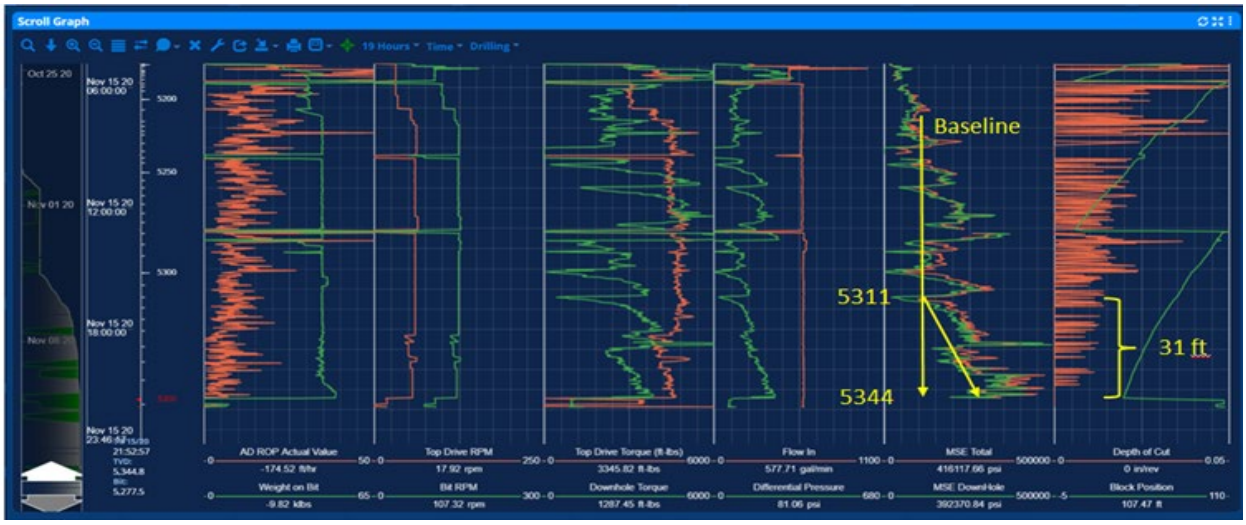

Figure 21. A good example of MSE returning to the baseline and then – ultimately and quickly increasing as an indicator of bit failure.

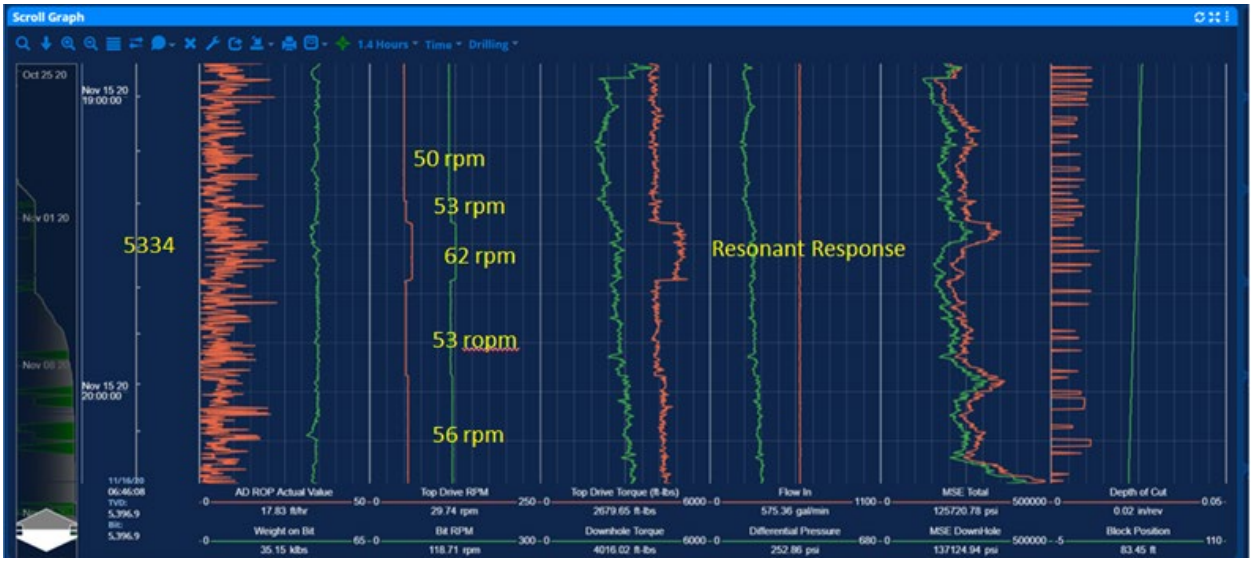

Figure 22. An rpm step rate test was carried out and clearly demonstrated resonant response to be avoided.

Recommendations

- Confirm the maximum weight and torque values for the VRSS, MWD and mud motor before going in the hole.

V.2 Drilling BHA 10: 5,345' to 5,473'

BHA 10 (Table 10 and Figure 23) drilled 124 ft with an average ROP of 13 fph. The BHA

was pulled since the core point was reached. Verticality was maintained without any issues. The motor, Vertical Scout RSS, and shock sub appeared to be undamaged and functional at the surface. The bit (Ulterra U616M) came out in good shape; it was just a slow bit for this formation. **There may have also been weight transfer issues that impeded functionality of this bit.**

Lessons Learned

- The motor used to drill this section was a 9 5/8" Scout, 7/8 5.9 stage rev/gal 0.155. Scout recommends running a 9 5/8" 7/8 5.7 stage rev/gal 0.242 in the future.
- Ulterra allowed all the weight on bit that was needed. The WOB was varied from 35k to 55K to identify optimal running conditions.
- The VRSS was having difficulties holding angle and it was necessary to use lower weights. This was a major cause of chipped cutters, whirl, shock, vibrations and low ROP.
- At a depth of 5,345' the maximum WOB for VRSS was prescribed by the vendor as 35,000 lb_f. In the future, confirm the maximum weight for the MWD, MM and VRSS before going in the hole.
- MSE, shock and vibe, and stick slip were all indicators of low bit performance. Figure 24 indicates the importance of entering the correct motor parameters for MSE. An rpm step test is shown in Figure 25 and Figure 26 reinforces the characteristic rapid ROP drop during early bit life.

Table 10. BHA 19 (5345 to 5473 ft)

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Ulterra U616M	Ulterra	54132	8 3/4		0.95	0.95	4 1/2 REG
2	712 Vertical Scout RSS	Scout	712-VS08-011	7 1/8		19.6	20.55	4 1/2 IF
3	6 1/2 Scout 7/8 3.0 Straight Fixed 8 15/16 Stab Pin	Scout	650-05-433	6 1/2		28.48	49.03	4 1/2 IF
4	6 1/2" Shock Sub NOV	NOV	147-0009	6 3/4	2 1/4	10.81	59.84	4 1/2 IF
5	6 3/4 Stabil Drill NM Stabilizer	Stabil	SD 610501	6 3/4		6.87	66.71	4 1/2 IF
6	6 1/2" Scout UBHO	Scout	650-UBHO-083	6 1/2	2 3/4	3.11	69.82	4 1/2 IF
7	6 3/4 NMDC	Stabil Drill	SD 55831	6 3/4		30.35	100.17	4 1/2 IF
8	7 Stands of DC's		Rig	6 1/2	3	644.15	744.32	4 1/2 IF
9	3 Stands of HWDP					276.35	1020.67	4 1/2 IF

Figure 23. Photographs of the Ulterra U616M after being tripped out. As with all other bits there was a characteristic rapid ROP-drop in the first 100 feet or so. 16mm cutter inefficiency was demonstrated. Ulterra allowed all the weight on bit that was needed. The WOB ranged from 35K to 55K lb. The VRSS had difficulties holding angle and had to use lower weights - this was a major cause of low ROP.

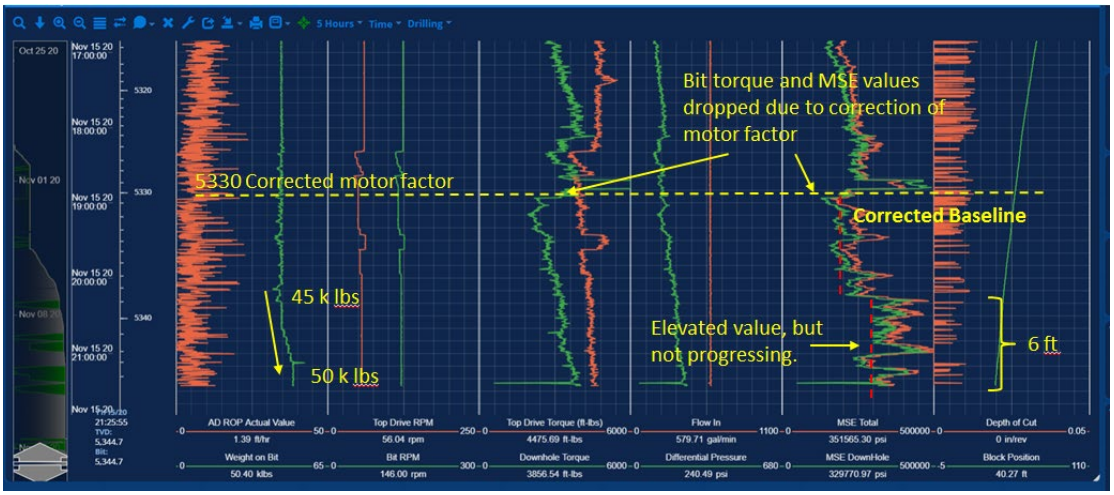

Figure 24. Correct motor factors entered.

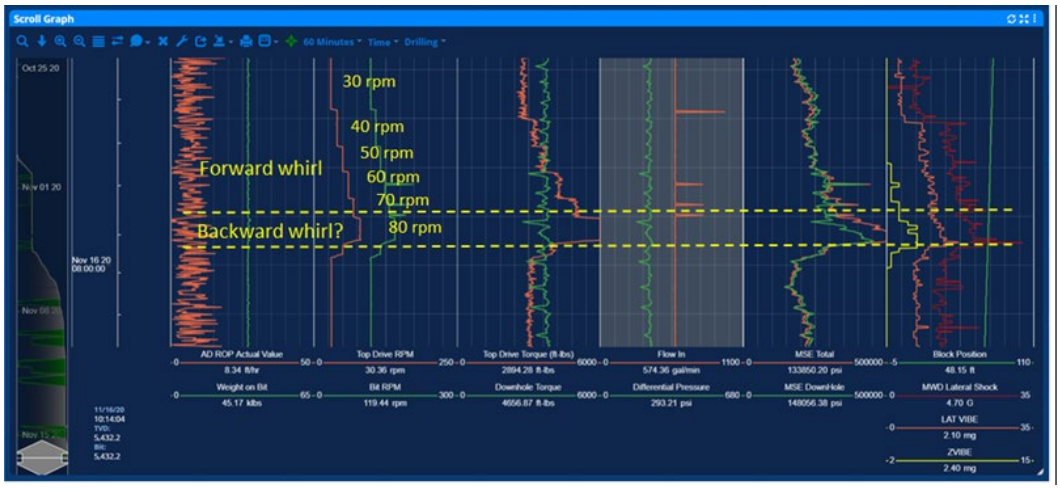

Figure 25. Another example of using step testing and MSE to optimize ROP, bit life.

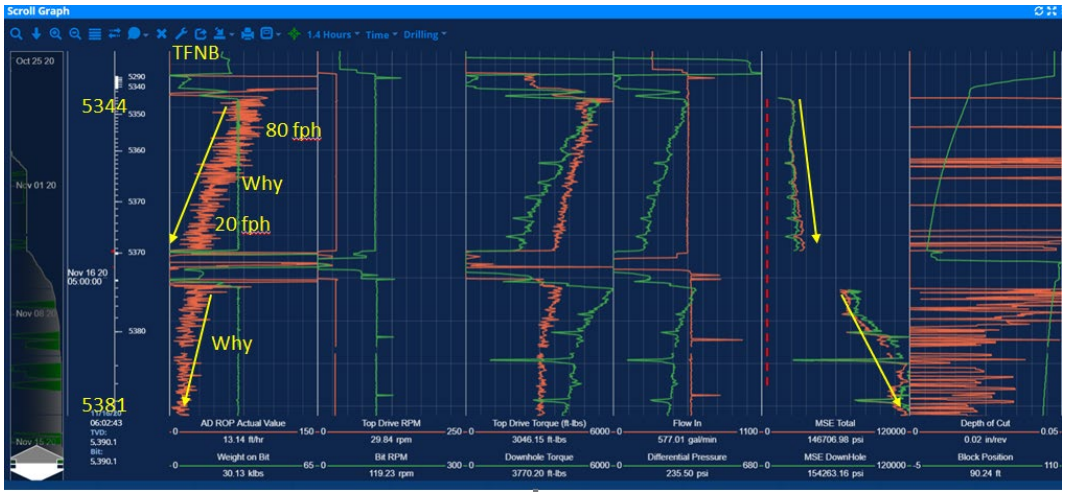

Figure 26. Characteristic early-life rate reduction.

V.3 Log 9 5/8" Intermediate Casing: Surface to 5,110'

Due to scheduling issues, Schlumberger ran a cement evaluation survey at this time. Run #1 was the Isolation Scanner, IBC, CBL and it was followed by Run #2 for temperature. This provided an indication of cement quality and a baseline for casing wear assessments. The granite contact is at 4552± ft MD/TVD. There was no openhole logging of the intermediate hole because of the open alluvium sections above. All logs are posted to the Geothermal Data Repository.

V.4 Coring BHA 11: 5,473' to 5,494'

BHA 11 (the coring bit is shown in Figure 27) went in at 5,473' and was tripped out due to slow ROP at 5,494'. The specifics of this coring assembly are as follows.

- CCl 700 Series – Equipped with JMS for jam mitigation
- 90' of core barrel

- Bit Type: CCl – 913 (Figure 27)
- Depth Cored: 5,473’ - - 5,494’. 21’ of core cut. 15.5’ of core recovered.
- ROP 3’/hr. 350-400 GPM. 4K-8K WOB.
- 5.5’ of core was presumed to have been milled or left on bottom. Later it was felt that the core did not break off from the bottom of the hole. Improved core catching is required.

Table 11 is a synopsis of all coring activity in the well.

Figure 27. Two views of the recovered core bit with severely damaged cutters.

Table 11. Synopsis of all Coring Activity in Well 16A(78)-32

Summary: Coring Runs and Drill Aheads/Clean Bottom											
Run	1	2	Drill ahead/ cleaned bottom	3	Drill ahead/ cleaned bottom	4	Drill ahead to next core point	5 Slant Section	Drill ahead/ cleaned bottom	6 Slant Section	Total
BHA Type	90’ JMS	90’ JMS	Drilling	90’ JMS	Drilling	60’ JMS	Drilling	30’ Conv.	Drilling	30’ Conv.	
Depth In	5,473'	5,494'	5,505'	5,846'	5,856'	5,858'	5,892'	10,995'	10,971'	10,973'	
Depth Out	5,494'	5,504'	5,844'	5,856'	5,858'	5,892'	10,995'	10,971'	10,973'	10,987'	
Cored /Drilled	21’	10’	339’	10’	2’	34	5,103’	16’	2’	14’	105’
Recovered	15.5’	1.2’	N/A	8.8’	N/A	31.5’	N/A	7.20’	N/A	10.20’	74.4’
JMS Deployments	2	2	N/A	1	N/A	1	N/A	N/A	N/A	N/A	6

V.5 Coring BHA 12: 5,494' to 5,504'

BHA 12 (the bit is shown in Figure 28) went in at 5,494' and was tripped out due to slow ROP at 5,504'. The specifics are:

- CCl 700 Series – Equipped with JMS.
- 90' of core barrel.
- Bit Type: CCl – 913.
- 10' of core cut. 1.2' of core recovered.
- ROP 3.2'/hr. 350-400 GPM. 40-60 RPM. 4K-8K WOB.
- 8.8' of core presumed milled or left on bottom.

Figure 28. Core Run 2, bit DBR. Core recovered is shown at right.

V.6 Temperature Survey BHA 13: 5,504'

BHA 13 was run for a 16-hour temperature buildup survey. The survey tool was landed at 5,499' MD. The survey is shown in Figure 29.

V.7 Drilling BHA 14: 5,504' to 5,846'

BHA 14 (Figures 30 and 31 and Table 12) drilled 342 ft with an average ROP of 8.7 fph. This was run while waiting on coring bits. Due to tolerances for the VRSS, WOB was dramatically dropped mid-run. While the bit was cored out, it came out of the hole in gauge, with undamaged side cutters.

Lessons Learned:

- A 0.16 rpg motor proves to be ROP/DOC limiting and a 0.24 rpg motor would ;likely be more optimal.
- As with other bits, ROP dropped after being initially high.

- 16mm cutters are not efficient after reaching the granite.
- The WOB helped to keep the axial vibrations down. When the WOB was higher than 45 klb there were low levels of axial vibrations. For surface RPMs lower than 40 rpm there were low levels of lateral vibrations.
- "The lithology showed to have some effect on the bit dynamics. Scout felt that when "hematite" (per mud logger) was absent, it is possible that the bit can have a bigger bite resulting in higher ROP and higher tangential shocks at the bit. A higher motor torque may help to minimize this effect (7/8 5.7). *Whether it is hematite or a different mafic mineral, this correlation should be looked at.*
- The bit suffered severe damage, probably produced by the constant axial and tangential shocks observed at the end of the run caused by the reduction in WOB.

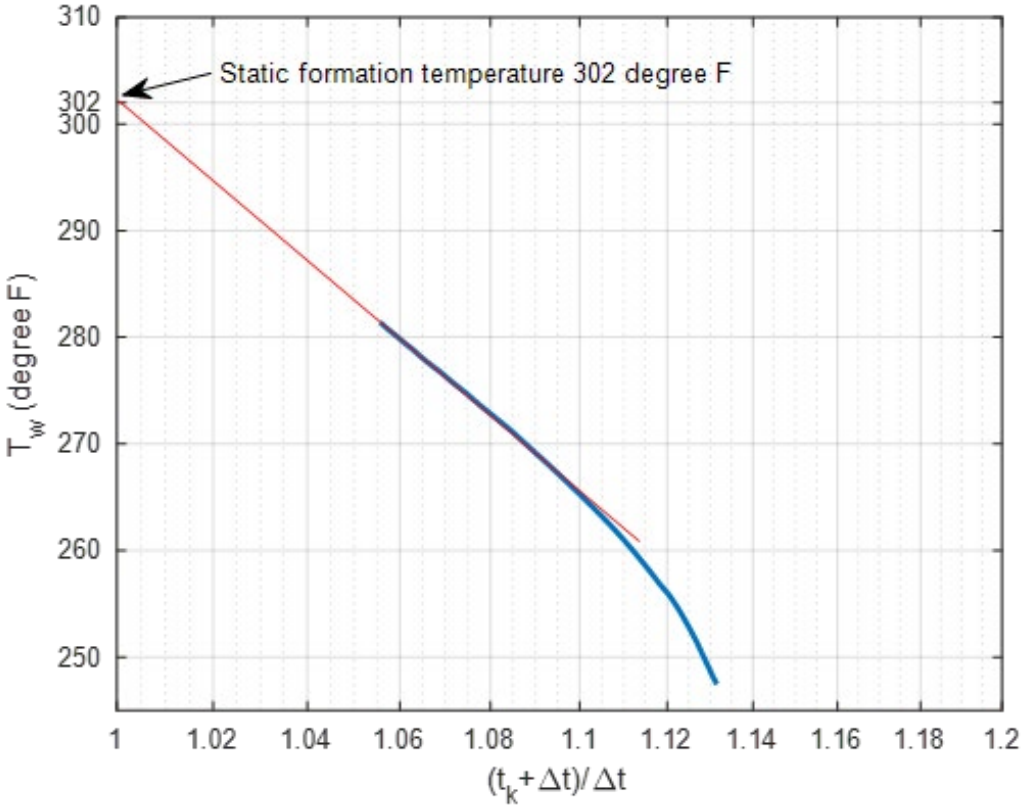

Figure 29. A pseudo static temperature measurement was made at 5499 ft MD. Using standard, Horner-type extrapolations, the temperature at depth was inferred to be approximately 300°F.

Table 12. BHA 14: 5,504' to 5,846'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed TKC66	Reed	A271699	8 3/4		1	1	4 1/2 REG
2	712 Vertical Scout RSS	Scout	712-VS08-011	7 1/8		19.6	20.6	4 1/2 IF
3	6 1/2 Scout 7/8 3.0 Straight Fixed 8 11/16 Stab Pin	Scout	650-05-433	6 1/2		28.48	49.08	4 1/2 IF
4	6 1/2" Shock Sub NOV	NOV	147-0009	6 3/4	2 1/4	10.81	59.89	4 1/2 IF
5	6 3/4 Stabil Drill NM Stabilizer	Stabil	SD 610501	6 3/4		6.87	66.76	4 1/2 IF
6	6 1/2" Scout UBHO	Scout	650-UBHO-083	6 1/2	2 3/4	3.11	69.87	4 1/2 IF
7	6 3/4 NMDC	Stabil Drill	SD 55831	6 3/4		30.35	100.22	4 1/2 IF
8	8 Stands of DC's		Rig	6 1/2	3	734.92	835.14	4 1/2 IF
9	3 Stands of HWDP					276.35	1111.49	4 1/2 IF

Bit TKC66-P3; TFA = 0.90
Motor 7/8 3.0; Single 8 15/16'' Stab
String Stabilizers 8 5/8"
Shock Sub in the String

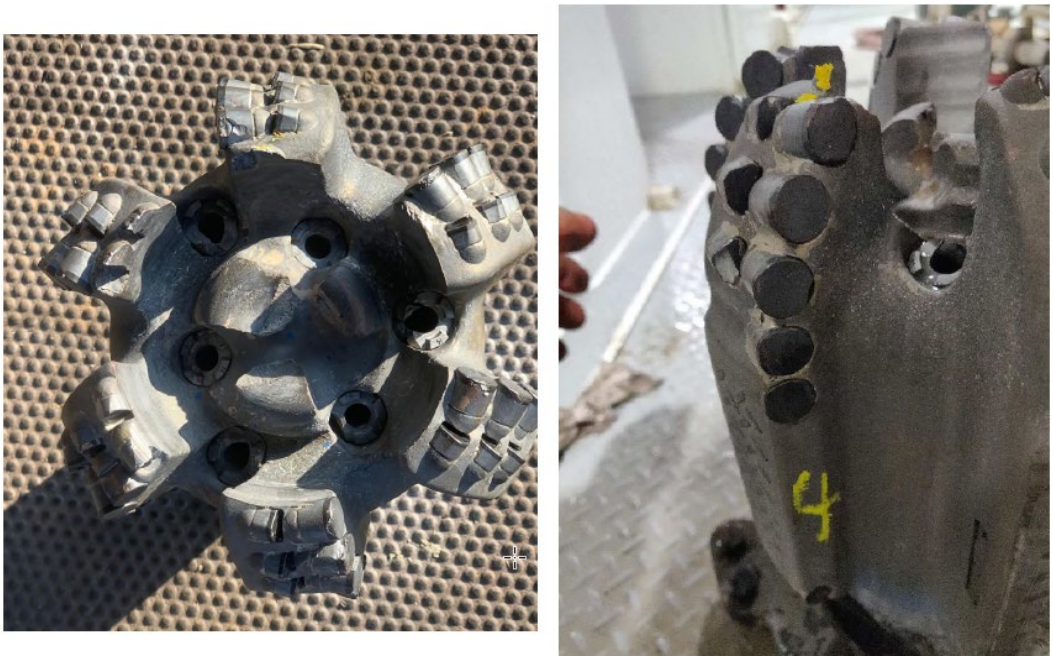

Figure 30. ReedHycalog TKC66-P3 bit. Bit grading: 8-3-CR-C-X-I-CT-CP.

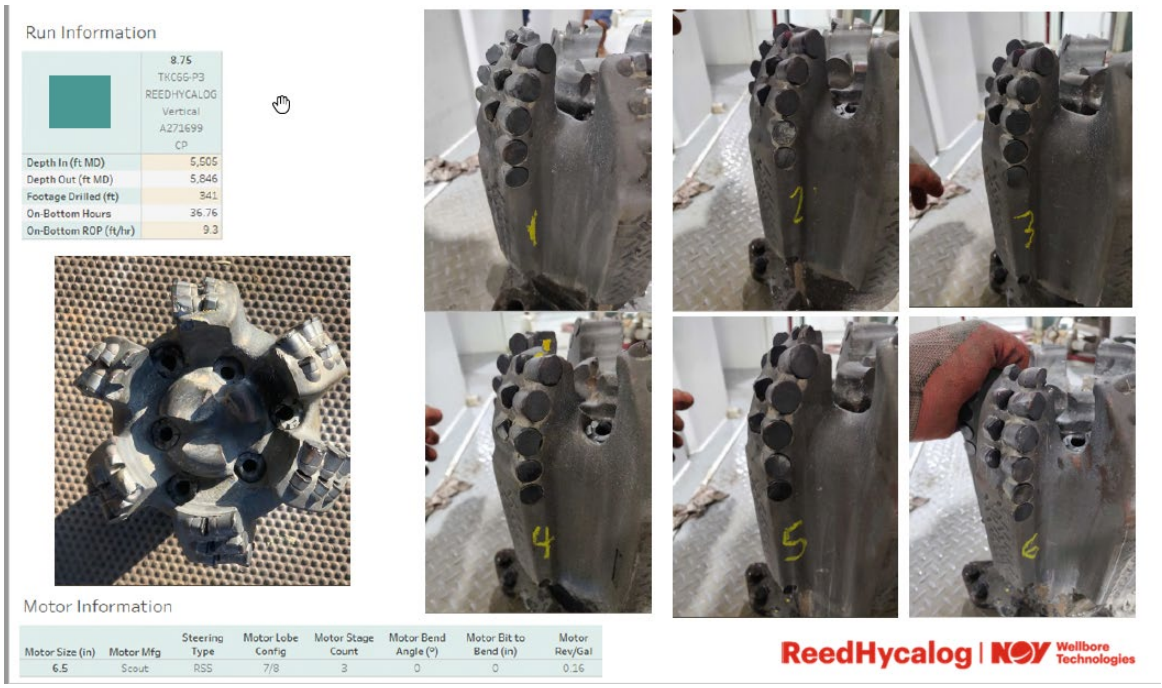

Figure 31. ReedHycalog TKC66-P3 bit. Bit grading: 8-3-CR-C-X-I-CT-CP.

V.8 Coring BHA 15: 5,846' to 5,856'

This is the third coring run. BHA 15 went in at 5,846' and was tripped out due to slow ROP at 5,856'. The specifics are as follows.

- CCl 700 Series – Equipped with JMS.
- 90' of core barrel.
- Bit Type: CCl – 913 (Figure 32)
- 10' of core cut. 8.8' of core recovered.
- ROP 1.94'/hr. 350-400 GPM. 40-60 RPM. 4K-8K WOB.
- 1.2' of core presumed left on bottom.
- No break off bottom

Figure 32. Canamera bit CCl 913, after core run 3.

V.9 Drilling BHA 16: 5,856' to 5,858'

BHA 16 (Figure 33 shows the bit that was run.) was a cleanup run to prepare the bottom of the hole for the next core run. The BHA was an Ulterra SPL 616 bit, bit sub, a re-run of the Scout 7/8 3.0 motor, a 6-3/4" NM Stabilizer, eight stands of drill collars, and 3 stands of HWDP.

Figure 33. Ulterra SPL 616.

V.10 Coring BHA 17: 5,858' to 5,892'

BHA 17 (Figure 34 shows the bit) went in at 5,858' and was tripped out due to slow ROP at 5892 ft MD. KOP was called at 5,892' MD. The specifics of this core run are:

- CCl 700 Series – Equipped with JMS.
- 60' of core barrel.
- Bit Type: CCl – 713.
- 34' of core cut. 31.5' of core recovered.
- ROP 5.5'/hr. 350-400 GPM. 40-60 RPM. 4K-8K WOB.
- 2.5' of core presumed milled or left on bottom.

V.11 String Shot

In an attempt to assess the capabilities of surface instrumentation and ideally refine the velocity model, a string shot was performed. When the first shot was not detected, it was repeated – it was not detected either. The specifics are:

1. Run in hole to 5,750' with string shot, 10' long of primer cord, (800 grains) Shot tool at time of 16:42:30.
2. Run in hole to 5,700' with 15" string shot and primer cord (1200 grains) Shot tool at time of 18:16:20.

Figure 34. This is the bit for core run 4. The seven blades seemed to perform well.

V.12 Recommendations for the Vertical Section

WOB helped to keep the axial vibrations down. WOB higher than 45 klb showed low levels of axial vibrations. Surface RPMs lower than 40 rpm showed low levels of lateral vibrations. The last bit (BHA 14) suffered severe damage probably produced by the constant axial and tangential shocks observed at the end of the run caused by a reduction in WOB mandated by the VRSS.

VI. Drilling Operations for the Curve Section

Drill nominally at 5° per 100' with KOP at 5,892 ft MD/TVD (refer to Figure 35). The projected curve landing was at 65° at 7,262 ft MD. The plan (and actual) was to hold azimuth at nominally 105°. Other activities included running a UBI log and a gyro survey from 7,390' to 5,100'. It was necessary to carry out a reamer run from 5,634' to 7,390'. The reaming was done at 120'/hr with an 8 3/ 4" bit, 8 5/8" roller reamer, one 6" drill collar, an 8 ½" roller reamer, 6 joints of HWDP, a string mill, HWDP, jars, HWDP, and finally drill pipe.

VI.1 Drilling BHA 18: 5,892' to 6,360'

BHA 18 (Table 13 and Figures 36 and 37) drilled 468 ft with an average ROP of 34 fph. Of the 468 feet, 139 ft were sliding (30%) with an ROP of 33 fph. Rotating accounted for 329 ft (70%) with an ROP of 35 fph. The motor yields were 10.2 deg/100 ft. Bit grading was 1-1-WT-A-X-I-NO-BHA. Kickoff started 74 ft high from the planned KOP. This was intentional to get a feel for the BHA. This resulted in being ahead of the plan by up to 58 ft at 6300 ft. To account for this, that was followed by 220 ft of rotation to get closer to the plan.

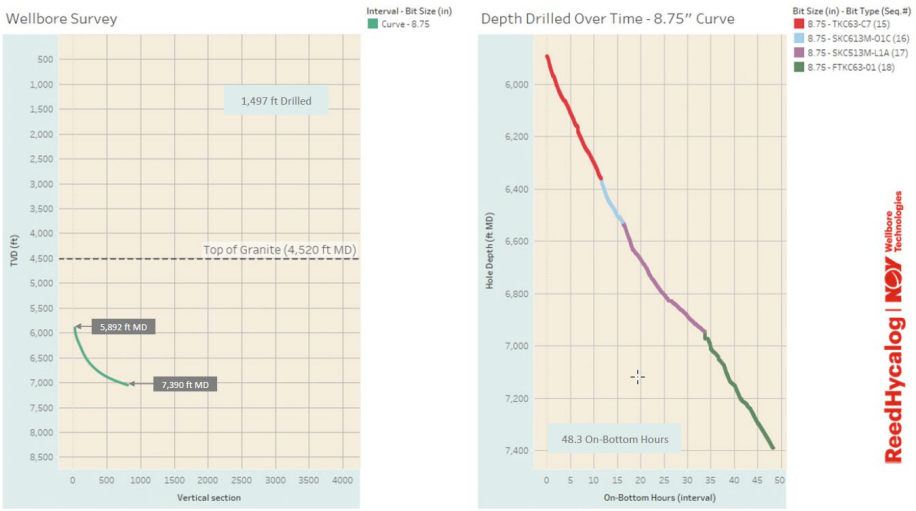

Figure 35. Bits used to drill the curve.

Lessons Learned:

- Changed straight motor to fixed 1.5° conventional drive-type
- Changed from 0.16 to 0.242 rpg.
- This BHA is a good selection to kick off the curve without taking the risk of getting behind the plan. If using the same motor at this depth in the curve in a future well, kick off the curve right on the plan, unless already behind by KOP.
- Motor fit should be between 170-190 F; TVD of 5885 ft
- Monitor bit performance utilizing MSE (Figure 38).

Table 13. BHA 18 (drilled from 5892 to 6,360 ft)

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC bit	Reed Hycalog	A255857	8 3/4		1	1	4 1/2 REG
2	6 1/2" Scout 7/8 5.7, Fixed 1.50, 8 1/4" Stab, valve	Scout	650-05-376	6 1/2	1 1/4	33.56	34.56	4 1/2 IF
3	6 1/2 Scout String Sub with PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	36.9	4 1/2 IF
4	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	46.12	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-083	6 1/2	2 3/4	3.11	49.23	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	79.58	4 1/2 IF
7	6 3/4" NMDC (2 joints)	Stabildrill	SD56089 SD49788	6 3/4	3 1/4	60.66	140.24	4 1/2 IF
8	6 1/2" DC's (2 stands)		RIG	6 1/2	3	183.22	323.46	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3 1/4	1384.33	1707.79	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	4 1/4		1707.79	I.F.

BHA highlights:
Bit TKC63 C-7; TFA = 0.84
Motor 7/8 5.7; Fixed 1.50, Single 8 ¼'' Stab
No String Stabilizers nor Roller reamers

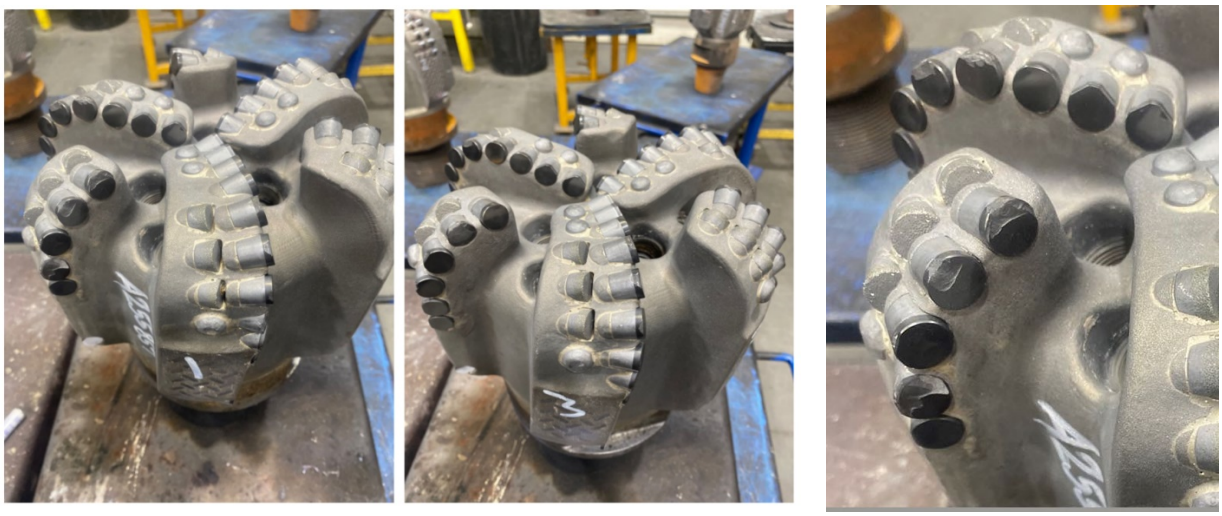

Figure 36. NOV Reed Hycalog TKC63 PDC. This bit exceeded performance expectations. These were the first 13 mm cutters used in the granite and the 13 mm efficiency was demonstrated. The initial ROP drop-off was reduced and overall, the sustained ROP was higher (see Figure 30). Also, tool face control was important - shaped 3D Cutters in the cone and Torque-Control Components (TCC) in the cone (1.5mm off-tip). Bit grading: 1-2-WT-A-X-I-CT-PR.

Figure 37. NOV Reed Hycalog TKC63 PDC. This bit exceeded performance expectations. These were the first 13 mm cutters used in the granite and the 13 mm efficiency was demonstrated. The initial ROP drop-off was reduced and overall, the sustained ROP was higher. Also, tool face control was important - shaped 3D cutters in the cone and Torque-Control Components (TCC) in the cone (1.5mm off-tip). Bit grading: 1-2-WT-A-X-I-CT-PR.

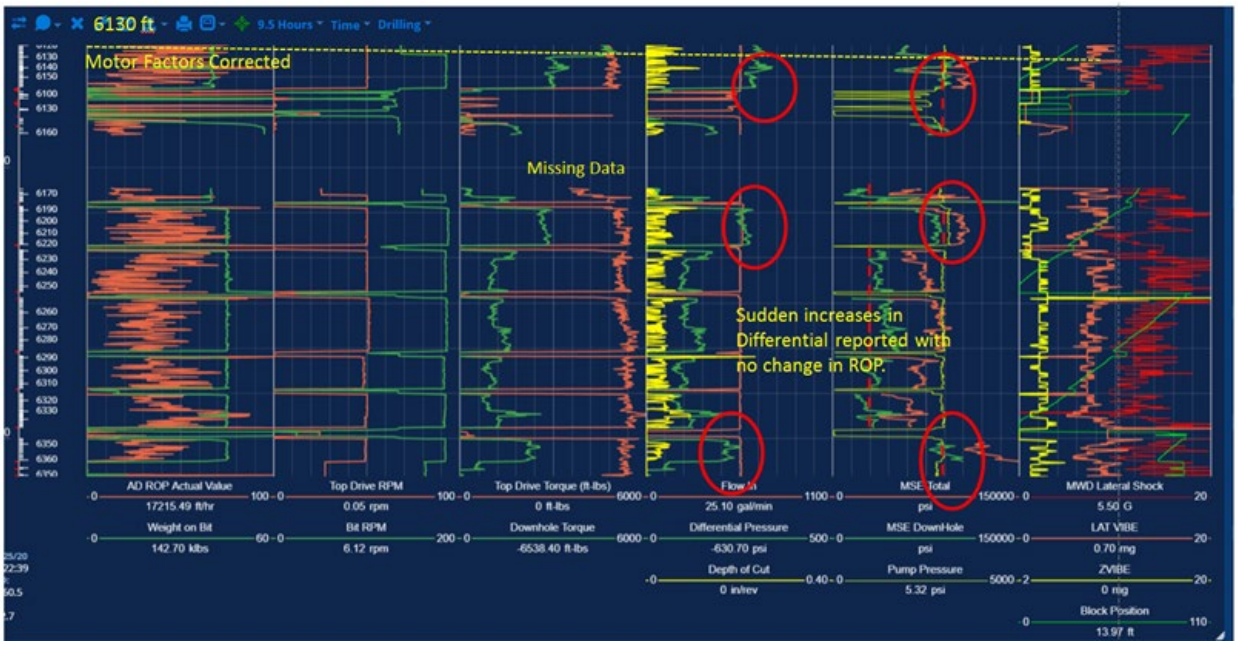

Figure 38. Drilling parameters as diagnostics. This figure shows a sudden increase in differential with no change in ROP.

VI.2 Cooldown BHA 19

This BHA re-ran the ReedHycalog TKC 63 C7 8-3/4-inch bit, a bit sub with a float and drill pipe thereafter. The purpose was to cool down the hole in preparation for logging.

VI.3 Cooldown BHA 20

This BHA re-ran the ReedHycalog TKC 63 C7 8-3/4-inch bit, a bit sub with a float and drill pipe thereafter. The purpose was to cool down.

VI.4 Drilling BHA 21: 6,360' to 6,526'

BHA 21 (Table 14 and Figures 39 through 41) used one NM stabilizer at the top of the motor. It drilled 166' with an average ROP of 33 fph. Motor yields were 6.5 deg/100 ft. The BHA became geometrically stuck after sliding 43 ft (the stabilizer blade started 39 ft from the bit). The performance was:

- Sliding footage was 96 ft (58%) at an ROP of 32 fph
- Rotating footage was 70 ft (42%) at an ROP of 34 fph
- MWD Circulating Temperature: 172->181 F, one cooler was on
- Inclination IN: 18; Inclination OUT: 21 deg
- Bit grading: 1-1-WT-A-X-I-NO-BHA

Table 14. BHA 19 (6,360' to 6,526')

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog SKC613M-01C PDC bit	Reed Hycalog	A232400	8 3/4		1	1	4 1/2 REG
2	6 1/2" Scout 7/8 5.7, Fixed 1.50, 8 1/4" Stab, valve	Scout	650-05-218	6 1/2	1 1/4	33.01	34.01	4 1/2 REG
3	6 1/2 Scout String Sub with PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	36.35	4 1/2 IF
4	6 3/4 x 8 5/8" NM Stab	Stabildrill	SD 610501	6 7/8	3	6.87	43.22	4 1/2 IF
5	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	52.44	4 1/2 IF
6	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	55.52	4 1/2 IF
7	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	85.87	4 1/2 IF
8	6 3/4" NMDC (2 joints)	Stabildrill	SD56089 SD49788	6 3/4	3 1/4	60.66	146.53	4 1/2 IF
9	6 1/2" DC's (2 stands)		RIG	6 1/2	3	183.22	329.75	4 1/2 IF
10	5" HWDP (15 stands)		RIG	5	3 1/4	1384.33	1714.08	4 1/2 IF
11	5" Drill Pipe to surface		RIG	5	3 1/4		1714.08	4 1/2 REG

BHA highlights:
Bit SKC613M-01C; TFA = 0.84
Motor 7/8 5.7; Fixed 1.50, Single 8 ¼" Stab
NonMag string stabilizers in top of motor – blade started 39 ft from the bit

Lessons Learned and Recommendations

- Do not put blade stabilizer in the slide portion of the hole.
- Consider using roller reamers in this granitoid if needed for stabilization.

Figure 39. Bit SKC613M-01C and stabilizer damage. Bit grading: 1-1-WT-A-X-I-NO-BHA

Figure 40 Bit SKC613M-01C. Bit grading: 1-1-WT-A-X-I-NO-BHA. This BHA was pulled because it became geometrically stuck (string stabilizer).

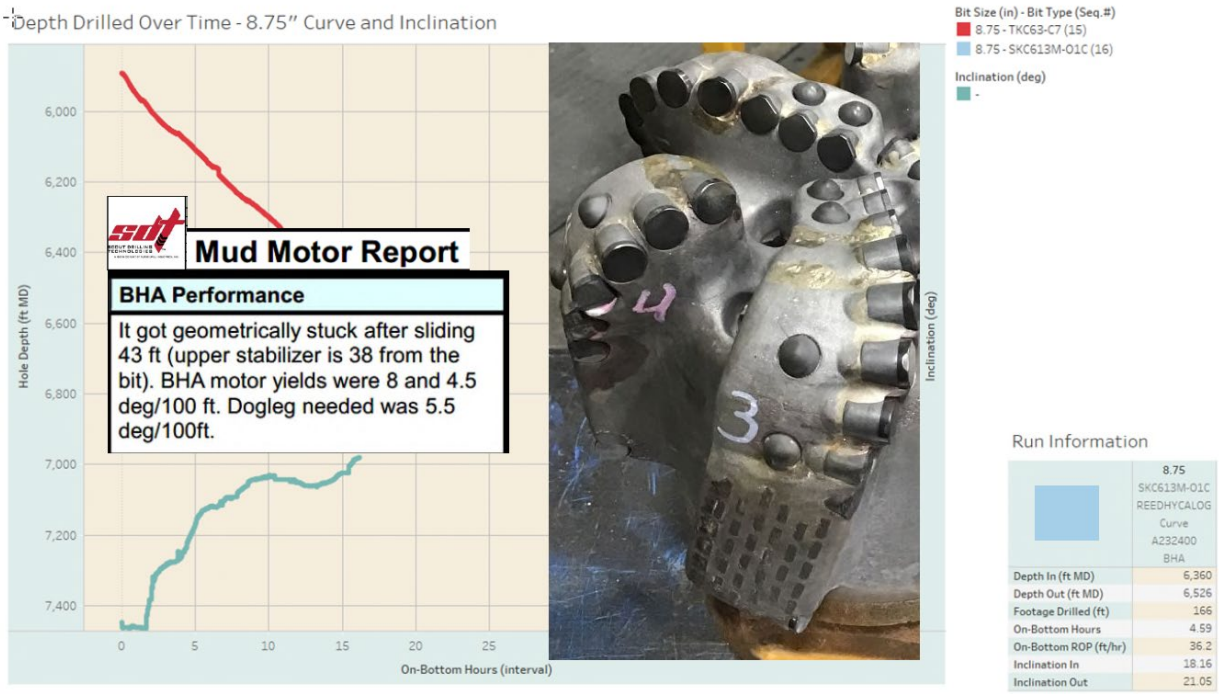

Figure 41. Bit SKC613M-01C. Bit grading: 1-1-WT-A-X-I-NO-BHA

VI.5 Drilling BHA 22: 6,526' to 6,945'

BHA 22 (Table 15 and Figures 42 and 43) drilled 419 ft with an average ROP of 23 fph.

Motor yields were 9.5 deg/100 ft. There appeared to be weight transfer issues after drilling 100 ft of new hole and reaching a 30° inclination. Bit grading: 2-2-CT-S-X-I-WT-BHA.

- Sliding footage: 304 ft (73%) at 22 fph
- Rotating footage: 115 ft (27%) at 24 fph
- MWD Circulating Temperature: 175->180°F with one cooler on; circulated at the shoe, 5200 ft
- Inclination IN: 21; Inclination OUT: 45 deg
- Bit grading: 2-2-CT-S-X-I-WT-BHA

Lessons Learned:

- TCCs were placed near profile (1mm off-tip). The TCCs may have been limiting DOC/ROP (60K applied). The subsequent bit had no TCCs and outperformed.
- Top performing bits in the tangent did not have TCCs.
- TCC's ≥ 1.5mm off-tip still may be necessary at KOP.

Table 15. BHA 22: 6,526' to 6,945'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog SKC513M-L1A PDC bit, 4x12-3x13s	Reed Hycalog	A276122	8 3/4		1	1	4 1/2 REG
2	6 1/2" Scout 7/8 5.7, Fixed 1.50, 8 1/4" Stab, valve	Scout	650-05-218	6 1/2	1 1/4	33.01	34.01	4 1/2 REG
3	6 1/2 Scout String Sub with PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	36.35	4 1/2 IF
4	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	45.57	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	48.65	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	79	4 1/2 IF
7	6 3/4" NMDC (2 joints)	Stabildrill	SD56089 SD49788	6 3/4	3 1/4	60.66	139.66	4 1/2 IF
8	6 1/2" DC's (2 stands)		RIG	6 1/2	3	183.22	322.88	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3 1/4	1384.33	1707.21	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1707.21	4 1/2 REG

BHA highlights:
Bit SKC513M-L1A; TFA = 0.83
Motor 7/8 5.7; Fixed 1.50, Single 8 ¼" Stab - Re-run
No String Stabilizers nor Roller reamers

Figure 42. SKC513M-L1A. BHA pulled for non-bit-related reasons. Bit grading: 2-2-CT-S-X-I-WT-BHA.TCCs may have limited DOC/ROP (60K was applied). The subsequent bit had no TCCs and outperformed this bit.

Figure 43. BHA pulled for non-bit-related reasons. Bit grading 2-2-CT-S-X-I-WT-BHA.

VI.6 Drilling BHA 23: 6,945' to 7,262'

BHA 23 (Table 16 and Figures 44 and 45) drilled 444 ft with an average ROP of 27 fph. The bit was an FTKC63-01 PDC with TFA = 0.83. The motor was 7/8 5.7; Fixed 1.50, Single 8 ¼'' Stab. There were no string stabilizers or roller reamers. Motor yields were 11.2 deg/100 ft. The MWD circulating temperature ranged from 175°F to 180°F. There were weight transfer issues after drilling 94 ft of new hole - sliding difficulty increased and total ROP dropped. Bit grading was 1-1-WT-A-X-I-NO-BHA. The statistics for this bit

run were:

- Sliding 125 ft (28%) with an ROP of 18 fph
- Rotating 320 ft (72%) with ROP of 34 fph.

Table 16: BHA 23 (6,945' to 7,262')

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog FTKC63-01	Reed Hycalog	A276121	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2 Scout 7/8 5.7 Fixed 1.50 8 1/4" Stab, valve	Scout	650-05-211	6 1/2	1 1/4	33.92	34.77	4 1/2 IF
3	6 1/2 Scout String Sub with PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	37.11	4 1/2 IF
4	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	46.33	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	49.41	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	79.76	4 1/2 IF
7	6 3/4" NMDC (2 joints)	Stabildrill	SD56089 SD49788	6 3/4	3 1/4	60.66	140.42	4 1/2 IF
8	6 1/2" DC's (2 stands)		RIG	6 1/2	3	183.22	323.64	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3 1/4	1384.33	1707.97	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1707.97	4 1/2 REG

Figure 44. FTKC63-01. TCC has been removed and performance improved. Durability was sufficient. There was excellent dull condition and excellent build-rates. Landed the curve with this bit. Bit grading was 1-1-WT-A-X-I-NO-BHA.

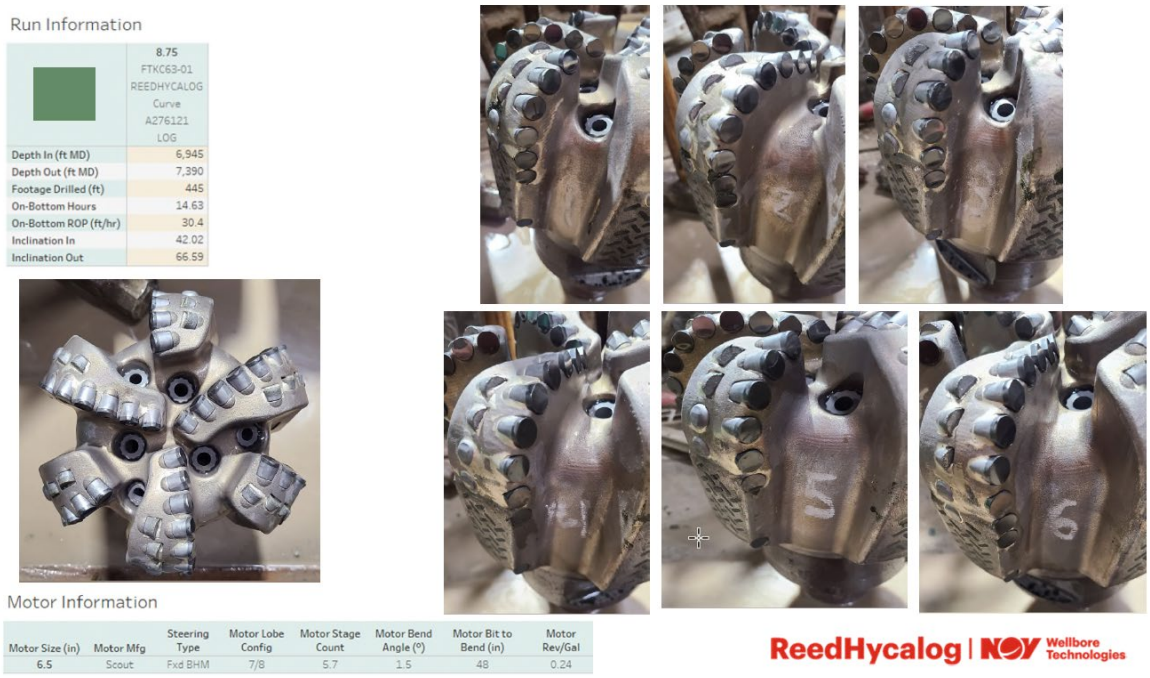

Figure 45. FTKC63-01. Bit grading was 1-1-WT-A-X-I-NO-BHA

VI.7 Lessons Learned and Recommendations for Curve Section

- When tripping in or out of the hole with the curve assembly, stop and circulate to cool down sensors and MWD.
- A 1.50° fixed motor is a good selection to drill curves with 8°/100 ft DLS or less.
- Use an agitator such as a Vibe Scout tool after reaching 30° inclination to transfer weight better and improve sliding efficiency.
- Start the curve at the planned depth.
- Do NOT use string stabilizers. Instead use a roller reamer under gauge by ¼" or more on this solid/consolidated/in-gauge granite formation – **high risk of geometrically sticking.**
- Calibrate the temperature model with the coolers effect observed on this well based on MWD circulating temperatures.
- Motor fit selection was made with the mud cooler model, communication was key to turning on the mud coolers according to the temperatures observed on the MWD and the motor specifications. No motor chunking was reported.
- Recommend a motor fit between 170-190°F – if the curve finishes before 7000 ft TVD.
- Drill the curve without a shock sub - this helped on shock and vibes.
- All bits showed good steerability and tool face control.

VII. Drilling Operations Tangent Section

The tangent was drilled at nominally 65° at an azimuth of 105°. The BHAs used in the tangent are highlighted in Figure 46.

VII.1 Drilling BHA 23: 7,262' to 7,390'

The tangent section was started with the previous BHA (BHA 23). See the previous section.

VII.2 Reaming BHA 24: 5,634' to 7,390'

The reamer assembly consisted of a ReedHycalog 8 3/4" bit, near bit roller reamer, drill collar, roller reamer, heavy weight drill pipe, string mill, jars, and heavy weight drill pipe.

VII.3 BHA 25 Gyro Assembly

This was a slick assembly, exclusively for the gyro survey.

VII.4 BHA 26 Cooldown

This was a slick assembly, exclusively for cooling down the hole prior to a UBI run.

VII.5 BHA 27 Cooldown

This was a slick assembly, exclusively for cooling down the hole before the first attempted XLOT.

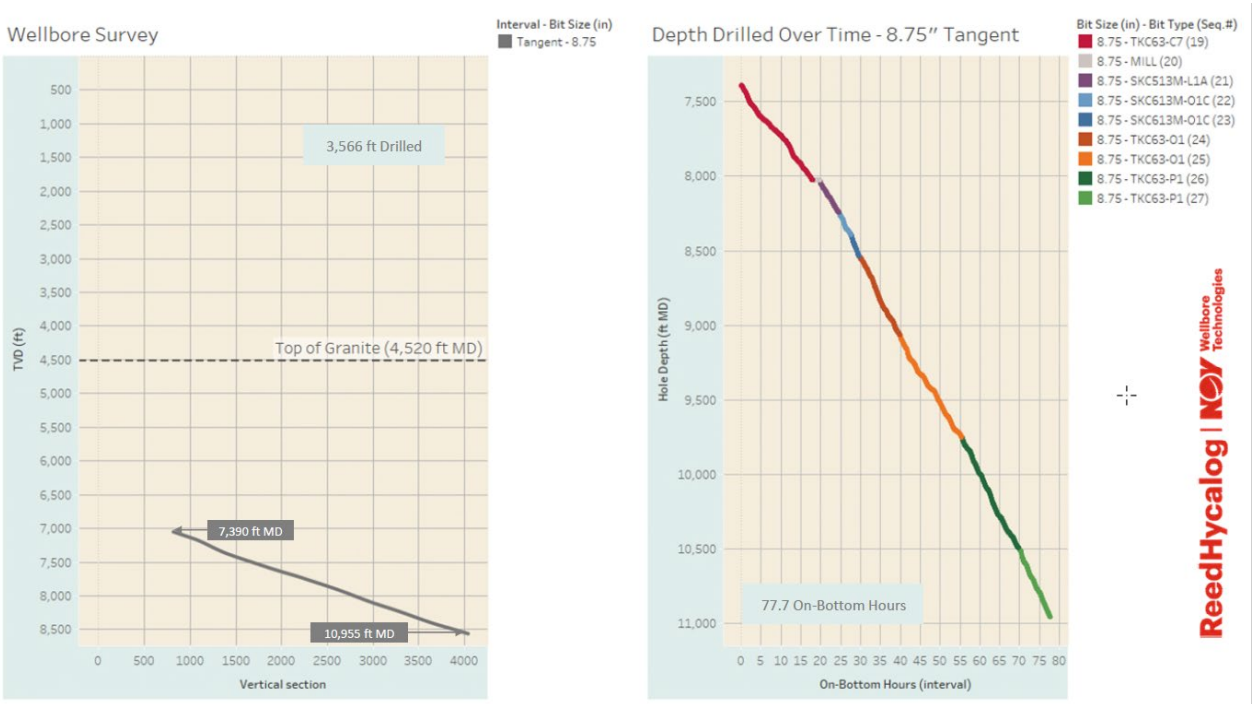

Figure 46. Bit runs in the tangent section.

VII.6 BHA 28 XLOT

This was an assembly with the packer. There was a bullnose guide shoe, two crossovers, the packer and two additional crossovers. The packer was run to 7,325'. It was not possible to get the tool to shift. The tool at surface after being run, is shown in Figure 47.

Figure 47. Packer after retrieval.

VII.7 BHA 29 Cleanout Packer Debris (Drill from 7389' to 7390')

This was a cleanout run. The assembly consisted of a TKC63 PDC bit, motor-6 1/2" 7/8 5.7, Fixed 1.25, 8 1/4" stab, sub-6 1/2 Scout string sub with PUK sensor, 6 5/8 x 8 1/2" roller reamer and Monel collars and HWDP.

VII.8 Drilling BHA 30: 7,390' to 8,024'

BHA 30 (Table 17 and Figures 48 and 49) drilled 634 ft with an average ROP of 31 fph. This was partitioned as:

- Sliding 264 ft (42%) with an ROP of 23 fph,
- Rotating 370 ft (58%) with an ROP of 40 fph.

Motor yields were 8.5 deg/100 ft. Two coolers were used to maintain an MWD circulating temperature between 185°F to 200°F. Bit grading was 4-8-RO-S-X-I-BT-PR. There were no issues sliding with the roller reamer. The BHA had an aggressive tendency

to build/drop/walk. There were weight transfer issues after drilling 180 ft - ROP dropped and sliding difficulty increased.

Table 17. BHA 30: 7,390' to 8,024'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14s	Reed Hycalog	A255857	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 1/4" Stab, valve	Scout	650-05-438	6 1/2	1 1/4	34.24	35.09	4 1/2 IF
3	6 1/2 Scout String Sub with PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	37.43	4 1/2 IF
4	6 5/8 x 8 1/2" Roller Reamer	Redback	GU 3783	8 1/2	2 1/4	6.63	44.06	4 1/2 IF
5	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	53.28	4 1/2 IF
6	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	56.36	4 1/2 IF
7	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	86.71	4 1/2 IF
8	6 3/4" NMDC (2 joints)	Stabildrill	SD56089 SD49788	6 3/4	3 1/4	60.66	147.37	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3	1384.33	1531.7	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1531.7	4 1/2 IF

Figure 48. Ringed out TKC 63-C7 after drilling 634 feet.

Figure 49. At left, a roller reamer was run above the motor. At right and in the middle panel is the bit, after recovery. TKC 63-C7 drilled 634 ft. It had a very aggressive tendency to build/drop/walk. Weight transfer issues were encountered after drilling 180 ft. ROP dropped and sliding became more difficult. Bit grading was 4-8-RO-S-X-I-BT-PR.

Lessons Learned and Possible Recommendations/Considerations

- Run a double stabilized motor
- Roller reamer at top of motor to control rotary drilling trends
- Run an agitator to transfer the weight better and improve sliding efficiency
- Motor and agitator fit 190° - 210°F.
- Use bits with longer gauge – 4” to 6”.

VII.8 BHA 31: Cooldown

BHA 31 was a slick BHA used to cool down the well in advance of the second attempted XLOT.

VII.9 BHA 32. XLOT Run 2 (Extended Leak off Test)

The packer was run to 7,974 ft. The tool failed. The ball did not seat, and the tool did not shift. On tripping the packer out of the hole, both packer elements were gone

Lessons Learned:

Confirm that vendor has materials on site to repair packers, if at all possible.

VII.9 BHA 33. Milling/Fishing BHA

It was necessary to circulate out any potential packer debris. This slick assembly consisted of a reverse circulating finger basket, bit sub, HWDP, jars, and HWDP.

VII.10 Drilling BHA 34: 8,024' to 8,241'

BHA 34 (Table 18 and Figures 50 and 51) drilled 217 ft with an average ROP of 41 fph. A double stab mud motor was used on this BHA to hold the tangent better. The partitioning between sliding and drilling was as follows.

- Sliding 54 ft (25%) with an ROP of 27 fph,
- Rotating 163 ft (75%) with an ROP of 49 fph.

Motor yields were 8.3 deg/100 ft. Three coolers were on for an MWD circulating temperature of 238->181°F. Bit grading was 8-1-CR-C-X-I-WT-PP. There were weight transfer issues after drilling 106 ft – ROP dropped and sliding difficulty increased. The bit was drilling ahead at 41' hr ROP and then was damaged in a few feet.

Table 18. BHA 34: 8,024' to 8,241'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog SKC513M-L1A PDC, 3x13-4x12s	Reed Hycalog	A276122	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 1/4" x 8 1/4" Double	Scout	650-05-551	6 1/2	1 1/4	34.47	35.32	4 1/2 IF
3	6 1/2 Scout Sub-PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	37.66	4 1/2 IF
4	6 3/4 NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	46.88	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	49.96	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabil Drill	SD 55831	6 3/4	3 1/4	30.35	80.31	4 1/2 IF
7	6 3/4 NMDC with crowfoot	Stabildrill	SD 49788	6 3/4	3 1/4	30.4	110.71	4 1/2 IF
8	6 3/4 NMDC	Stabildrill	SD 56089	6 7/8	3 1/4	30.26	140.97	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3	1384.33	1525.3	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1525.3	4 1/2 IF

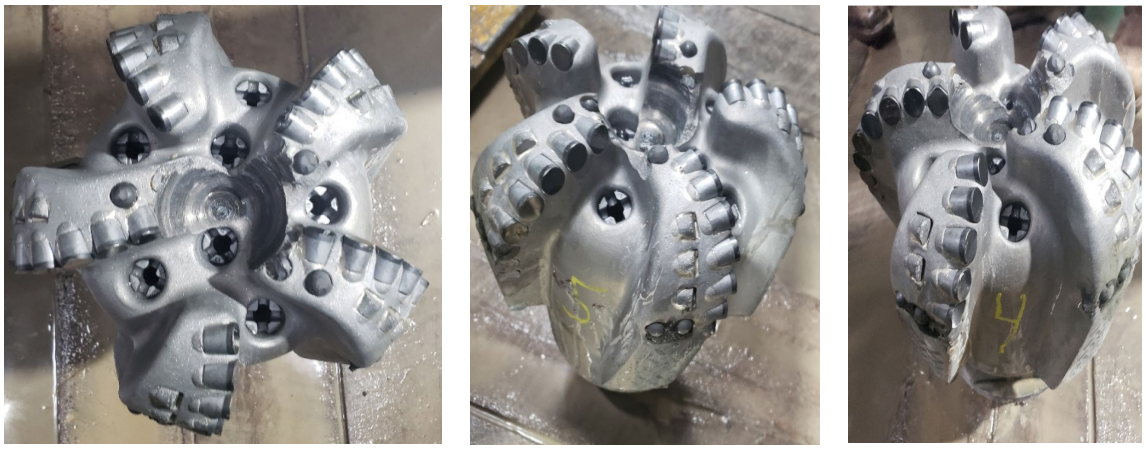

Figure 50. Bit SKC513M. Note the five blades. Bit grading: 8-1-CR-C-X-I-WT-PP - cored out bit.

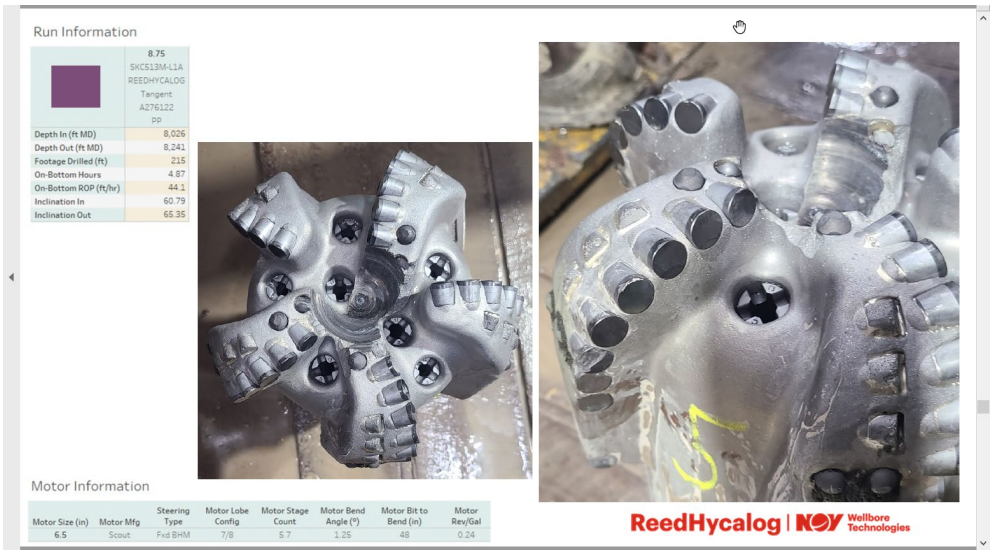

Figure 51. Bit SKC513M. Note the five blades. Bit was cored out.

Lessons Learned:
One connection was made during crew change and rig activity may have been hurried. The drill string was only picked up three feet off bottom when completing the connection. The driller went back to drilling but the cutters were still engaged in the granite causing the damage. The lesson learned is "work with the drillers during crew changes."

The decision had been made to try a 5-blade with the associated more aggressive cutting structure and the anticipated higher DOC[3] than previous bits. This bit was cored out after low footage. *6-blade (or more) bits appear to be required for durability*. The WOB is high compared to drilling in sedimentary settings and the "excessive" WOB can lead to rapid/severe DBR.

VII.11 Drilling BHA 35: 8,241' to 8,535'

BHA 35 (Table 19 and Figures 52 and 53) drilled 294 ft with an average ROP of 55 fph. The bit was pulled in order to log the hole. The footages are:

- Sliding 50 ft (17%) with an ROP of 29 fph.
- Rotating 244 ft (83%) with an ROP of 68 fph.

Motor yields were 6.7 deg/100 ft. Three coolers were on for an MWD circulating temperature of 230->200°F. Staging procedures were performed at 5800 and 7200 ft to enhance cooldown. The bit grading was 2-1-CT-C-X-I-CT-LOG. There were weight transfer issues after drilling 114 ft – ROP dropped and sliding difficulty increased.

[3] DOC is depth of cut.

Washout was found in one HWDP and there was wear in the MWD Monel and the motor's wear pad. The rotary drilling trend was 2.3 deg/100 ft to walk right.

There were two separate bit runs. The first was 8241 to 8391 ft. The string was pulled because of a washout that was found. While drilling this section, 250 psi pump pressure was lost. Tripping out with a wet string it was determined that some HWDP tool joints were washed out (refer to Figure 54). The rig laid down all of the Frontier HWDP, and picked up rental HWDP. Afterwards, since the bit was green, it was re-run and drilled to 8535 ft; it was pulled to log the well. A gyro was dropped and a survey was run on the way out of the hole.

Table 19. BHA 35: 8,241' to 8,535'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog SKC613M-O1C PDC, 3x13-3X14's	Reed Hycalog	A230682	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 1/4" x 8 1/4" Double	Scout	650-05-551	6 1/2	1 1/4	34.47	35.32	4 1/2 IF
3	6 1/2" Scout Sub-PUK sensor	Scout	650-CSS-005	6 1/2	3 1/4	2.34	37.66	4 1/2 IF
4	6 3/4" NM Pony Collar	Stabildrill	SD 55005	6 3/4	3 1/4	9.22	46.88	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-076	6 1/2	2 3/4	3.08	49.96	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabill Drill	SD 45410KRC	6 3/4	3 1/4	29.41	79.37	4 1/2 IF
7	6 3/4" NMDC with crowfoot	Stabildrill	SD 49788	6 3/4	3 1/4	30.4	109.77	4 1/2 IF
8	6 3/4" NMDC	Stabildrill	SD 56089	6 7/8	3 1/4	30.26	140.03	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3	1383.99	1524.02	2 3/8 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1524.02	4 1/2 IF

Figure 52. ReedHycalog SKC613M-O1C. The bit grading was 2-1-CT-C-X-I-CT-LOG. The bit was pulled to log the hole. The TCCs are 2mm off tip. The ROP was the highest to this point. There were weight transfer issues after drilling 114 ft. At right is a drill collar in the hydraulic tongs.

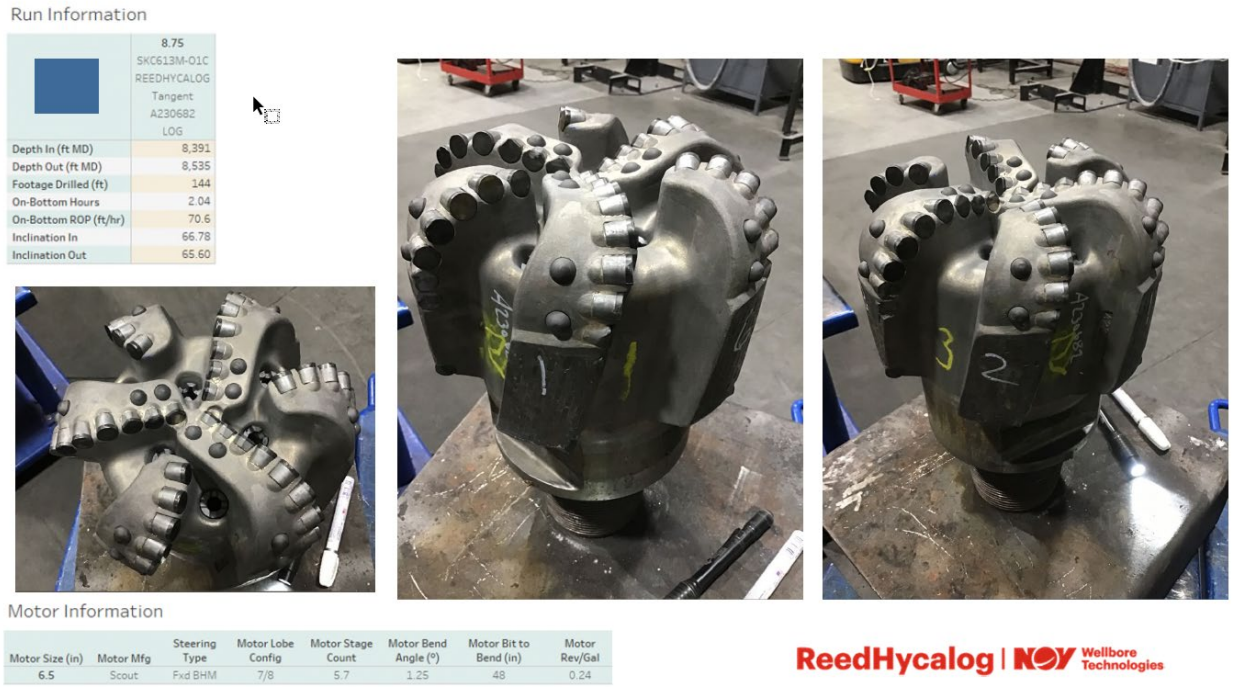

Figure 53. ReedHycalog SKC613M-O1C. The bit grading was 2-1-CT-C-X-I-CT-LOG. The bit was pulled to log the hole.

Figure 54. This BHA was pulled because of evidence of washout, which was diagnosed and the HWDP was replaced.

Lessons Learned:
The TCC's were 2 mm off tip and are probably not needed in the tangent. The ROP was the highest in the granite to this point in the well. The dull condition was excellent (although footage was low since the bit was pulled for logging and other operations).

- *Perform more visual inspection while tripping to avoid washouts.*

VII.12 BHA 36 XLOT Run 3 (Extended Leakoff Test)

The assembly was a bullnose guide shoe, casing pup, crossover, landing collar, crossover, toe sub, packer, crossover, packer, crossovers, and handling sub. The tool failed - the packer did not seal (Figure 55). The chronology was as follows.

- Run packer elements to 8,458 ft MD.
- Test lines from pump truck to 5,000 psi.
- Pump down ball to ball, seat, and pressure up to 957 psi. Hold for 5 minutes.
- Pressure up to 2100 psi to shear pins and set packer. Pinned at 1,897 psi.
- Pressure up to 2,700 psi to open landing collar. Pinned at 2,705 psi. There was a pressure drop that verified opening.
- Started the XLOT and established circulation to the annulus, stop test.

Figure 55. Packer assembly.

VII.13 Cooldown BHA 37 (run 1)

This was a slick assembly run to cool down the well before the UBI run. Run UBI on PetroMac taxi to 8,535'. This log was successfully run and proved the viability of taxiing in equipment at this angle.

VII.14 Cooldown BHA 37 (run 2)

Re-run the slick assembly to cooldown before the check shot. A check shot was fired: 3 1/8" perforating gun, 3 JSPF at 120° phasing, total 1,300 grains. This shot was not detected by monitoring equipment.

VII.15 Drilling BHA 38: 8,535' to 9,064'

BHA 38 (Table 20 and Figures 56 and 57) drilled 529 ft with an average ROP of 48 fph. The partitioning between sliding and rotating was:

- Sliding 138 ft (26%) with ROP of 32 fph.
- Rotating 391 ft (74%) with ROP of 58 fph.

The motor yields were 7.5 deg/100 ft. Three coolers were on for an MWD circulating temperature of 230->190°F. Staging procedures were performed at 5800 and 7200 ft to ensure cooldown. Rotary drilling trends went from left to right and build.

The bit grading was 3-6-RO-N-X-I-WT-PR. Localized ring out occurred just past the nose. The footage was the second longest up to this point in the well. According to ReedHycalog, WOB was high compared to sedimentary applications. The mud weight was 9.1 ppg, viscosity 41 s/qt, TORQease 4%, Beads 3 lb/bbl.

Table 20. BHA 38: 8,535' to 9,064'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A270819	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 3/8" x 8 1/4" Double	Scout	650-05-546	6 1/2	1 1/4	35.32	36.17	4 1/2 IF
3	6 1/2 Scout sub-PUK sensor	Scout	650-CSS-003	6 1/2		2.61	38.78	4 1/2 IF
4	6 3/4" NM Pony Collar	Stabildrill	SD 56830	6 3/4	3 1/4	8.98	47.76	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-072	6 1/2	2 13/16	3.13	50.89	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabildrill	SD 56089	6 7/8	3 1/4	30.26	81.15	4 1/2 IF
7	6 3/4" NMDC with Crowfoot	Stabildrill	SD 49788	6 3/4	3 1/4	30.4	111.55	4 1/2 IF
8	6 3/4" NMDC	Stabill Drill	SD 45410KRC	6 3/4	3 1/4	29.41	140.96	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3	1396.48	1537.44	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1537.44	4 1/2 IF

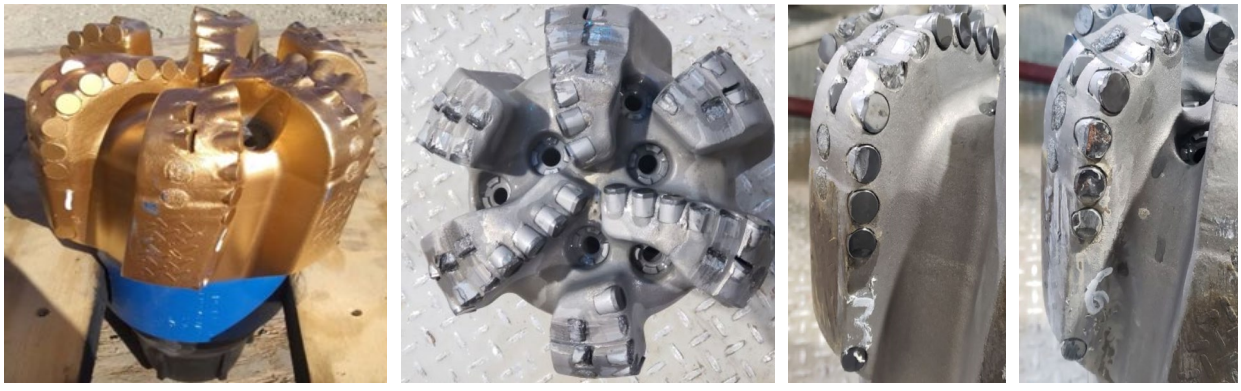

Figure 56. This bit was a TKC63. The bit grading was 3-6-RO-N-X-I-WT-PR.

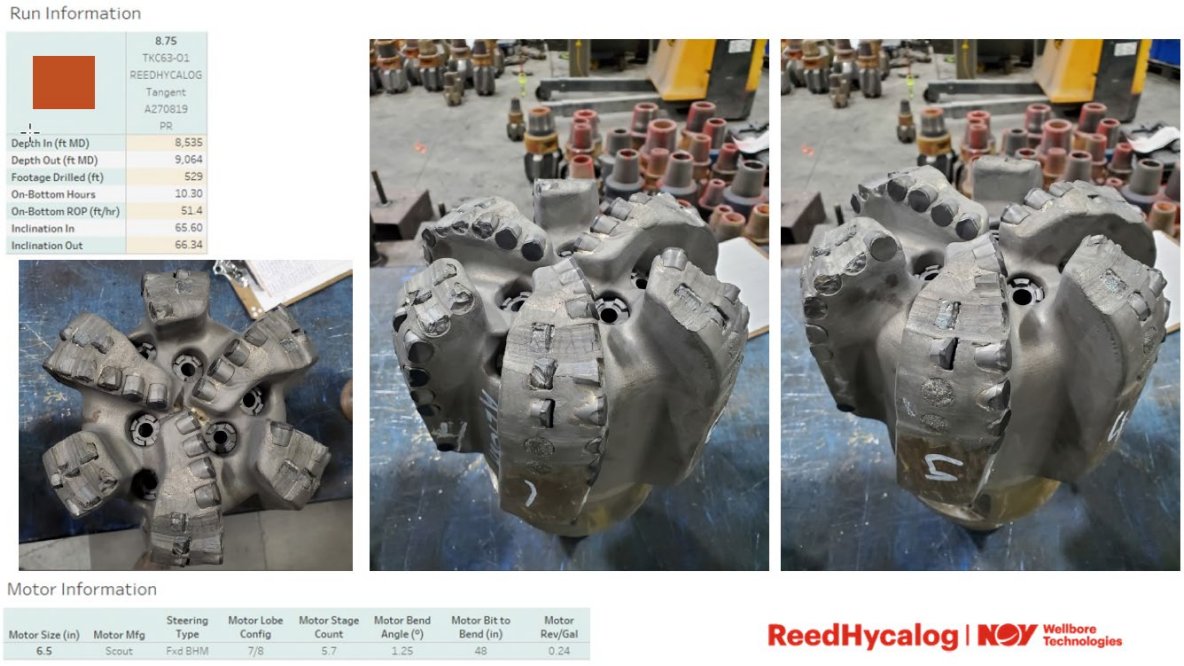

Figure 57. This bit was a TKC63. The bit grading was 3-6-RO-N-X-I-WT-PR.

Lessons Learned:

- ROP was high with less WOB applied.
- Excessive WOB led to rapid/severe DBR.
- Closely monitor MSE, shocks, vibrations, and whirl
- The torque and drag parameters were higher than modeled. High lateral vibrations were recorded. Vibration data are available in the Geothermal Data Repository.

Recommendations

- Run a double stabilized motor with an under-gauge roller reamer at the top of the motor.
- Run an agitator such to transfer weight.
- Consider using longer gauge bits in the tangent section.

VII.16 Drilling BHA 39: 9,064' to 9,748'

BHA 39 (Table 21 and Figure 58 and 59) drilled 684 ft with an average ROP of 41 fph. The specifics are:

- Sliding 163 ft (24%) with an ROP of 24 fph.
- Rotating 521 ft (76%) with an ROP of 53 fph.

The motor yields were 7.5 deg/100 ft. Three coolers were running for an MWD circulating temperature of 220->190°F. Staging procedures were performed at 5800 and 7500 ft to guarantee cooldown. Bit grading was 2-7-RO-S-X-I-CT-PR. There continued to be weight transfer issues after drilling one stand of new hole.

As in the previous run a similar high WOB was applied. The same localized ringout was observed. The ringout occurred at the end of the run over a short depth span.

Table 21. BHA 39: 9,064' to 9,748'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog FTKC63-01 PDC, 3x13-3x14's	Reed Hycalog	A270978	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 3/8" x 8 1/4" Double	Scout	650-05-546	6 1/2	1 1/4	35.32	36.17	4 1/2 REG
3	6 1/2" Scout Sub-PUK Sensor	Scout	650-CSS-003	6 1/2		2.61	38.78	4 1/2 IF
4	6 3/4" NM Pony Collar	Stabildrill	SD 56830	6 3/4	3 1/4	8.98	47.76	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-072	6 1/2	2 13/16	3.13	50.89	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabildrill	SD 56089	6 7/8	3 1/4	30.26	81.15	4 1/2 IF
7	6 3/4" NMDC	Stabildrill	SD 49788	6 3/4	3 1/4	30.4	111.55	4 1/2 IF
8	6 3/4" NMDC	Stabill Drill	SD 45410KRC	6 3/4	3 1/4	29.41	140.96	4 1/2 IF
9	5" HWDP (15 stands)		RIG	5	3	1396.48	1537.44	4 1/2 IF
10	5" Drill Pipe to surface		RIG	5	3 1/4		1537.44	4 1/2 IF

BHA Highlights:
Bit TKC63-O1; TFA = 0.84
Motor 7/8 5.7; Fixed 1.25, Double 8 1/4 x 8 1/4 '' Stab – Re-run
No string stabilizers nor roller reamers

Figure 58. This bit is an FTKC63-01. Bit grading: 2-7-RO-S-X-I-CT-PR - ring out. The bit drilled 684 ft with an average ROP of 41 fph.

Figure 59. This bit is an FTKC63-01. Bit grading: 2-7-RO-S-X-I-CT-PR - ring out. The bit drilled 684 ft with an average ROP of 41 fph.

Lessons Learned:
For this run, the bit design had been changed for higher durability.

- Higher back rakes
- Higher cutter count in the nose
- Larger chamfer

There was more aggressiveness.

- Alternating shaped 3D cutter layout ("SaberTooth")
- Higher shaped 3D cutter count

VII.17 BHA 40: Reamer Run

The wellbore torque and drag were significantly higher than anticipated. It was decided to make a reamer run from 7,225' to 9,748'. During the reamer run, all beads were removed from the wellbore. The mud was very foamy and this caused problems with pump cavitation. The TORQease percentage was lowered to 2.5% of the drilling fluid by volume. The reamer BHA is shown in Table 22.

Lessons Learned

- *Do not use beads and search for higher quality lubricants.*

- The torque and drag were reduced after removing the beads from the system but the lubrication issue persisted.

Table 22. BHA 40: Reamer Run (7,225' to 9,748')

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC73 H1	Reed Hycalog	PDC	8 3/4		0.85	0.85	4 1/2 REG
2	Near bit reamer with float	RIG	AR8031	6 3/4	3 1/2	6.82	7.67	4 1/2 IF
3	6 1/2" DC (1 joint)	RIG	RIG	6 1/2	3 1/4	30	37.67	4 1/2 IF
4	String reamer 6 3/4 x 8 1/2"	RIG	AR8070	6 3/4	2 1/4	6.44	44.11	4 1/2 IF
5	6 1/2" DC (1 joint)	RIG	RIG	6 1/2	3 1/4	30	74.11	4 1/2 IF
6	String reamer 6 3/4 x 8 1/2"	RIG		6 3/4	2 1/4	6.53	80.64	4 1/2 IF
7	6 1/2" DC (1 joint)	RIG	RIG	6 1/2	3 1/4	30	110.64	4 1/2 IF
8	5" HWDP (3 stands)	RIG	RIG	5	3	279.2	389.84	4 1/2 IF
9	Watermellon 6 1/2 x 7 7/8"	RIG	AM7001	6 1/2	2 3/4	7.18	397.02	4 1/2 IF
10	5" HWDP (11 stands)	RIG	RIG	5	3	1023.7	1420.72	4 1/2 IF
11	Drilling jar	RIG	RIG	6 1/2	2 7/8	30.57	1451.29	4 1/2 IF
12	5" HWDP (1 stand)	RIG	RIG	5	3	93.1	1544.39	4 1/2 IF
13	5" Drill Pipe to surface	RIG	RIG	5	3 1/4		1544.39	4 1/2 IF

VII.18 Drilling BHA 41: 9,748' to 10,490'

BHA 41 (Table 23 and Figures 60) drilled 742 ft with an average ROP of 47 fph. A double stab mud motor plus Vibe Scout friction reduction tool (agitator) plus push pipe were used on this BHA.

- Sliding 133 ft (18%) with an ROP of 29 fph.
- Rotating 609 ft (82%) with an ROP of 55 fph.

The motor yields were 7.5 deg/100 ft. Three coolers were on for an MWD circulating temperature of 278->218°F. Staging procedures were performed at 5,800' and 7,800' to facilitate cooldown. Bit grading was 1-3-CT-S-X-I-WT-PR. The agitator (Vibe Scout) provided efficient sliding and there was no need to oscillate pipe. There was also better tool face control. The ROP stayed consistent for the entire run. Rotary drilling trends were still erratic – build/drop/walk right.

Lessons Learned

- Motor and Vibe Scout temperature ratings of 220° to 250°F were inadequate.
- The agitator did help with the slides. The stator of the agitator needs to be rated at a temperature above 300°F. The bit was pulled because the agitator failed.
- The TORQease percentage was 2.0% of the drilling fluid by volume. Search for a better lube. The torque and drag were high.
- This bit set the technical limit for footage on this well. High ROP was maintained with a lower WOB. Localized ring out was mitigated during the bit run.

Table 23. BHA 41: 9,748' to 10,490'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A271436	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 1/4" x 8 1/4" Double	Scout	650-05-412	6 3/4	1 1/4	34.5	35.35	4 1/2 IF
3	6 1/2" Scout Sub-PUK Sensor	Scout	650-CSS-003	6 1/2	3 1/4	2.61	37.96	4 1/2 IF
4	6 3/4" NM Pony Collar	Stabildrill	SD 56830	6 3/4	3 1/4	8.98	46.94	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-072	6 1/2	2 13/16	3.13	50.07	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabildrill	SD50319	6 5/8	3 1/4	28.77	78.84	4 1/2 IF
7	6 3/4" NMDC with crowsfoot	Stabildrill	SD53497	6 3/4	3 1/4	28.73	107.57	4 1/2 IF
8	6 3/4" NMDC	Stabildrill	SD56088	6 5/8	3 1/4	30.46	138.03	4 1/2 IF
9	5" HWDP (3 stands)		RIG	5	3	279.3	417.33	4 1/2 IF
10	5" Drill Pipe (23 stands)		RIG	5	3 1/4	2185.39	2602.72	4 1/2 IF
11	6 1/2" Vibe Scout	Scout	650-PLS04-034	6 1/2	2 7/8	29.26	2631.98	4 1/2 IF
12	5" Drill Pipe (13 stands)		RIG	5	3 1/4	1226.43	3858.41	4 1/2 IF
13	5" HWDP (12 stands)		HWDP-3	5	3	1117.18	4975.59	4 1/2 IF
14	5" Drill Pipe to surface		RIG	5	3 1/4		4975.59	4 1/2 IF

Figure 60. This bit, TKC63, drilled 742 ft with an average ROP of 47 fph. Bit grading was 1-3-CT-S-X-I-WT-PR.

Drilling BHA 42: 10,490' to 10,955'

BHA 42 (Table 24 and Figures 61 and 62) drilled 465 ft with an average ROP of 53 fph. A double stab mud motor with a Vibe Scout friction reduction tool (agitator) and push pipe were used on this BHA. The sliding and rotating specifics are as follows.

- Sliding 80 ft (17%) with an ROP of 30 fph.
- Rotating 385 ft (83%) with an ROP of 62 fph.

Motor yields were 7.5 deg/100 ft. Three coolers were utilized to maintain an MWD circulating temperature of between 228°F and 265°F. Staging procedures were performed at 5,800, 7,500, and 9,200 ft for cooldown. Bit grading was 1-1-WT-A-X-I-NO-TD. The agitator again facilitated efficient sliding and there was no need to oscillate pipe. There was better tool face control. ROP remained similar throughout the run. Rotary drilling trends were still erratic – build/walk left.

Table 24. BHA 42: 10,490' to 10,955'

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A271437	8 3/4		0.85	0.85	4 1/2 REG
2	6 1/2" Motor 7/8 5.7, Fixed 1.25, 8 1/4" x 8 1/4" Double	Scout	650-05-413	6 3/4	1 1/4	34.02	34.87	4 1/2 IF
3	6 1/2" Scout Sub-PUK Sensor	Scout	650-CSS-003	6 1/2	3 1/4	2.61	37.48	4 1/2 IF
4	6 3/4" NM Pony Collar	Stabildrill	SD 56830	6 3/4	3 1/4	8.98	46.46	4 1/2 IF
5	6 1/2" NM UBHO	Scout	650-UBHO-072	6 1/2	2 13/16	3.13	49.59	4 1/2 IF
6	6 3/4" NMDC with MWD	Stabildrill	SD50319	6 5/8	3 1/4	28.77	78.36	4 1/2 IF
7	6 3/4" NMDC	Stabildrill	SD53497	6 3/4	3 1/4	28.73	107.09	4 1/2 IF
8	6 3/4" NMDC	Stabildrill	SD56088	6 5/8	3 1/4	30.46	137.55	4 1/2 IF
9	5" HWDP (3 stands)		RIG	5	3	279.3	416.85	4 1/2 IF
10	5" Drill Pipe (23 stands)		RIG	5	3 1/4	2185.39	2602.24	4 1/2 IF
11	6 1/2 Vibe Scout	Scout	650-PLS04-060	6 1/2	2 5/8	27.72	2629.96	4 1/2 IF
12	5" Drill Pipe (13 stands)		RIG	5	3 1/4	1226.43	3856.39	4 1/2 IF
13	5" HWDP (12 stands)		HWDP-3	5	3	1117.18	4973.57	4 1/2 IF
14	5" Drill Pipe to surface		RIG	5	3 1/4		4973.57	4 1/2 IF

BHA Highlights:
Bit TKC63-P1; TFA = 0.84
Motor 7/8 5.7; Fixed 1.25, Double 8 1/4 x 8 1/4 '' Stab
Vibe Scout (agitator)
Push pipe – HWDP in the vertical/curve interval

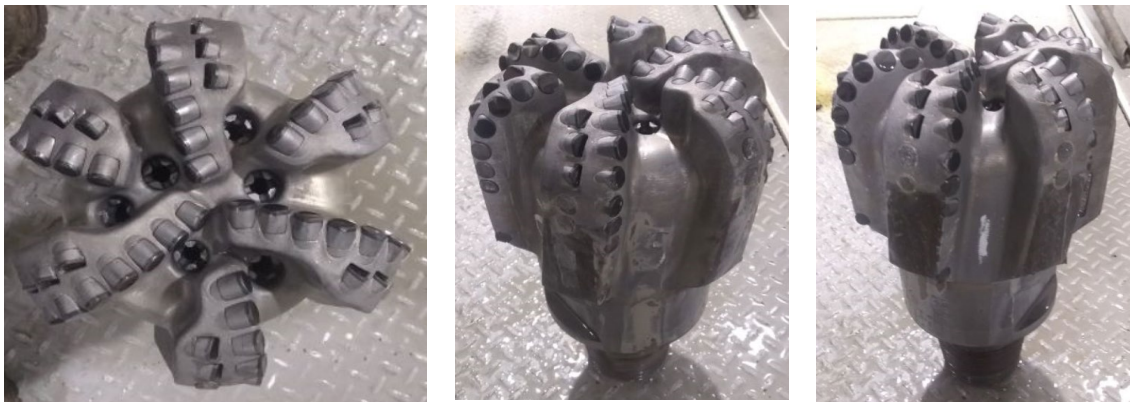

Figure 61. The bit was a TKC63-P1. This bit drilled 465 ft with an average ROP of 53 fph. Bit grading was 1-1-WT-A-X-I-NO-TD.

Run Information

	8.75 TKC63-P1 REEDHYCALOG Tangent A271437 TD
Depth In (ft MD)	10,490
Depth Out (ft MD)	10,955
Footage Drilled (ft)	465
On-Bottom Hours	8.10
On-Bottom ROP (ft/hr)	57.4
Inclination In	64.86
Inclination Out	68.60

Motor Information

Motor Size (in)	Motor Mfg	Steering Type	Motor Lobe Config	Motor Stage Count	Motor Bend Angle (°)	Motor Bit to Bend (in)	Motor Rev/Gal
6.5	Scout	Fxd BHM	7/8	5.7	1.25	48	0.24

Figure 62. The bit was a TKC63-P1. This bit drilled 465 ft with an average ROP of 53 fph. Bit grading was 1-1-WT-A-X-I-NO-TD.

Lessons Learned:

- An alternative lubricant was tried. Pro1lube was mixed with the existing TORQease in the mud system for better lubricity. The torque and drag were still high.
- Research the best lubricant to be utilized.

VII.20 Gyro BHA 43:

A dedicated gyro survey was run. The assembly is shown in Table 25.

Table 25. Gyro Survey from TD

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A271437	8 3/4		0.85	0.85	4 1/2 REG
2	Bit Sub with float valve/crossfoot	Rig	RIG	6 1/4	3	2.75	3.6	2 3/8 IF
3	5" HWDP (15 stands)		RIG	5	3 1/4	1396.48	1400.08	4 1/2 IF
4	5" Drill Pipe to surface		RIG	5	3 1/4		1400.08	4 1/2 IF

VII.21 Coring BHA 44: Tripped Out Due to Torque and Hole Drag.

BHA 44 went in at 10,955' and was tripped out due to high torque and drag at 10,955' (starting at approximately 10,700 ft MD). No core was cut/recovered. The specifications of the assembly are as follows.

- CCl 700 Series – Equipped with JMS.
- 60' of core barrel.
- Bit Type: CCl – 713.

Lessons Learned:

- Make a reamer run prior to running the core assembly.

VII.22 Reamer BHA 45 Clean out BHA

BHA 45 (Table 26) was a cleanup run to prepare the bottom of the hole for the next core run. This was run in the hole to approximately 9700 ft. High torque was attributed to the 8-5/8" inch string reamer. **This was a very important observation.** The BHA was pulled out of the hole.

Table 26. Reamer BHA 45

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A271437	8 3/4		0.85	0.85	4 1/2 REG
2	NB reamer 6 3/4x8 5/8"-float	RIG	AR8008	6 3/4	2 1/2	6.76	7.61	4 1/2 IF
3	6 1/2" DC (1 joint)	RIG	RIG	6 5/8	2 7/8	31.3	38.91	4 1/2 IF
4	String reamer 6 3/4 x 8 5/8"	RIG	AR8016	6 3/4	2 1/4	6.6	45.51	4 1/2 IF
5	6 1/2" DC (1 joint)	RIG	RIG	6 5/8	2 7/8	29.95	75.46	4 1/2 IF
6	String reamer 6 3/4 x 8 5/8"	RIG	AR8017	6 3/4	2 3/16	6.49	81.95	4 1/2 IF
7	6 1/2" DC (1 joint)	RIG	RIG	6 5/8	2 7/8	31.35	113.3	4 1/2 IF
8	5" HWDP (3 stands)	RIG	RIG	5	3	279.2	392.5	4 1/2 IF
9	Watermellon 6 1/2 x 7 3/4"	RIG	AM7006	6 1/2	2 3/4	6.88	399.38	4 1/2 IF
10	5" HWDP (11 stands)	RIG	RIG	5	3	1023.7	1423.08	4 1/2 IF
11	Drilling jar	RIG	RIG	6 1/2	2 7/8	30.57	1453.65	4 1/2 IF
12	5" HWDP (1 stand)	RIG	RIG	5	3	93.1	1546.75	4 1/2 IF
13	5" Drill Pipe to surface	RIG	RIG	5	3 1/4		1546.75	4 1/2 IF

VII.23 Reamer BHA 46 Clean out BHA

BHA 46 (Table 27) was a cleanup run to prepare the bottom of the hole for the next core run. An 8-1/2" inch string reamer was used in this assembly. Clean out was from 8,648' to 9,350' MD, at a rotation of 40 rpm, 660 gpm, and torque from 8,100 to 10,000 ft-lb_f. There were stall outs and the hole was reworked until clean. High viscosity sweeps were pumped every 200 ft to recover fine granite (including just below the curve).

Table 27. Reamer BHA 46

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Reed Hycalog TKC63 PDC, 3x13-3x14's	Reed Hycalog	A271437	8 3/4		0.85	0.85	4 1/2 REG
2	NB reamer 6 3/4x8 5/8"-float	RIG	AR8032	6 3/4	2 1/4	6.85	7.7	4 1/2 IF
3	5" HWDP (1 stand)	RIG	RIG	5	3	93.13	100.83	4 1/2 IF
4	String reamer 6 3/4 x 8 1/2"	RIG	AR8009	6 3/4	2 1/4	6.3	107.13	4 1/2 IF
5	5" HWDP (3 stands)	RIG	RIG	5	3	279.7	386.83	4 1/2 IF
6	Watermellon 6 1/2 x 7 3/4"	RIG	AM7006	6 1/2	2 3/4	6.88	393.71	4 1/2 IF
7	5" HWDP (10 stands)	RIG	RIG	5	3	930.3	1324.01	4 1/2 IF
8	Drilling jar	RIG	RIG	6 1/2	2 7/8	30.57	1354.58	4 1/2 IF
9	5" HWDP (1 stand)	RIG	RIG	5	3	93.35	1447.93	4 1/2 IF
10	5" Drill Pipe to surface	RIG	RIG	5	3 1/4		1447.93	4 1/2 IF

VII.24 Coring BHA 47: 10,955' to 10,971'

The chronology of the core runs at TD are shown in Table 28. BHA 47 went in at 10,955' and was tripped out due to core jamming at 10,971'. The specifications are as follows.

- CCI 700 Series – Equipped with JMS.
- one 30 ft conventional core barrel.
- Bit Type: CCl – 713 (Figure 63)
- 16' of core cut. 7.2' of core recovered.
- ROP 4.9'/hr, 350-400 gpm, 40-60 rpm, and 4K-8K WOB.
- 8.8' of core presumed milled or left on bottom, mandating a subsequent cleanout run.

Table 28. Core Runs at TD

Coring Runs – Slant Section			
Run	5	6	Total
Barrel Length	30' Conv.	30' Conv.	
Cut	16'	14'	30'
Recovered	7.20'	10.20'	17.4'

Figure 63. CCI-713, run at the toe of the well.

Lesson Learned

- Revisit the metallurgy of the core barrels. Aluminum may not be appropriate at the elevated temperatures.

VII.25 Clean Out BHA 48: 10,971' to 10,973'

This was a clean out run was to remove the lost core in the well and drill an additional two feet.

Lesson Learned

- High viscosity sweeps help clean out the well bore.

VII.26 Coring BHA 49: 10,973' to 10,987'

BHA 49 was run to 10,973' and was tripped out due to a core jam at 10,987'. The specifics are:

- CCI 700 Series – Conventional
- 30' of core barrel
- Bit type: CCI – 713
- 14' of core cut, 10.2' of core recovered
- ROP 4.03 ft/hr. 350-400 GAL/MIN. 40-60 RPM. 4K-8K WOB
- 3.8' of core presumed milled or left on bottom

VII.27 Reamer BHA 50: Clean Out BHA

BHA 50 (Table 29) was a cleanup run to prepare the hole to run 7" casing. A gyro tool was dropped at a depth of 9,300' and surveys were taken from 9,300' to 6,000'. This

was a repeat run because of battery failure for part of a previous run.

Table 29. Reamer BHA 50: Clean Out BHA

BHA Detail								
#	Description	Mfg.	Serial #	O.D.	I.D.	Length	Sum	Top Conn
1	Ulterra CF613 PDC, 3x13-3x14's	Ulterra	45992	8 3/4		0.85	0.85	4 1/2 REG
2	NB reamer 6 3/4x8 5/8"-float -crowsfoot	RIG	AR8008	6 3/4	2 5/16	6.76	7.61	4 1/2 IF
3	6 1/2" DC (1 joint)	RIG	RIG	6 5/8	2 7/8	31.3	38.91	4 1/2 IF
4	String reamer 6 3/4 x 8 1/2"	RIG	AR8024	6 3/4	2 1/4	6.54	45.45	4 1/2 IF
5	5" HWDP (2 joints)	RIG	RIG	5	3	61.39	106.84	2 3/8 IF
6	String reamer 6 3/4 x 8 1/2"	RIG	AR8010	6 3/4	2 1/4	6.44	113.28	4 1/2 IF
7	5" HWDP (1 stand)	RIG	RIG	5	3	92.55	205.83	4 1/2 IF
8	Watermellon 6 1/2 x 7 3/4"	RIG	AM7001	6 1/2	2 3/4	7.18	213.01	4 1/2 IF
9	5" HWDP (13 stds + 1 joint)	RIG	RIG	5	3	1241.1	1454.11	4 1/2 IF
10	5" Drill Pipe to surface	RIG	RIG	5	3 1/4		1454.11	4 1/2 IF

VII.28 Recommendations for Drilling the 8.75” Tangent Interval

- Rotary directional drilling trends were erratic with both BHA designs that we used on this tangent interval
- Run a 1.25° fixed double stabilized motor with an under-gauge roller reamer at the top.
- Consider using bits with longer gauge – 4” to 6”.
- Use an agitator for better weight transfer and sliding efficiency.
- Use roller reamers, 1/4” or more under gauge in such high -strength, high modulus formations
- Blade stabilizers present a high risk of becoming geometrically stuck.
- After reaching 7,000 ft TVD, perform cooldown staging procedures for 20 to 30 minutes every 1,500’ MD with the first stage at 5,800’ TVD.
- Ensure a motor and agitator temperature rating of 200 to 250°F after passing 7,000’ TVD in this part of the reservoir (possibly earlier to the east of this geographic point).
- Use a calibrated temperature model with MWD readings for the mud coolers. This allows optimizing conventional directional tools for geothermal wells.
- Transitions from sliding to rotating showed some high tangential and radial shocks at the MWD and the motor top sub. It is recommended to keep low rpm (35 rpm) for an interval of 15’ to 30’ until the BHA is out of the transition zone.

VII.29 Cool Down BHA 51:

BHA 51 was run to cool down the hole prior to running logging tools. A drift tool was dropped inside the drill pipe prior to tripping out of the hole.

Lessons Learned

- Circulation to reduce temperature for the logging tools allow running logs on a taxi and using Schlumberger's Thrubit technology.

VII.30 Log Well with Schlumberger BHA 52 and 53 (10,987' MD to inside intermediate casing)

The initial logging run was a UBI tool. Maximum temperature rating for the tool is 350°F. Upon reaching logging depth the tool was reading a temperature of 330° and it was decided to pull the tool without logging and further cool the hole before proceeding. There were problems with a motor in the tool and with centralization materials.

After the PetroMac taxi run with the UBI, BHA 52 was run, This BHA used Schlumberger's ThruBit technology in which the logging tool could be pumped down the drill pipe and positioned outside the end of the drill string. Data were acquired as the drill string was tripped out of the hole. The hole was circulated and cooled down prior to inserting the logging tool. A quad-combo (gamma ray, resistivity, sonic, density/neutron) and FMI logging suite was run. On initial startup the density log failed. The remaining log data were downloaded at surface. Data for the sonic, neutron, GR, and resistivity logs were acceptable. The FMI data were unreadable and a second run of the log was required.

BHA 53 was an identical BHA to BHA 52 and was used to rerun the FMI log alone. The tool was recovered at surface and acceptable data were obtained on this run. Figure 64 shows preliminary logging data.

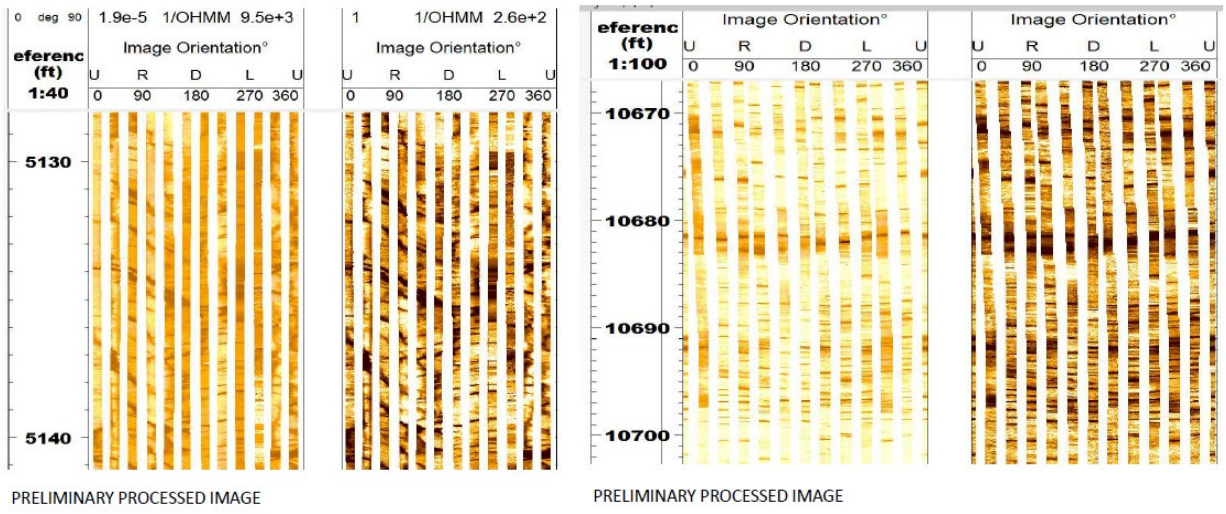

Figure 64. High quality FMI data were recovered as well as gamma ray, neutron, and dipole sonic data.

Lessons Learned

- Circulation to reduce the temperature for the logging tools was effective.

- The taxi worked well in this relatively smooth wellbore at 65°.
- The Thrubit tool allowed adequate cooldown for circulation although the temperature window was small.

VII.31 BHA 54: Plug Back Well to 10,787' MD

BHA 54 was customized to spot 200' of 100 mesh sand at the toe of the wellbore to create a barefoot section of open hole. 8000 lb of sand were pumped with the rig pumps using a high viscosity clean water fluid as a carrier.

VII.32 Production Casing:

Initial design of the production string was for a 7" liner to be set with a liner hanger at approximately 4,850' and a 7" tieback string of casing run to surface. The liner and hanger (Figure 65) were picked up and run to setting depth on drill pipe. It was attempted to set the hanger with no success. The decision was made to pull the liner hanger to surface, lay it down, and continue to run 7" casing, eliminating the hanger and tieback string. Casing was run to a setting depth of 10,787'. The cement program was redesigned and casing was cemented from 10,787' back to surface. The casing was 7", T-95, 38 ppf with JFELION premium connections. After spacers and washes, 433 bbl of RC ThermaLite-HT cement were pumped at 12.97 ppg. 15 bbl returned to surface.

Figure 65. Photograph of a portion of the liner hanger assembly before running in the hole.

Lesson Learned

- Displace with clean fresh water to remove the foamy drilling fluid.
- Use less retarder in the cement **when hole is adequately cooled down**.
- Perform reverse cement job. In this case, the float assembly precluded that option.

VIII. Completions Operations

VIII.1 Drill Out BHA 55

BHA 55 was used to drill out cement and floats , and also to clean out the 200 ft of sand in the barefoot section of the hole.

VIII.2 Mill BHA 56: Tapered Mill

BHA 56 consisted of a tapered mill to clean out any remaining cement and open float equipment to full gauge (Figure 66).

Figure 66. Tapered mill.

VIII.3 DFIT (Diagnostic Fracture Injection Test)

The DFIT consisted of running a packer (Figure 67) to 10,610' setting depth and dropping a ball to set. Upon dropping the ball the packer did not properly set. The planned DFIT procedure was continued using the full casing string as a dead string: low rate microfrac, DFIT with shut-in, DFIT with flowback, and DFIT with annulus open. (Figures 68 through 70). The first three test cycles provided reliable in situ information. *The fourth cycle confirmed that the packer had not sealed.*

The packer was released with some difficulty and successfully retrieved. No packer elements remained when the tool reached the surface.

Lessons Learned

- Ensure high temperature elements are available when contracted for.

Figure 67. Phtograph of the packer (before and after running).

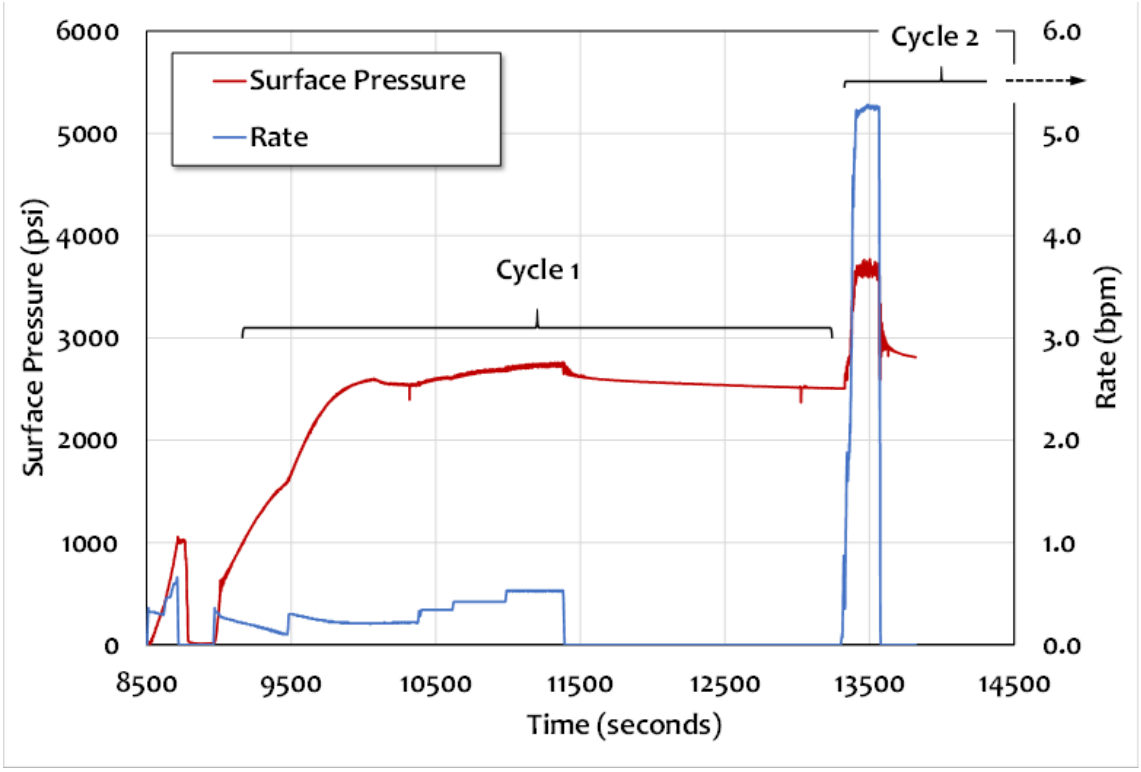

Figure 68. This is a plot of surface pressure and rate for the first DFIT cycle (at rates up to 0.5 bpm), followed by a brief shut in and then the injection portion of the standard DFIT test and the first part of the shut-in for that cycle. The entirety of Cycle 2 is shown in Figure 69.

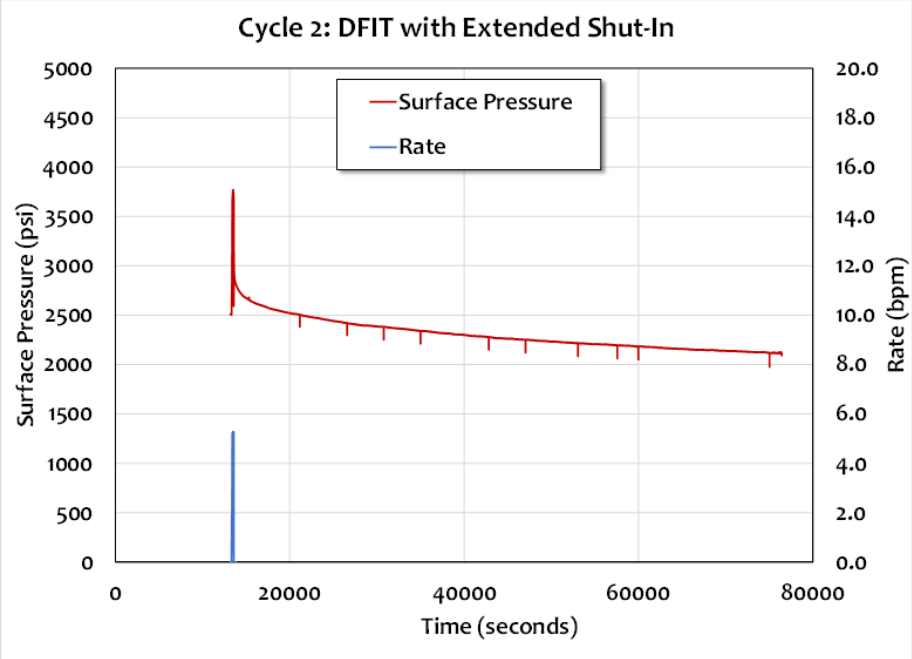

Figure 69. This is a plot of surface pressure and rate for the second DFIT cycle (pumping at 5 bpm for 2.5 minutes after rate stabilization), followed by a prologned shut in.

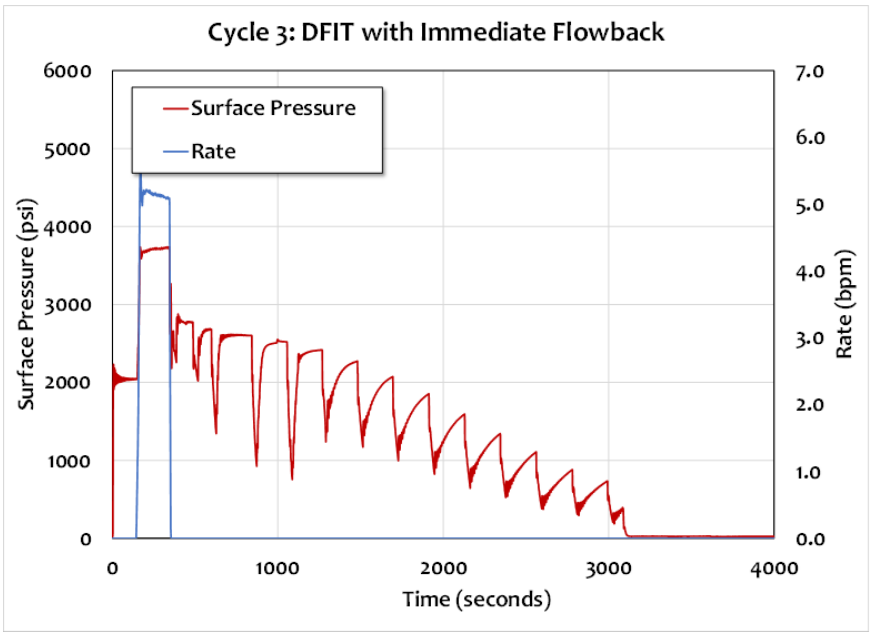

Figure 70. This is a plot of surface pressure and rate for the third DFIT cycle (pumping at 5 bpm for 2.5 minutes after rate stabilization), followed by a flowback sequence through a 1/64-inch choke (flow for 30 seconds followed by a three-minute shut-in, repeatedly).

IX. Secure Well

Thread-on wellhead and master valve were installed on the 7” casing (Figure 71).

Figure 71. Master valve

X. Bit Summary

Table 30 is a compilation of bit data for the entire well.

Table 30. Bit Summary

Bit Size Summary	Bit Type	Bit Part Number	Bit Mfg	Bit Serial Number	IADC	Class	Run Seq #	Depth In	Depth Out	Distance	Hrs	ROP	I	O	MD	LOC	B	G	OD	RP	Well Remarks	Common Well Name	Lic Form	API/UWI	Operator
17.5	TKC76-C5	10183360	REEDHYCALOG	A275580			1	28	1629	1601	11.92	134.3	0	1	CT	C	X	I	WT	TD		FORGE 16A(78)-32			UNIVERSITY OF UTAH
12.25	TKC66-R1	10175516	REEDHYCALOG	E266453		M	2	1629	1629	0	0.00		0	0	NO	A	X	I	NO	BHA		FORGE 16A(78)-32			UNIVERSITY OF UTAH
12.25	GF15BODJPS		SMITH BITS	RK6139			3	1629	1644	15	2.50	6.0	1	1	WT	A	E	I	NO	BHA		FORGE 16A(78)-32			UNIVERSITY OF UTAH
12.25	TKC66-R1	10175516	REEDHYCALOG	E266453		M	4	1644	4552	2908	59.58	48.8	2	1	WT	A	X	I	CT	FM		FORGE 16A(78)-32			UNIVERSITY OF UTAH
12.25	MDSI616		SMITH BITS	JM7398		P	5	4552	4964	412	29.08	14.2	6	2	CR	N	X	I	CT	PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
12.25	Z713S		SMITH BITS	JP4755			6	4964	5113	149	16.33	9.1	0	0	NO	A	X	I	NO	PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	GTX63		ULTERRA	R28DF			7	5112	5113	1	10.00	0.1	8	8	WT	A	E	1		PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	XS616		SMITH BITS	JV2705			8	5113	5345	144	13.31	10.8	0	1	WT	S	X	I	BT	PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	U616M		ULTERRA	54132		PM	9	5345	5469	125	9.67	12.9	0	1	WT	S	X	I	NO	CP		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	CORE		OTHER	46206			10	5469	5504	35	3.50	10.0										FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	TKC66-P3	10179210	REEDHYCALOG	A271699		M	11	5504	5846	342	13.58	25.2	8	3	CR	C	X	I	CT	CP		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	CORE		OTHER	CORE			12	5846	5856	10	10.00	1.0										FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	U616M		ULTERRA	54131		PM	13	5856	5858	2	1.00	2.0										FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	CORE		OTHER	CORE			14	5858	5892	34	3.00	11.3										FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	TKC63-C7	10177060	REEDHYCALOG	A255857		M	15	5892	6360	468	11.60	40.3	1	2	WT	A	X	I	CT	PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	SK613MO1C	10159927	REEDHYCALOG	A232400		M	16	6360	6526	166	4.60	36.1	1	1	WT	A	X	I	NO	BHA		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	SKC513M-O1C	10191309	REEDHYCALOG	A276122			17	6526	6945	419	17.50	23.9	2	2	CT	S	X	I	WT	BHA		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	FTKC63-01	10191307	REEDHYCALOG	A276121			18	6945	7389	444	14.70	30.2	1	1	WT	A	X	I	NO	LOG		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	TKC63-C7	10177060	REEDHYCALOG	A255857		M	19	7389	8024	635	18.00	35.3	4	8	RO	S	X	I	BT	PR		FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	MILL		OTHER	MILL	MILL	OM	20	8024	8025	1	10.00	0.1										FORGE 16A(78)-32			UNIVERSITY OF UTAH
8.75	SKC513M-O1C	10191309	REEDHYCALOG	A276122			21	8024	8241	216	4.80	45.0	8	1	CR	C	X	I	WT	PP		FORGE 16A(78)-32			UNIVERSITY OF UTAH

Forge+2

…cont'd

Bit Size Summary	Bit Type	Bit Part Number	Bit Mfg	Spud	TD Date	WOB Min	WOB Max	Surf RPM Min	Surf RPM Max	DHM RPM Min	DHM RPM Max	Mud Code	Mud Wt Max	Run Date	Bit TFA	Flow Max	SPP Max	H S I	Dir Type	Inc In	Inc Out	Inc Max	Drive	BHA Summary
17.5	TKC76-C5	10183360	REEDHYCALOG	28-Oct-2020		0	32				223	G	9.20	29-Oct-2020	1.730	800.0		0.34	D		0.76	0.76	M	TKC76-C5, POSITIVE DISPLACEMENT MOTOR
12.25	TKC66-R1	10175516	REEDHYCALOG	28-Oct-2020		8	40	35	35	112	112	G		4-Nov-2020	1.490	700.0			D	0.76	0.76	0.76	M	TKC66-R1, POSITIVE DISPLACEMENT MOTOR
12.25	GF15BODJPS		SMITH BITS	28-Oct-2020		8	8	112	112	35	35	G	8.80	4-Nov-2020	0.920	700.0		1.63	D	0.76	0.76	0.76	M	GF15BODJPS, POSITIVE DISPLACEMENT MOTOR
12.25	TKC66-R1	10175516	REEDHYCALOG	28-Oct-2020		5	50	109	128	35	35	G	8.80	7-Nov-2020	1.490	700.0		0.62	D	0.76	1.45	1.45	M	TKC66-R1, POSITIVE DISPLACEMENT MOTOR
12.25	MDSI616		SMITH BITS	28-Oct-2020		40	45	120	128	40	55	G	9.00	9-Nov-2020	1.490	800.0		0.86	D	1.45	1.60	1.60	M	MDSI616, POSITIVE DISPLACEMENT MOTOR
12.25	Z713S		SMITH BITS	28-Oct-2020		40	60	40	55	116	128	G	9.00	10-Nov-2020	1.920	800.0		0.49	D	1.60	1.48	1.60	M	Z713S, POSITIVE DISPLACEMENT MOTOR
8.75	GTX63		ULTERRA	28-Oct-2020								G	9.00	10-Nov-2020	0.920			0.00	D	1.48	1.48	1.48	M	GTX63, POSITIVE DISPLACEMENT MOTOR
8.75	XS616		SMITH BITS	28-Oct-2020		45	45	89	89	140	140	G	9.30		0.920	575.0		1.87	D	1.48	1.56	1.56	M	XS616, POSITIVE DISPLACEMENT MOTOR
8.75	U616M		ULTERRA	28-Oct-2020		30	52	88	92	30	70	G	9.00	16-Nov-2020	0.910	575.0		1.73	D	1.56	0.76	1.56	M	U616M, POSITIVE DISPLACEMENT MOTOR
8.75	CORE		OTHER	28-Oct-2020								G			1.770				D	0.76	0.21	0.76	M	CORE, POSITIVE DISPLACEMENT MOTOR
8.75	TKC66-P3	10179210	REEDHYCALOG	28-Oct-2020		50	50	96	96	70	70	G	9.30	21-Nov-2020	0.900	600.0		2.22	D	0.21	2.12	2.12	M	TKC66-P3, POSITIVE DISPLACEMENT MOTOR
8.75	CORE		OTHER	28-Oct-2020								G	9.00						D	2.12	2.26	2.26	R	CORE
8.75	U616M		ULTERRA	28-Oct-2020								G	9.00		0.910			0.00	D	2.26	2.68	2.68	M	U616M, POSITIVE DISPLACEMENT MOTOR
8.75	CORE		OTHER	28-Oct-2020								W	9.00						D	2.68	2.83	2.83	R	CORE
8.75	TKC63-C7	10177060	REEDHYCALOG	28-Oct-2020		30	48	62	184	0	50	W	9.00	25-Nov-2020		600.0			D	2.83	17.32	17.32	M	TKC63-C7, POSITIVE DISPLACEMENT MOTOR
8.75	SK613MO1C	10159927	REEDHYCALOG	28-Oct-2020		30	45	132	134	50	50	W	9.00	26-Nov-2020	0.780	560.0		2.26	D	17.32	24.08	24.08	M	SK613MO1C, POSITIVE DISPLACEMENT MOTOR
8.75	SKC513M-O1C	10191309	REEDHYCALOG	28-Oct-2020		30	62	134	134	15	50	W	9.00	28-Nov-2020	0.830	585.0		2.19	D	24.08	49.11	49.11	M	SKC513M-O1C, POSITIVE DISPLACEMENT MOTOR
8.75	FTKC63-01	10191307	REEDHYCALOG	28-Oct-2020		30	62	136	186	0	50	W	9.00	29-Nov-2020	0.830	615.0		2.40	D	49.11	66.81	66.81	M	FTKC63-01, POSITIVE DISPLACEMENT MOTOR
8.75	TKC63-C7	10177060	REEDHYCALOG	28-Oct-2020		35	65	134	204	0	70	W	9.00	7-Dec-2020	0.840	565.0		2.03	D	66.81	60.79	66.81	M	TKC63-C7, POSITIVE DISPLACEMENT MOTOR
8.75	MILL		OTHER	28-Oct-2020								W							D				R	MILL
8.75	SKC513M-O1C	10191309	REEDHYCALOG	28-Oct-2020		50	50	136	136	70	70	W	9.00	8-Dec-2020	0.830	565.0		2.11	D	60.79	65.35	65.35	M	SKC513M-O1C, POSITIVE DISPLACEMENT MOTOR
8.75	SKH613M-O1C	10136473	REEDHYCALOG	28-Oct-2020		40	40	157	157	70	70	W	9.00	9-Dec-2020	0.840	650.0		3.13	D	65.35	66.78	66.78	M	SKH613M-O1C, POSITIVE DISPLACEMENT MOTOR
8.75	SKH613M-O1C	10136473	REEDHYCALOG	28-Oct-2020		40	50	69	156	70	70	W	9.00	9-Dec-2020	0.840	650.0		1.17	D	66.78	65.60	66.78	M	SKH613M-O1C, POSITIVE DISPLACEMENT MOTOR
8.75	TKC63-O1	10178841	REEDHYCALOG	28-Oct-2020		38	50	154	154	0	70	W	9.00	13-Dec-2020	0.840	640.0		2.99	D	65.60	66.34	66.34	M	TKC63-O1, POSITIVE DISPLACEMENT MOTOR
8.75	TKC63-O1	10178841	REEDHYCALOG	28-Oct-2020		30	50	154	224	0	70	W	9.00	14-Dec-2020	0.840	640.0		2.99	D	66.34	62.89	66.34	M	TKC63-O1, POSITIVE DISPLACEMENT MOTOR
8.75	TKC63-P1	10181656	REEDHYCALOG	28-Oct-2020		34	44	157	221	6	70	W	9.00	17-Dec-2020	0.840	645.0		2.95	D	62.89	64.86	64.86	M	TKC63-P1, POSITIVE DISPLACEMENT MOTOR
8.75	TKC63-P1	10181656	REEDHYCALOG	28-Oct-2020		34	40	149	155	0	60	W	9.00	19-Dec-2020	0.840	645.0			D	64.86	68.60	68.60	M	TKC63-P1, POSITIVE DISPLACEMENT MOTOR