

FORGE

16B(78)-32 Cement and Cross Well Circulation Operations

Fiber Optics Monitoring

Acquisition Date: **July 13, 2023**
Report **July 15, 2023**

Neubrex Energy Services (US), LLC

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Last update: July 15 2023

Acknowledgements



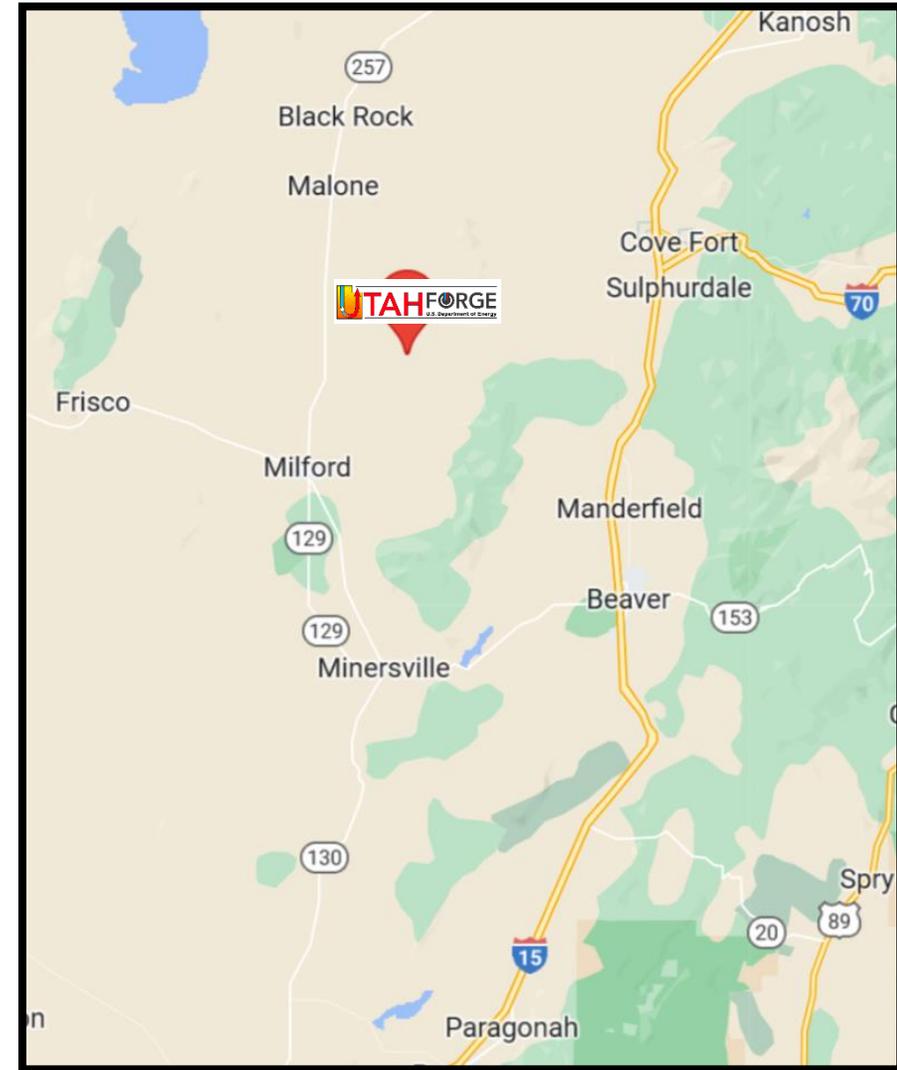
Funding for this work was provided by the U.S. DOE under grant DE-EE0007080 “Enhanced Geothermal System Concept Testing and Development at the Milford City, Utah FORGE Site”.

We thank the many stakeholders who are supporting this project, including Smithfield, Utah School and Institutional Trust Lands Administration, and Beaver County as well as the Utah Governor’s Office of Energy Development and Utah’s Congressional Delegation.

During field operations, Neubrex worked with many operational experts and received critical assistance from many people, including John McLennan, Joseph Moore, Kevin England, Leroy Swearingen, Alan Reynolds, Garth Larson, Monty Keown, Dr. Mukul Sharma, Ben Dyer, Dr. Peter Meier, Dimitrious Karvounis, Wayne Fishback. The frac, drilling, water management crews and HSE managers were instrumental in getting the surface and downhole work accomplished in a safe and effective manner.

Well Location

- Site in Beaver County, UT
- Project name
 - FORGE 16B Well



Site location

Evolution Zero - Neubrex Pre Ops Sensing Project Design



FORGE EVOLUTION ZERO Sensing Plan

1. PURPOSE

Neubrex will use all fiber optic sensing tools, methods and procedures to perform Distributed Fiber Optic Sensing (DFOS) data acquisition, signal processing and analysis of results from multiple operational evolutions related to Completions operations performance well testing of the 16A(78)-32 and 16B(78)-32 wells at the Forge site near Milford, Utah.

A. 16B(78)-32 Evolution Zero is cement pumping operational monitoring.

i. Objective: To monitor the details of temperature, strain and acoustic emissions during cementing operations, Neubrex will use available fiber optics provided by Operator to make DFOS measurements using:

ii. Rayleigh Frequency Shift Distributed Strain Sensing (RFS DSS using SR7100)

iii. Raman DTS Temperature Sensing (using Yokogawa 3000DTSX)

iv. Brillouin GAIN Spectra total absolute strain gradient mapping, full fiber. Baselines. (BR8100)

v. DAS, if fiber is allocated for Neubrex specialized TGD DAS technology up to 8000 Hz signal injection to fiber. (DAS S4000 TGD DAS)

2. CHALLENGES

1. Temperature in this well is significant issue and there is a need to see how fiber performs to interrogation. 240C

2. 45 degree slant well.

3. 10987 foot MD

4. 8559 foot TVD

5. Watch for termination issues or FIMT leakage issues on baselines and during operations.

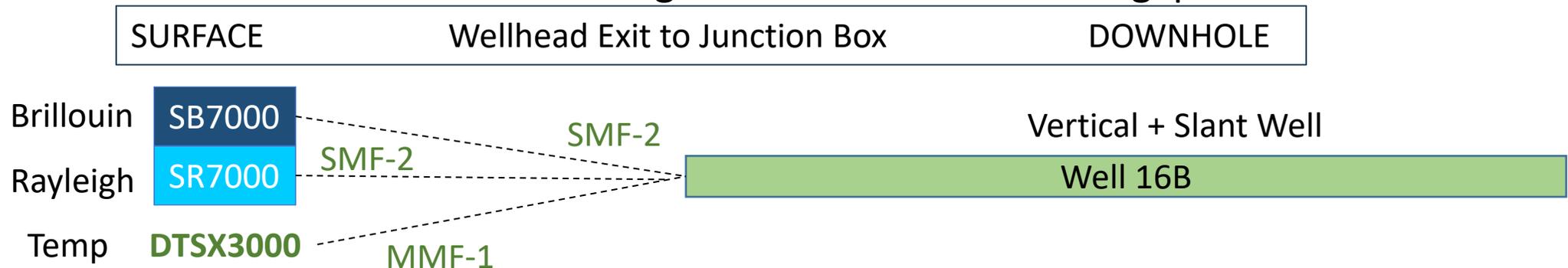
3. SENSING GOALS A. Track cement pumping key diagnostic features in data.

B. What can we use in DTS, Rayleigh and or DAS real time signatures to tell us when all good or when something is going wrong??

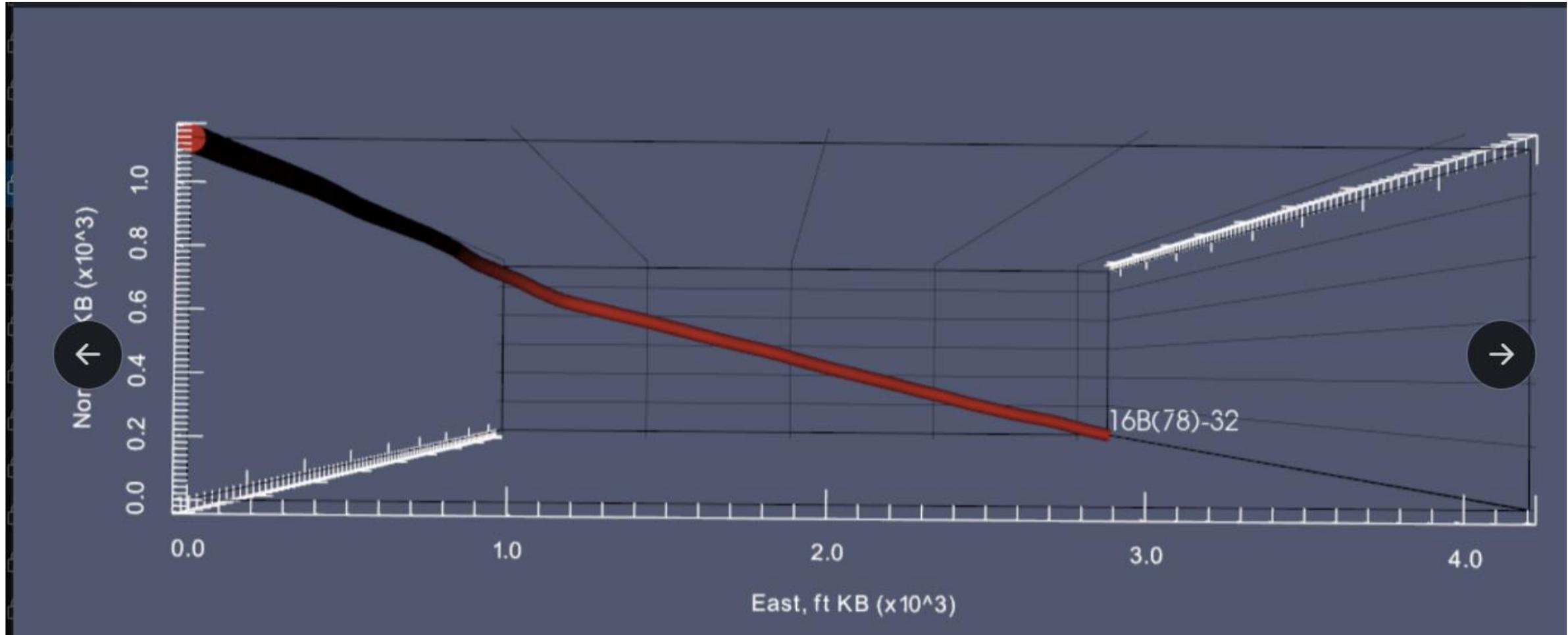
Neubrex Interrogator Unit connection schematic



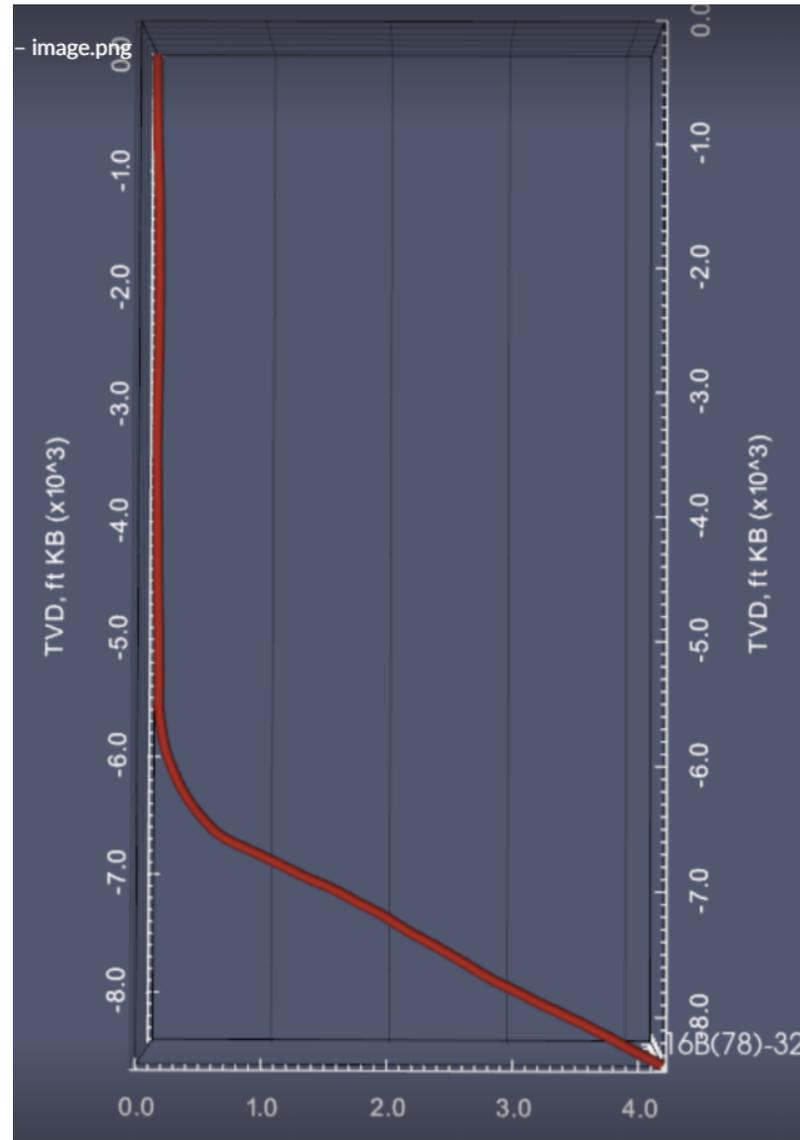
- The following IUs were used during data acquisition
- Full Time IU was SR7000 C-OTDR Rayleigh
- Periodic Baselines taken with BR8200 Brillouin PSP-BOTDR
- Full time DTSX3000 DTS IU (Yokagawa 1550nm DTS)
 - Measurements with Brillouin Interrogator Unit created limited gaps in RFS data



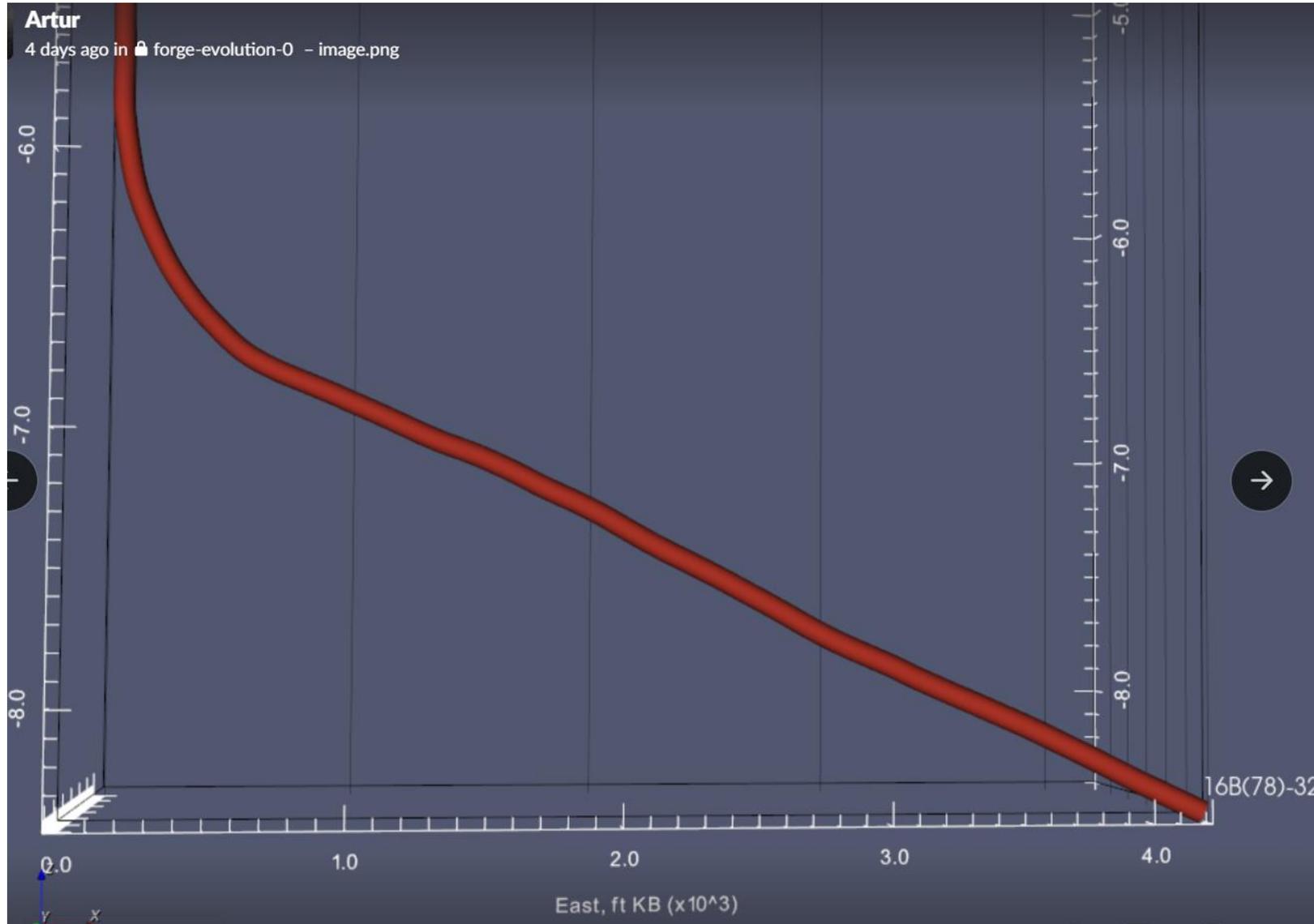
Birds Eye View of 16B Well



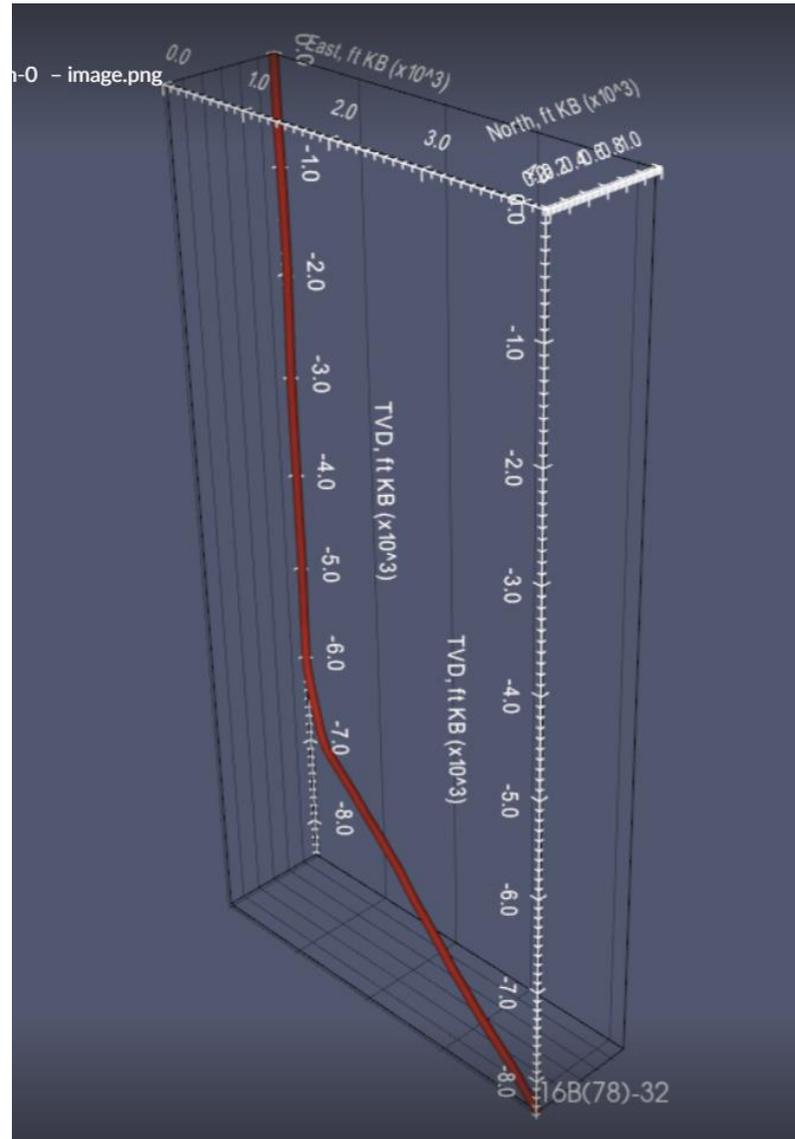
Side View of 16B Well



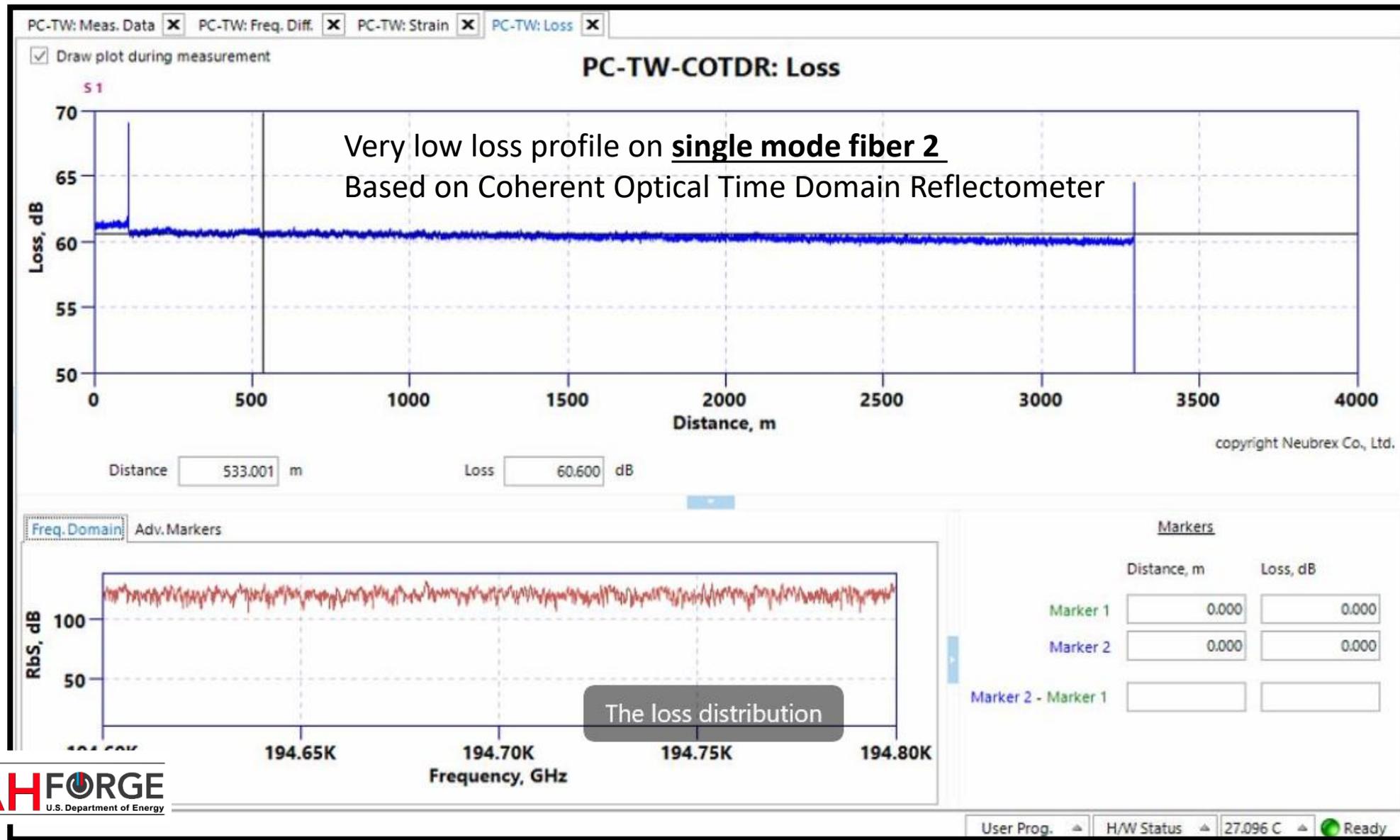
Zoom Slant Portion of 16B – Side View



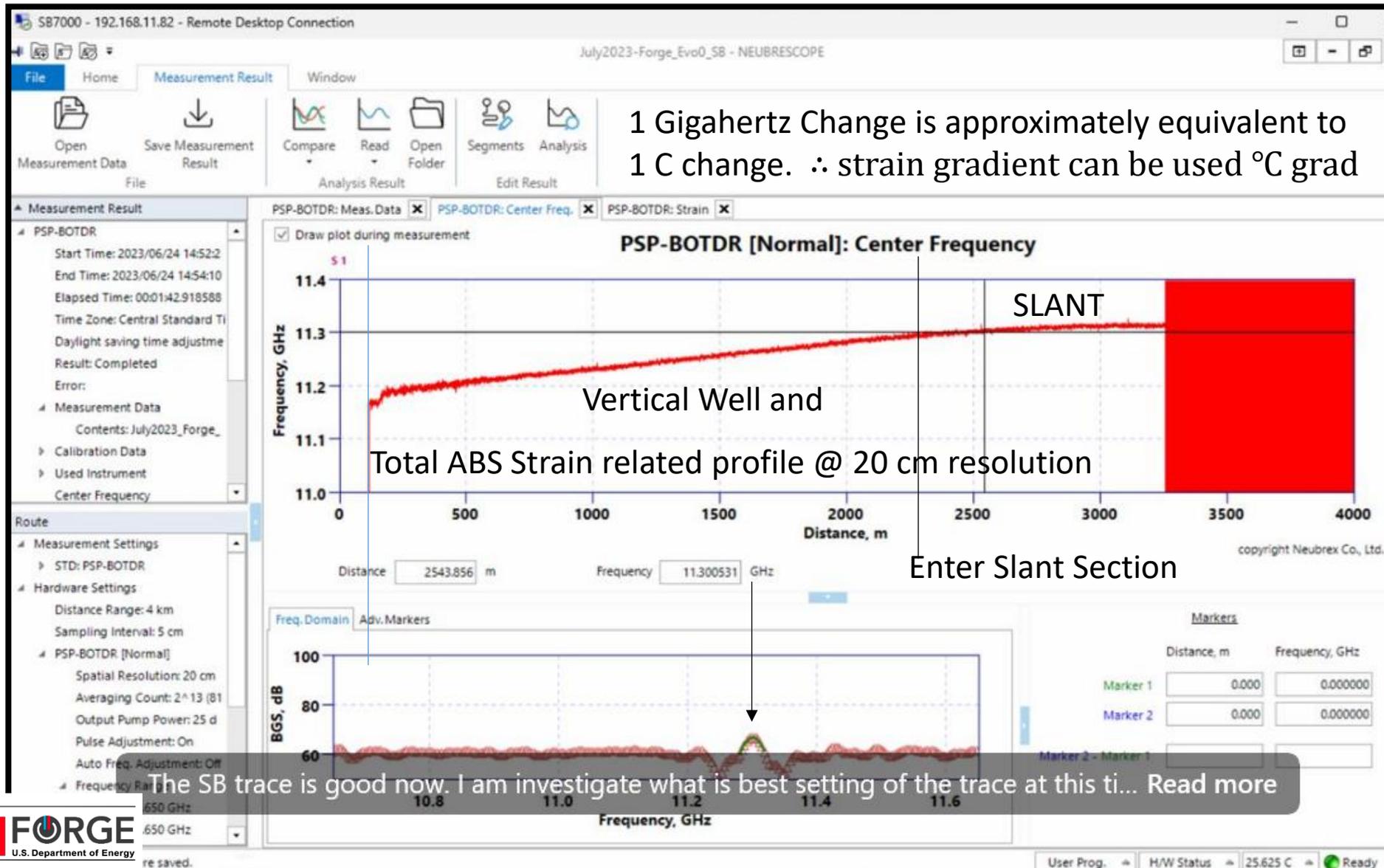
Oblique View of 16B Well Trajectory



Single Mode Fiber 2 – Pre-Cement Fiber Optical Loss Analysis



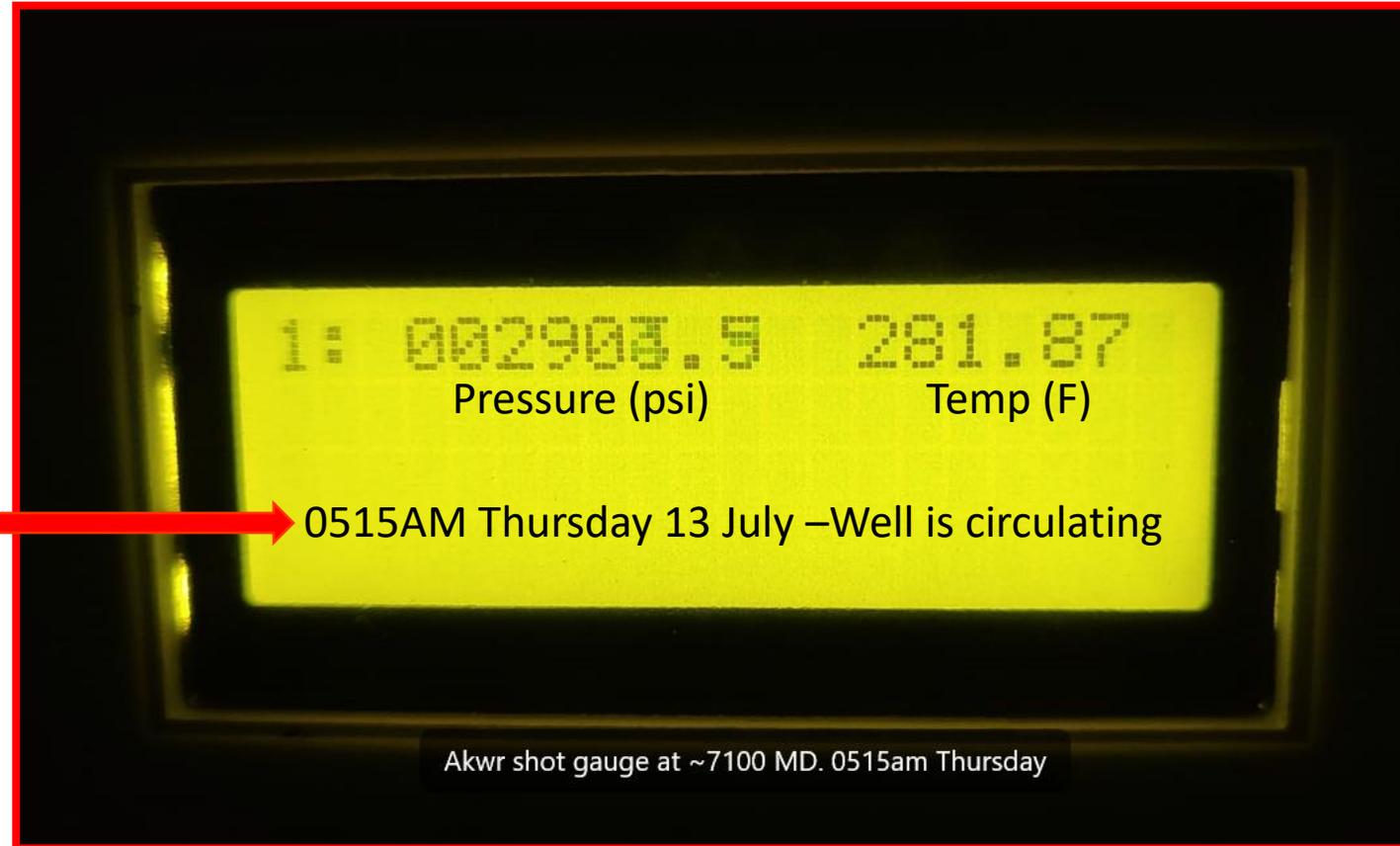
Single Mode Fiber 2 – Pre-Cement Total Absolute Strain



Baker Pressure - Temp Measures at DH PT Gauge Position



P T readouts from 7056 MD Gauge



From Alan Reynolds

Key Well Depths MD RKB - Note that Fiber Depths are not Corrected on all these plots. Need to Subtract 518 feet from Fiber depths that are shown on plots to get well md rkb



Alan Reynolds

Intermediate casing at 4837

KOP 5500

Landing point 7000

KB 31

TD 10213

Hanger 2.86 above ground level

7:17 AM



Cement Pumping Schedule from SLB Pre-Cement Meeting



Neubrex on location for Cement ops.

Step wise cement program as Communicated pre job by Schlumberger cement crew Foreman.

5 BBLS FRESH WATER

TEST LINE 5000 PSI

50 BBLS SPACER @ 12.5 PPG

630 BBLS LEAD @13.8 PPG

324 BBLS MIX WATER (4 GAL D175 PER TANK)

SHUT DOWN

DROP TOP PLUG

336 BBLS WATER DISPLACEMENT

BUMP PLUG 500 PSI

SHUT DOWN

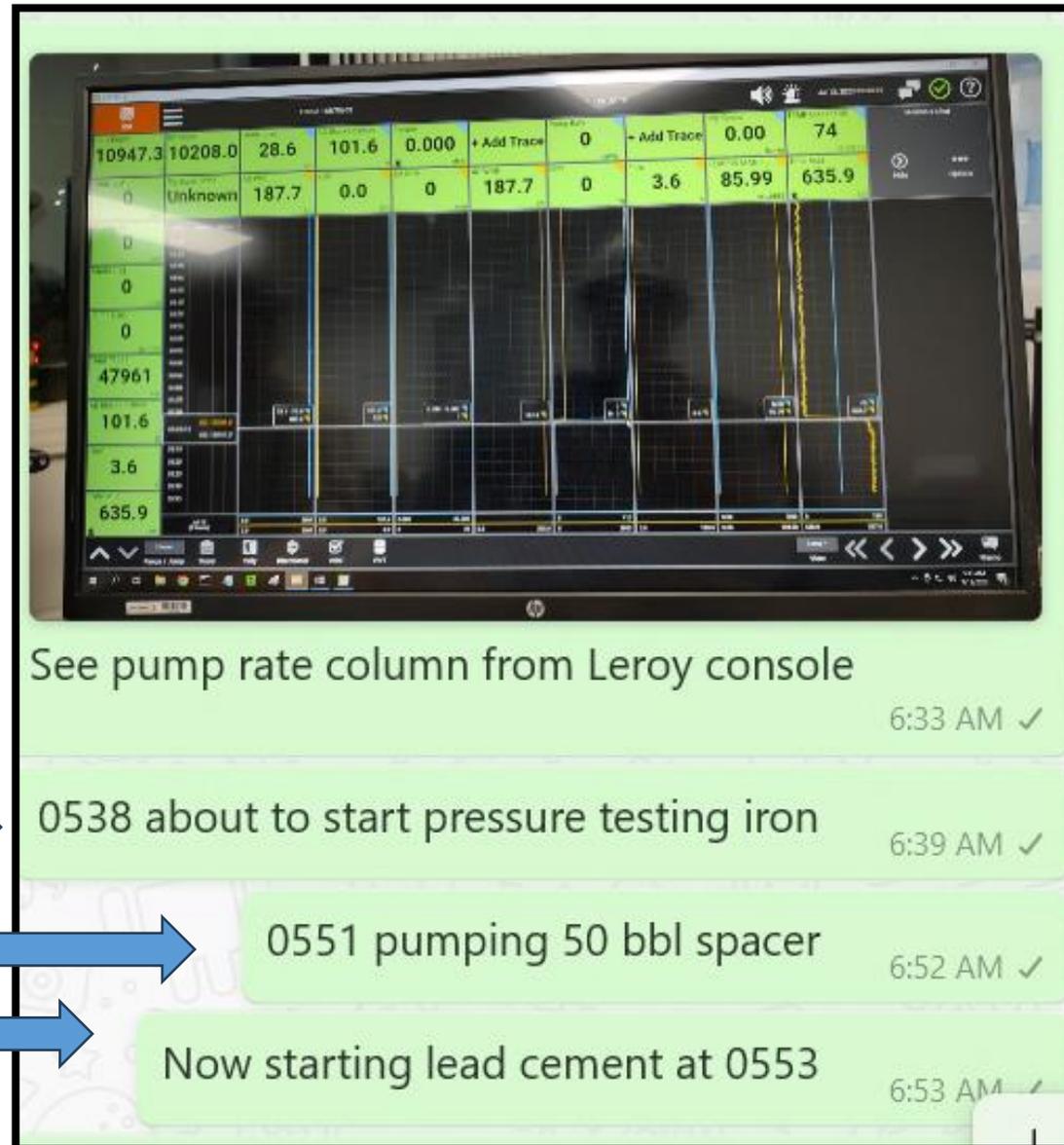
CHECK FLOAT

Cement pump schedule from SLB

Time Stamp Information Gathered on Location from Pump Crew

Neubrex on location for
Cement ops.

Leroy S. Command Center
console.



Value 1	Value 2	Value 3	Value 4	Value 5	+ Add Trace	Value 6	- Add Trace	Value 7	Value 8
10947.3	10208.0	28.6	101.6	0.000	0	0	0.00	74	
0	Unknown	187.7	0.0	0	187.7	0	3.6	85.99	635.9

See pump rate column from Leroy console 6:33 AM ✓

0538 about to start pressure testing iron 6:39 AM ✓

0551 pumping 50 bbl spacer 6:52 AM ✓

Now starting lead cement at 0553 6:53 AM ✓

These are Real Time Observation from the Field Displays of Neubrex. Depth registration is not final
On these following slides. The “surface fiber offset” distance must be removed to get MD RKB depths



Subtract 518 feet from any depth shown on vertical axis to approximate MD RKB.

6:15 PM ✓

This plot shows pre cementing, cementing and post cementing (curing) periods on RFS strain rate (left), RFS Strain Change (center) and DTS temperature (un calibrated to any gauge yet). Of interest right now is center plot where curing period exothermic top is probably indicative of the top of solid cement in the annulus. (Subtract 518 to get depth MD RKB).

6:18 PM ✓

The 10am to 11am period is especially important

6:20 PM ✓

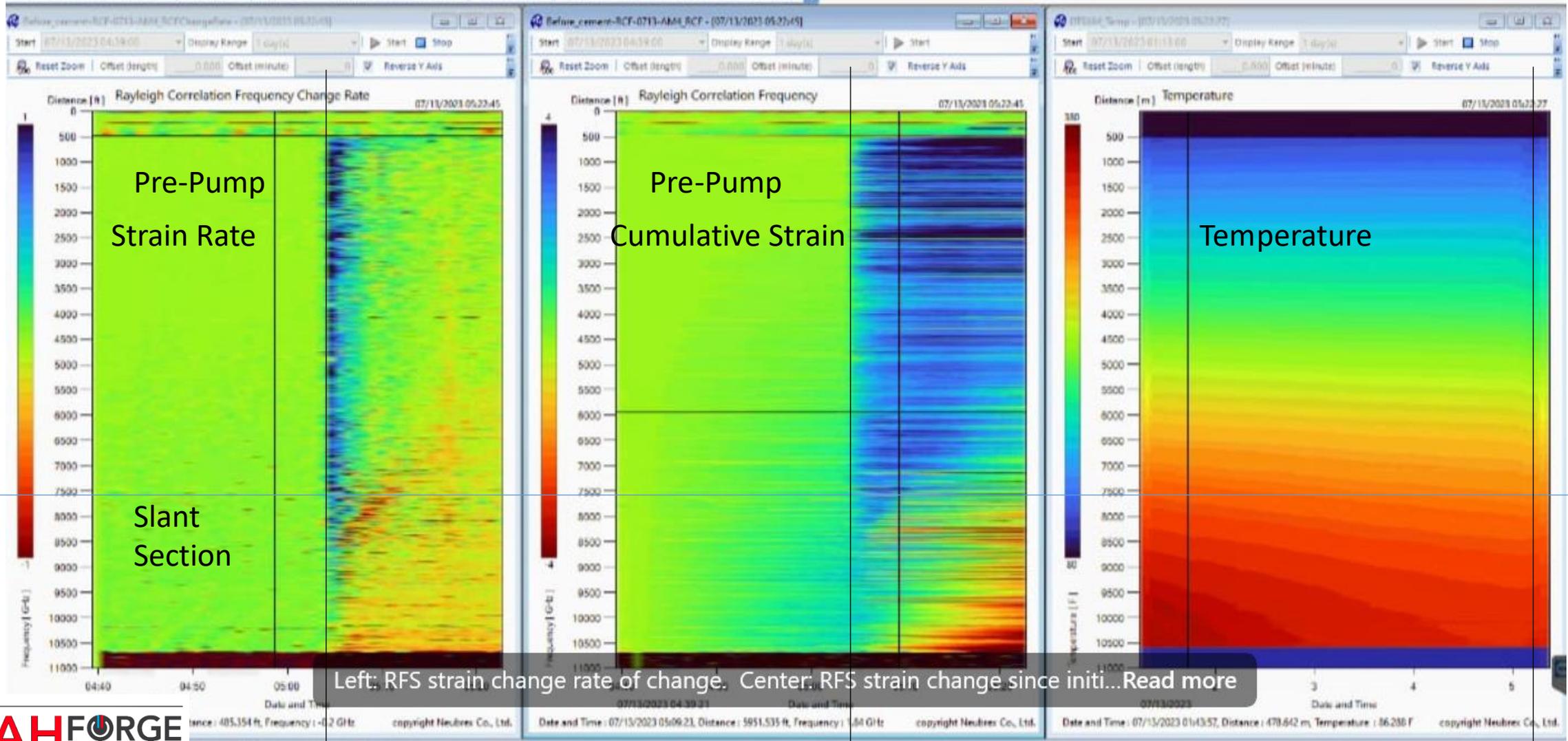
Testing Iron and Downhole Fiber Signal



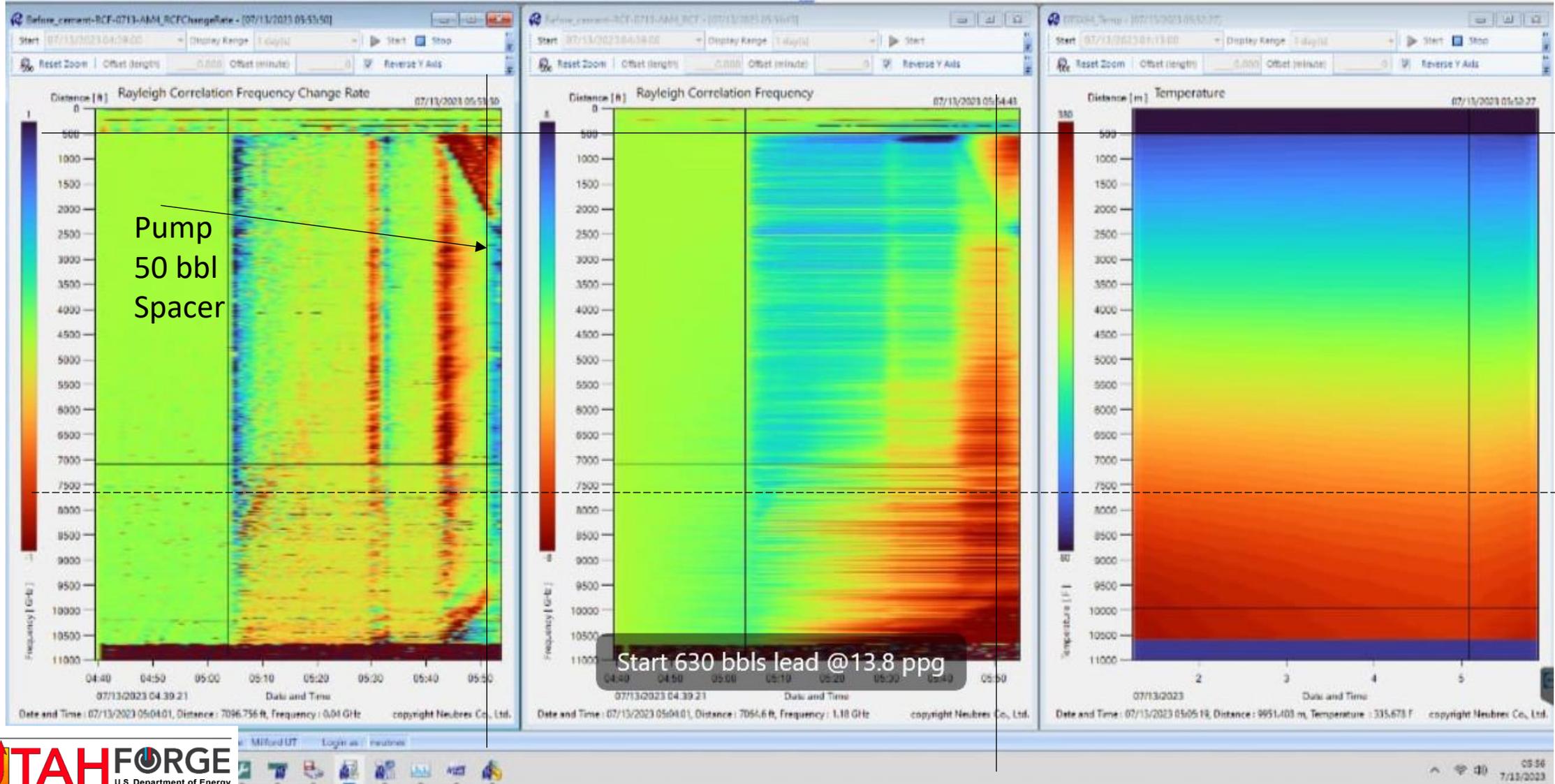
Strain Change Rate (optical units)

Strain Change (optical units)

DTS Temp (degrees F)



Pressure Testing and Spacer Time Period. Depths are fiber depths. Subtract 518 to get MD RKB Well Depth



Surface
Downhole

Slant Sec

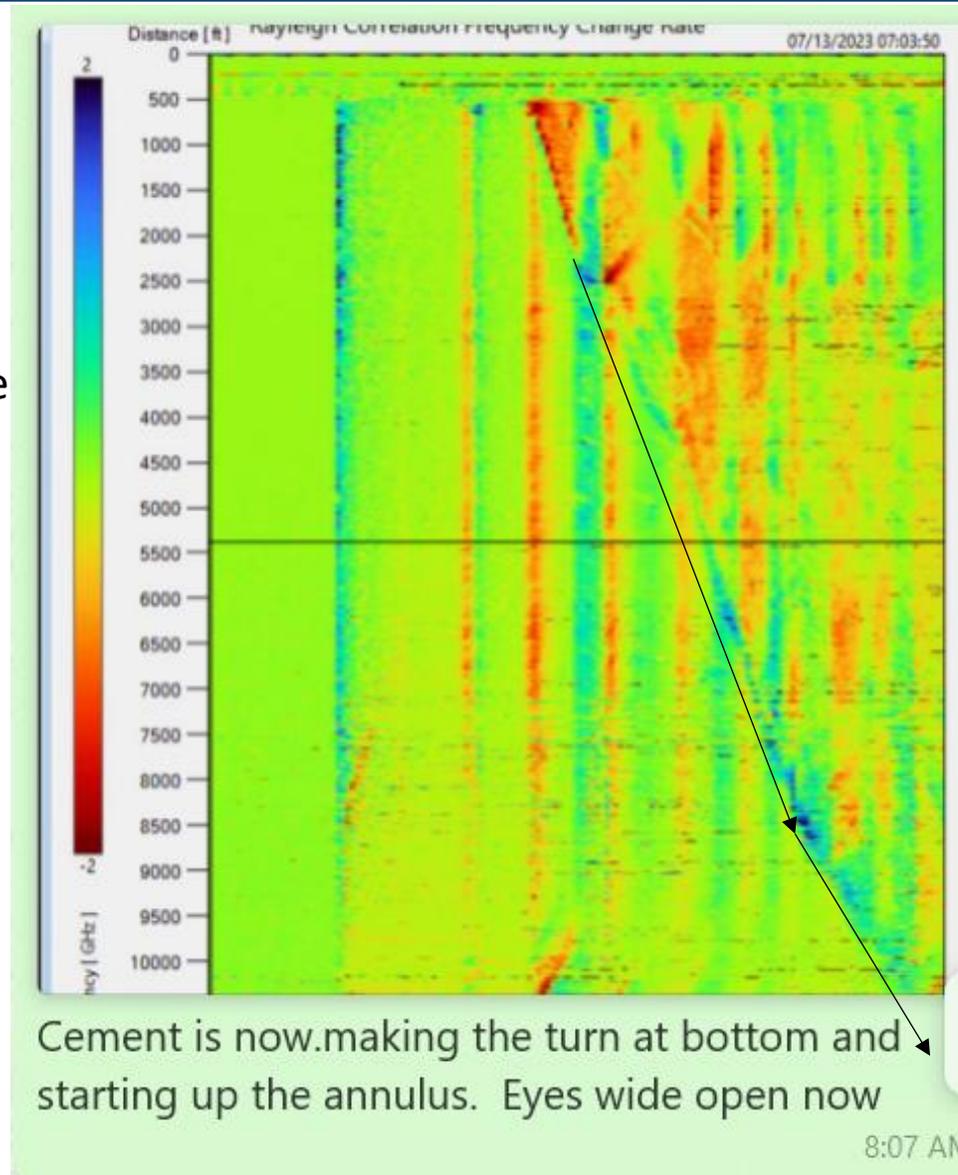


Cementing Pump and Fiber Optic Strain Rate Signal

Green is neutral – no significant Rayleigh frequency shift from Profile to profile depth point Across 56 second time interval.

Red= negative frequency shift rate Of change Over time interval, indicative Of **positive strain change rate**

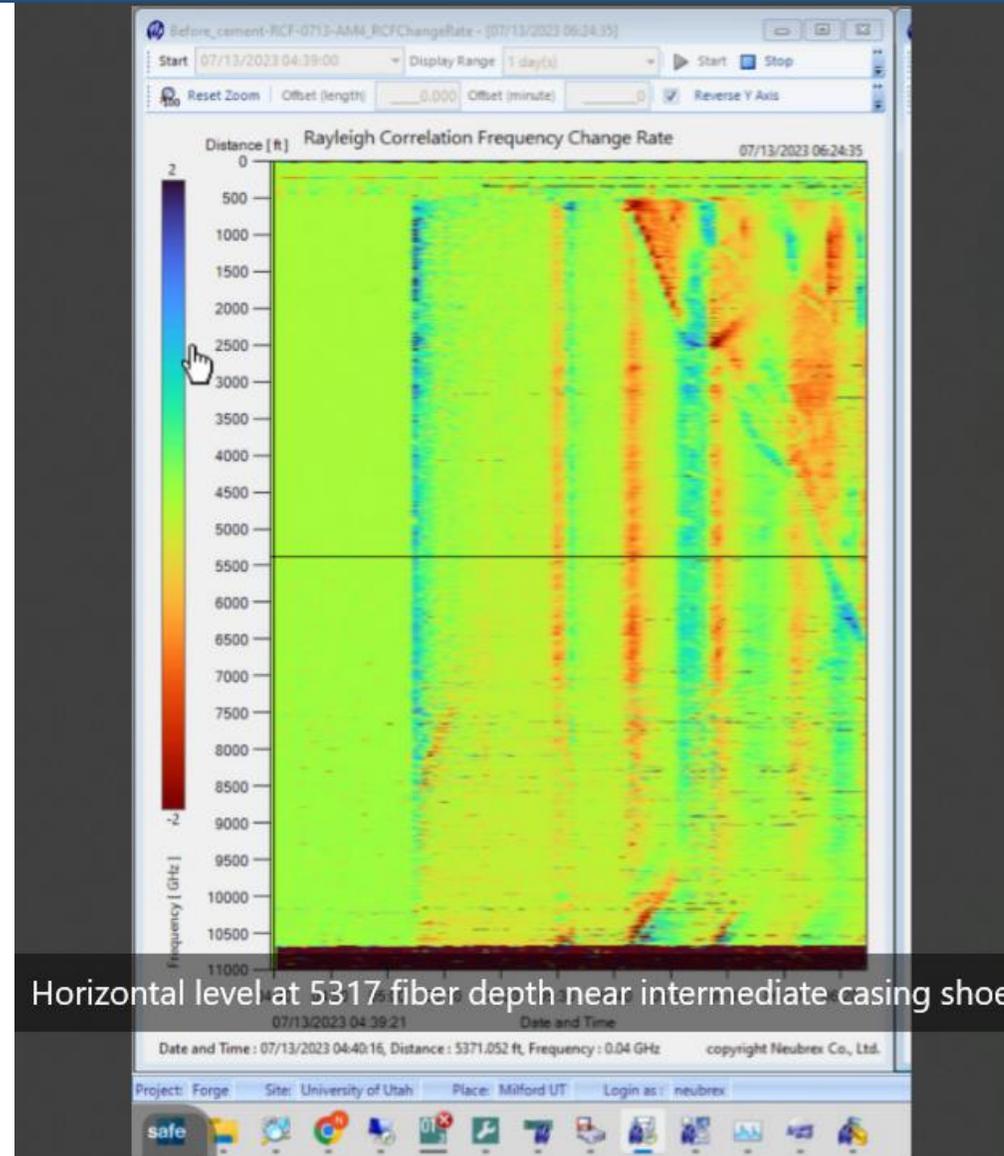
Blue= positive frequency shift rate Of change over time intervals, Indicative of **negative strain Change rate**



Any given depth interval has Alternating positive and negative Strain change rate. Like medium Period temp change is occurring In the well over time.

Velocity change in down going fluids.

Intermediate Shoe Depth shown on Neubrex Data with Vertical axis shown as Fiber Coordinates

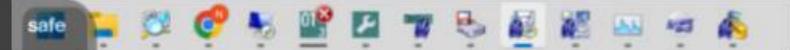


5317 Fiber Coordinates
Is 4837 MD RKB shoe depth

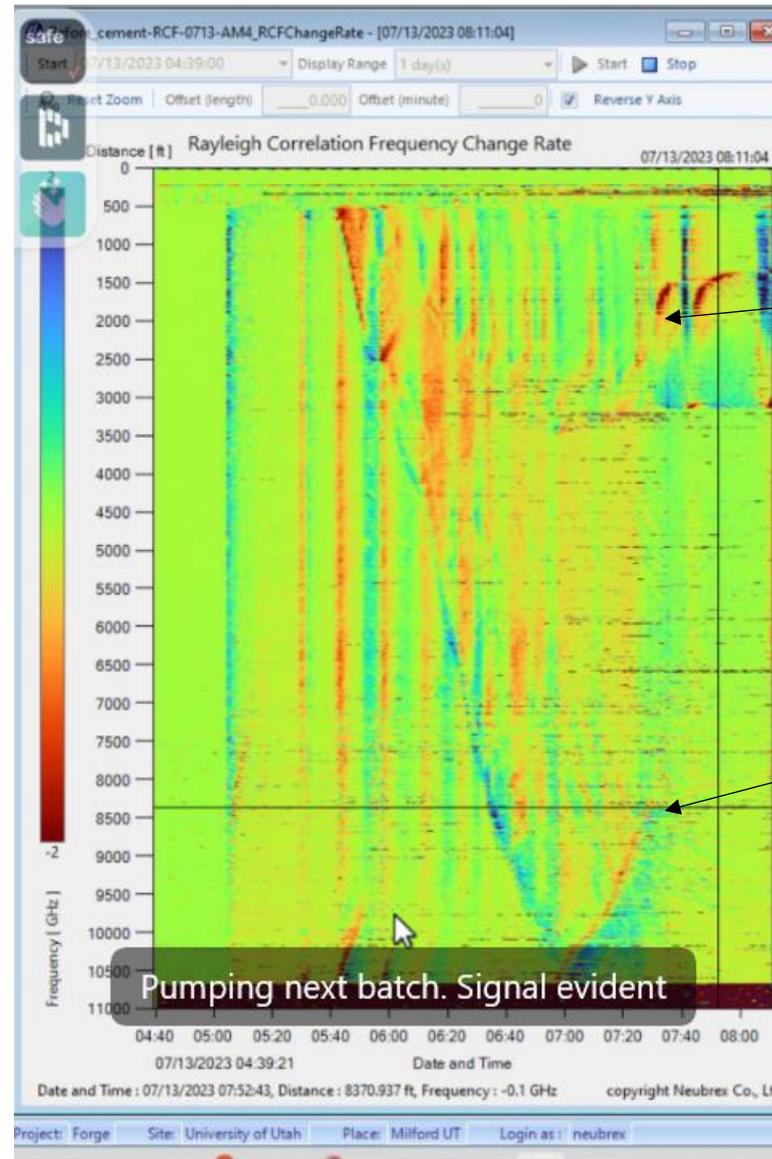
Horizontal level at 5317 fiber depth near intermediate casing shoe

Date and Time : 07/13/2023 04:39:21 Date and Time
Date and Time : 07/13/2023 04:40:16, Distance : 5371.052 ft, Frequency : 0.04 GHz copyright Neubrex Co., Ltd.

Project: Forge Site: University of Utah Place: Milford UT Login as : Neubrex



Had to stop pumper #1 and Switch to pump truck number 2. Down time. Strange Shallow

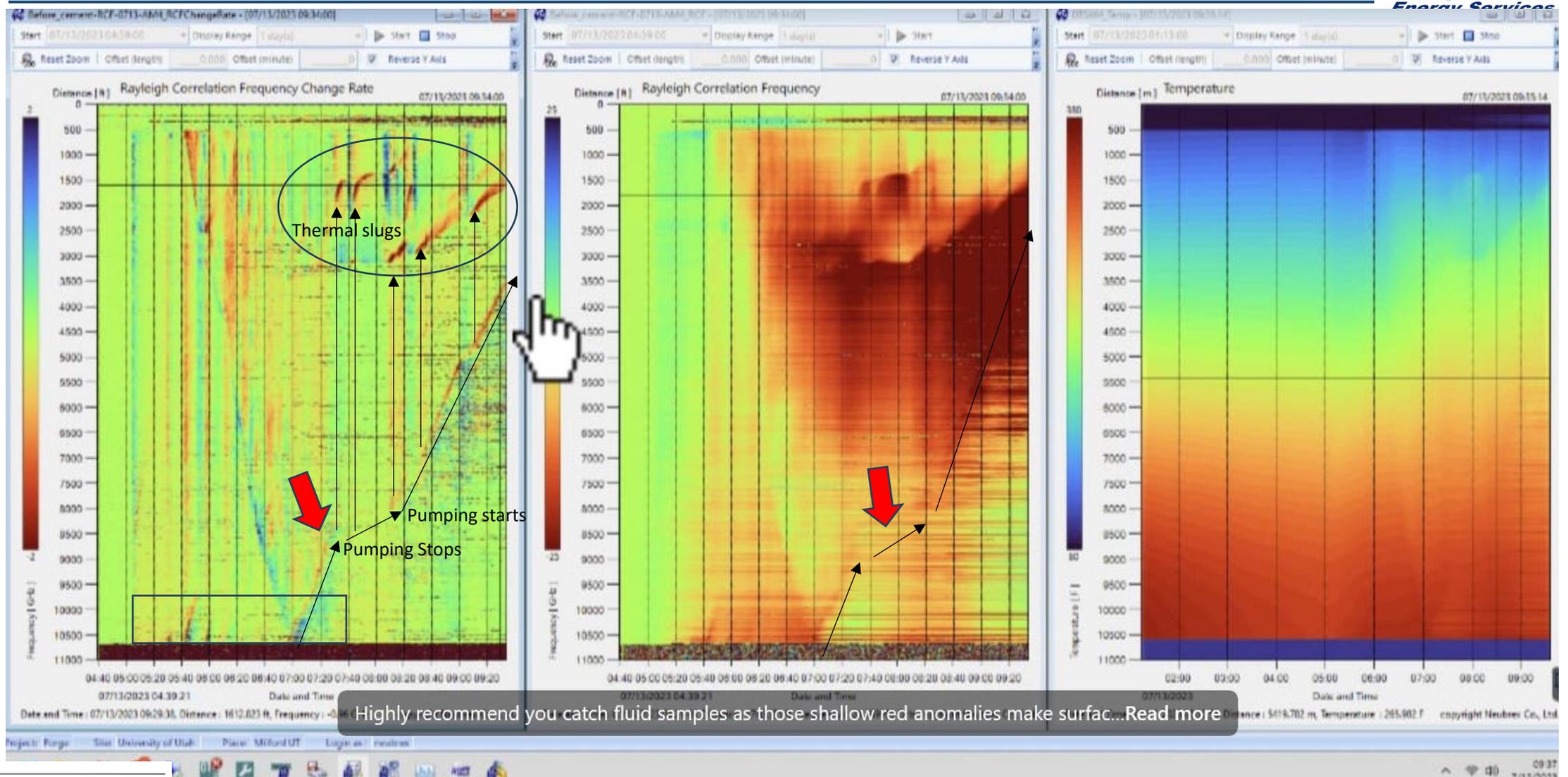


Shallow
RFS Anomaly
Temp Driven?
Not sure of
Cause
Of these
Shallow
Anomalies.

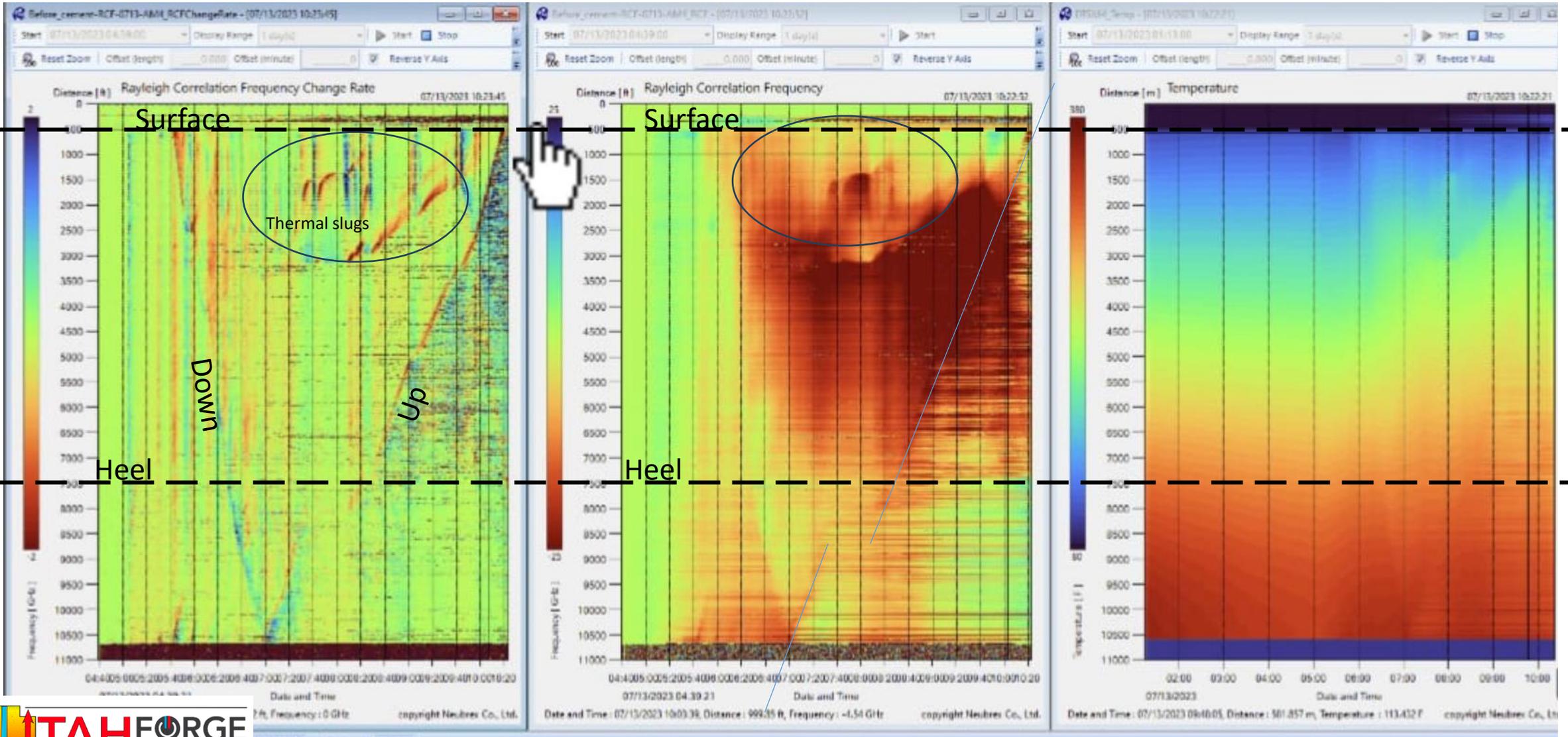
Stop pumps #1 due to
Equipment issue. Standby
While work on pumps.



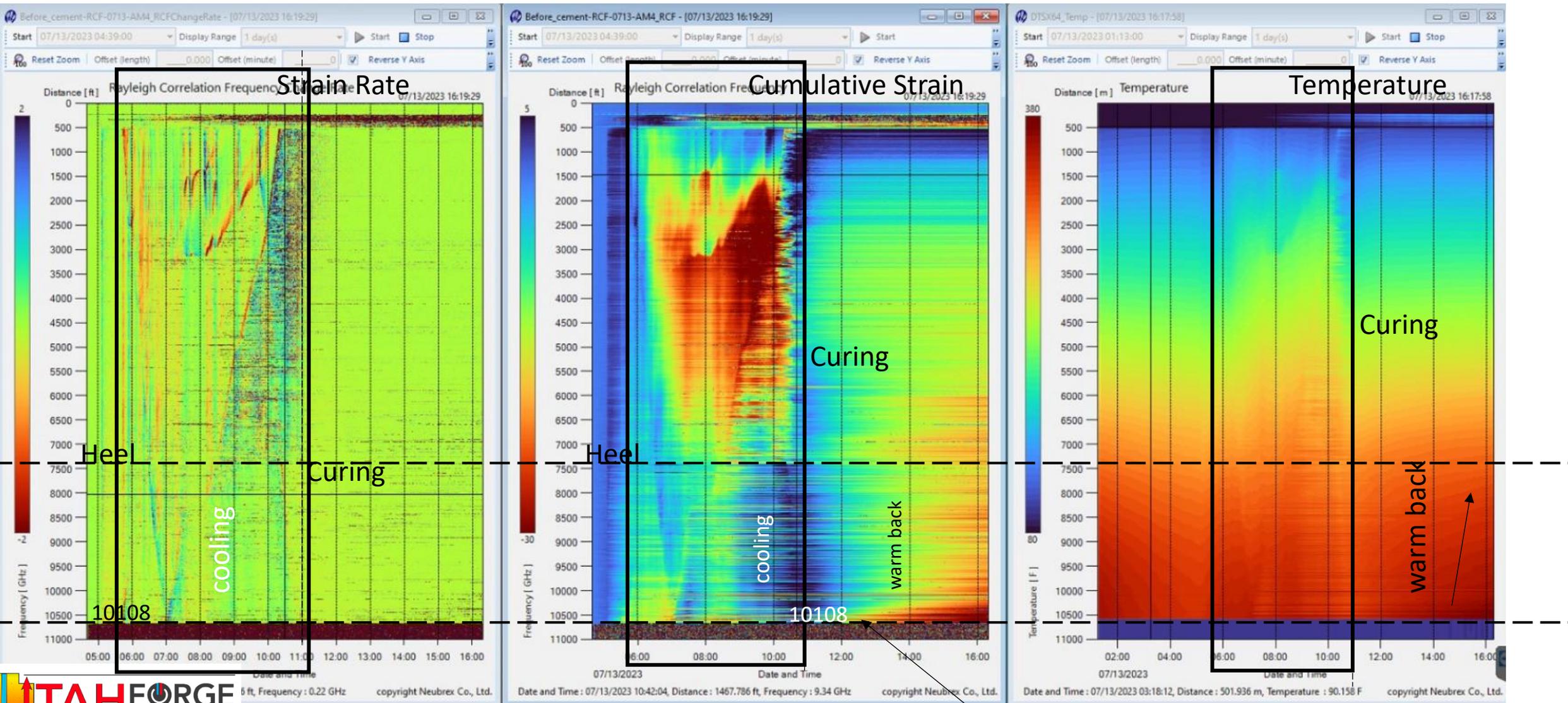
Continued cement pumping. Cement moving up the annulus slowly compared to heat slugs.



Continued cement pumping time. Cement making it to surface as per fiber optics .



Plug bumped. Now starting the curing period and warm-back. Curing in the Slant Section - NORMAL



FAST Warmback near bottom of Fiber

RAW DATA FILES SENT TO NEUBREX PROCESSORS FOR POST ACQUISITION PROCESSING



My Drive > Forge ▾



File type ▾ People ▾ Last modified ▾

Name	Last m...	↓
 July2023_Forge-Before_cement-RCF-0713-AM4_RLoss-...	5:25 PM	⋮
 July2023_Forge-Before_cement-RCF-0713-AM4_RCFCh...	5:23 PM	⋮
 July2023_Forge-Before_cement-RCF-0713-AM4_RCF_1.h5	5:22 PM	⋮
 July2023-FORGE_BCF_1.h5	5:21 PM	⋮
<div style="background-color: #ccc; padding: 5px; border-radius: 5px; text-align: center;">@Artur Guzik the Forge data uploaded to Drive.</div>		
 July2023_Forge-DTSX64_Temp_1.h5	5:20 PM	⋮

RAYLEIGH

Brillouin



Utah Forge

Monitored Well: 16B(78)-32

POST 16B Cement Cross Well Circulation Tests Fiber Optics Monitoring Field Operations: Jul 2023

Neubrex Energy Services (US), LLC

Dana Jurick | Executive VP, Neubrex Energy Services (US), LLC

Dr. Artur Guzik | Software Engineering and Services, Neubrex Infra AG

Last update: Jul 28, 2023

Timeline Report is Evolution 1



Project timeline and acquisition settings

Name	Target	Neubrex acquisition	
		start	end
Evolution 0	Cementing	Jul 13, 2023, 04:39	Jul 14, 2023, 11:14
Evolution 1	Post-cementing monitoring	Jul 15, 2023, 12:18	Jul 20, 2023, 15:40



Monitored wells



Monitored well and wells on the pad are listed in Table 1.

Table 1. Wells info

Well Name	API/UWI	MD, ft
16B(78)-32	NA	10,208.40

Reference elevation

- Kelly Bushing (KB) is the reference elevation in this project and report
- KB is 31 feet above the casing bowl
- Test heat performed
 - See reference and red arrow

Fiber information



End of Fiber Cable:

Fiber termination info and depth received from Operator.

Table 2. Fiber termination depths

Name	KB, ft	Termination, ft BF	Fibers
16B(78)-32	31	10,108.46	SM/MM

There are 2 separate sensing cables installed on this well (names are after casing tally)

- Shell cable (starts at 10,108.46 MD ft KB)
- Silixa cable (starts at 10,001.22 MD ft KB)

All measurements presented in this Report were made on **Shell** cable.

Casing tally – basic well and casing info



Table 3. Casing tally header

As Ran FORGE 16B(78)-32 Audited to KB							Instrumentation Casing Running Tally						
		Torque (ft-lbs)											
Casing	Min	Max	Opt			Fibre Start	10,108.46					ft	
7" 38# P110EC VAM TOP HT	20,850	25,450	23,150			Toe Gauge	N/A					ft	
7" 38# P110MS VAM TOP HT	20,850	25,450	23,150			Heel Gauge	7,056.67					ft	
Average Joint Length 4.5"	12.68			Open Hole		9.500"					ft	2.86	
Average Joint Length 5.5"	12.58			7" 38# P110EC VAM TOP HT		Drift: 5.795"					ft		
TD: 10208.40			7" 38# P110MS VAM TOP HT		Drift: 5.795"							ft	
Ground Level 10177.40			11.75" 65 lb/ft P110/125, BTC		Drift: 10.526"							ft	
Rat hole: 0.00			Cross-over from MS to EC		~ 8100'							ft	
If you have any questions regarding instrumentation and CCP installation on this tally please contact the originator - Alan Reynolds - 757 304 1977													
Item	JT #	Mud Fill	Comments	Threads off length	Cumm Length	Bottom Depth	Top Depth	Centralizers	CCP	Jt #	Protectors	Comments	
David Lynch Float Shoe	A			2.67	2.67	10,208.40	10,205.73	David Lynch Float Shoe		A			
7" 38# P110EC VAM TOP HT	A			47.10	49.77	10,205.73	10,158.63	One 9.125" Centralizer		A		31 0700 0913 S5V8S - pre-installed	
7" 38# P110EC VAM TOP HT	1		Test Shoe?	46.96	96.73	10,158.63	10,111.67	None		1	7000-35-01SRN20.3		
Termination Sub	B		Shell Fibre Start	6.43	103.16	10,111.67	10,105.24	None		B	None		
7" 38# P110EC VAM TOP HT	2			46.99	150.15	10,105.24	10,058.25	One 9.125" Centralizer		2	7000-35-01SRN20.3	31 0700 0913 S5V8S	
7" 38# P110EC VAM TOP HT	3			47.02	197.17	10,058.25	10,011.23	None		3	7000-35-01SRN20.3		
7" 38# P110EC VAM TOP HT Pup	Pup D			10.01	207.18	10,011.23	10,001.22	One Eccentralizer		Pup D	7000-35-01SRN20.3	30 0700 0900 S5V8S 0403	
7" 38# P110EC VAM TOP HT Pup	Pup A		Silixa Fibre Start	20.09	227.27	10,001.22	9,981.13	One Eccentralizer		Pup A	7000-35-01SRN20.3	31 0700 0900 S5V8S 0403	
7" 38# P110EC VAM TOP HT	4			46.02	273.29	9,981.13	9,935.11	One 9.125" Centralizer		4	7000-98-01-76-01P-4C	31 0700 0913 S5V8S	
7" 38# P110EC VAM TOP HT Pup	C		Full Optical Suite	10.38	283.67	9,935.11	9,924.73	One 9.125" Centralizer		C	7000-35-01SRN20.3	31 0700 0913 S5V8S	



Measurement Units

The time zone and unit system

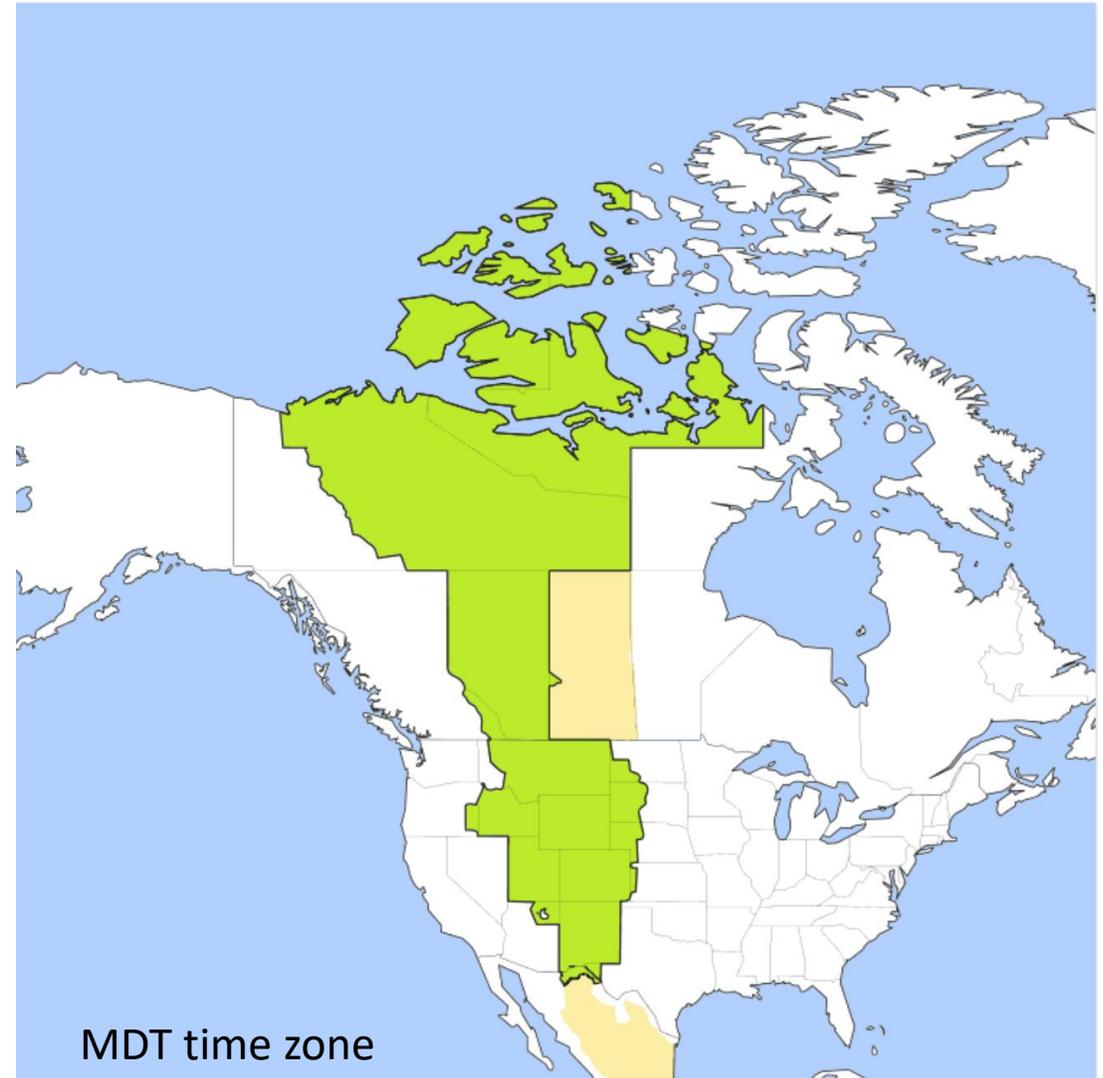
Measurement units

- Imperial (US) units are used in the report
 - Distance – foot, ft
 - Temperature – Fahrenheit degree, °F
 - Pressure – pound per square inch, psi

- Values of strain reported as micro-strain, $\mu\epsilon$
 - Unless stated otherwise

Time zone

- Results reported in this document are in ***Mountain Daylight Time (MDT)***
- Local time zone was ***Mountain Daylight Time (MDT)***
 - UTC Offset: UTC -6

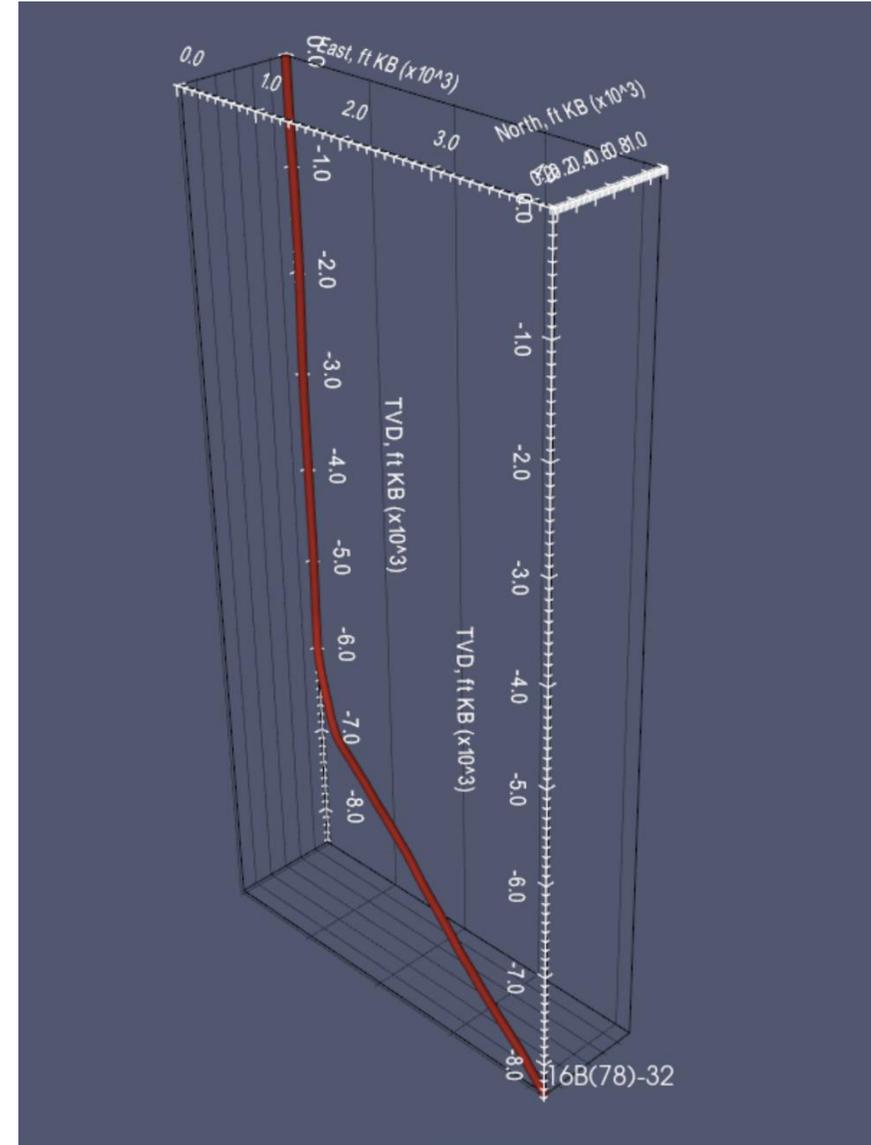
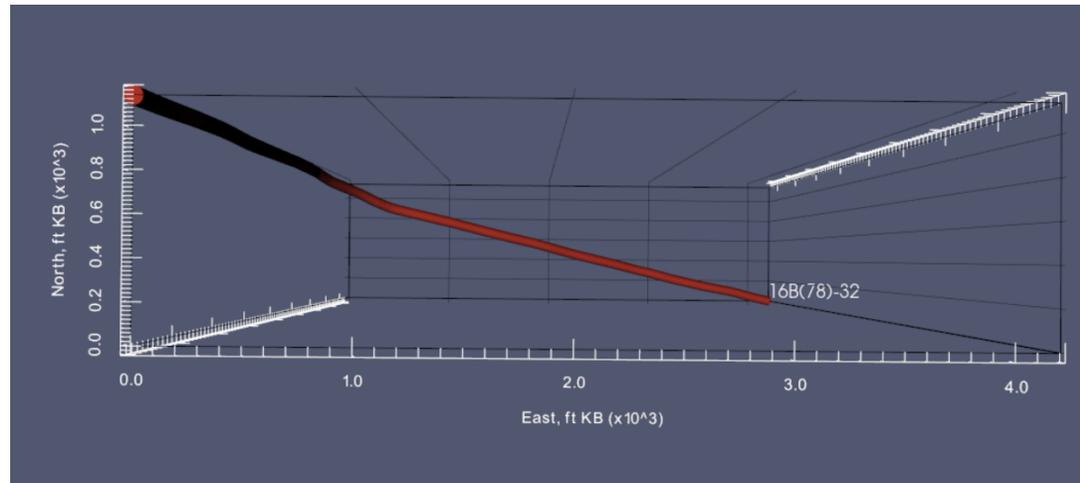




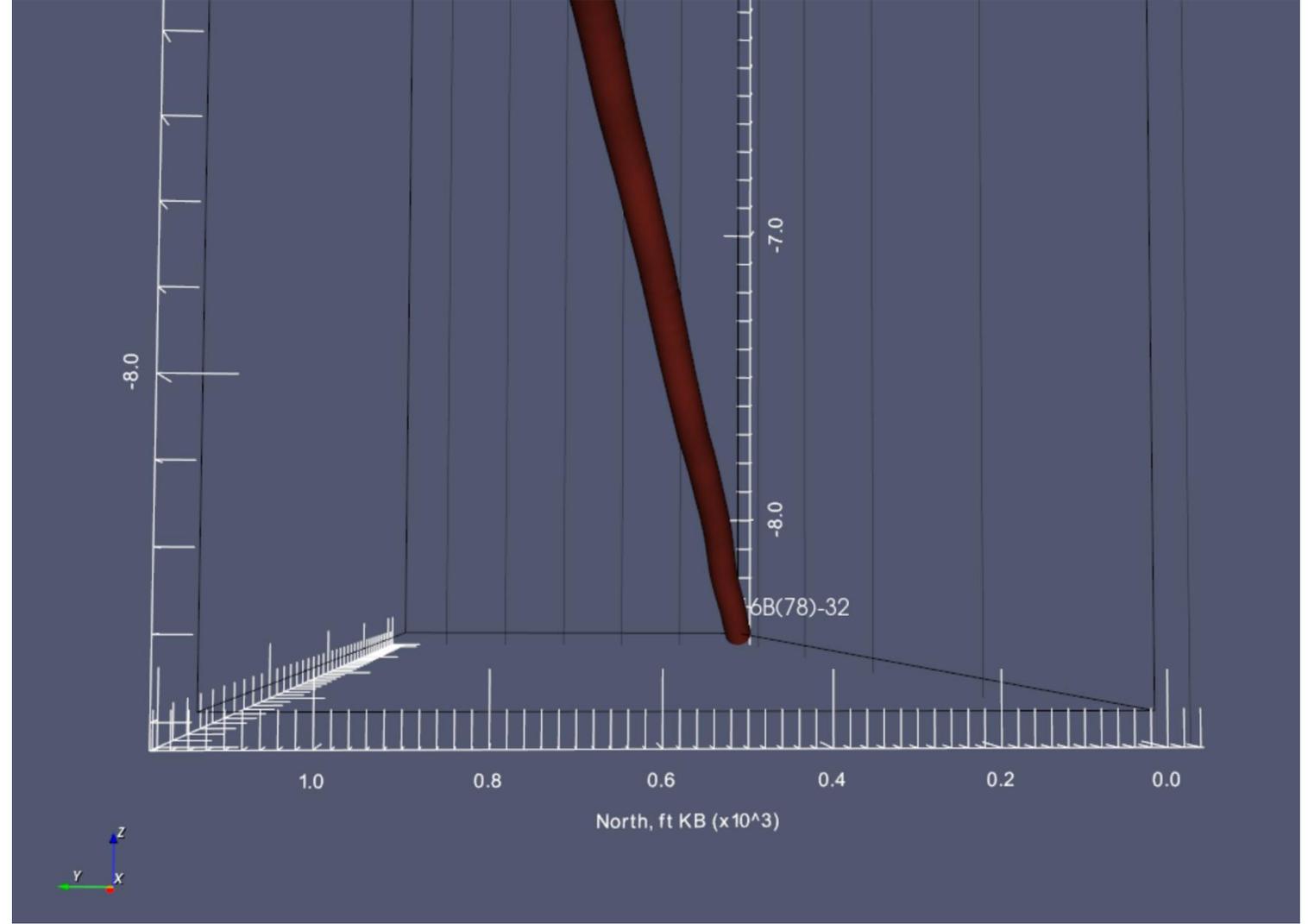
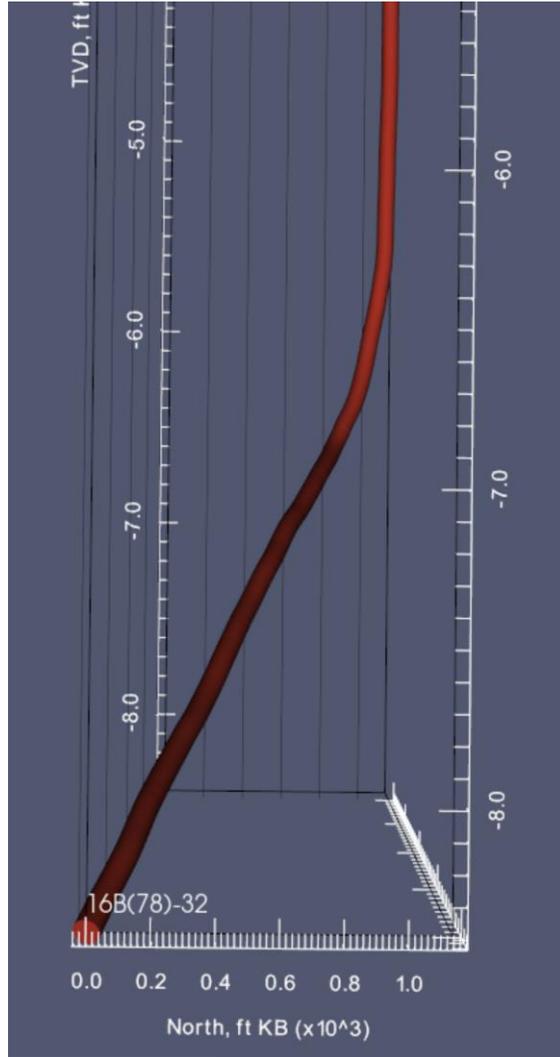
Well Survey Renderings

Based on schematics and deviation survey data provided by Operator

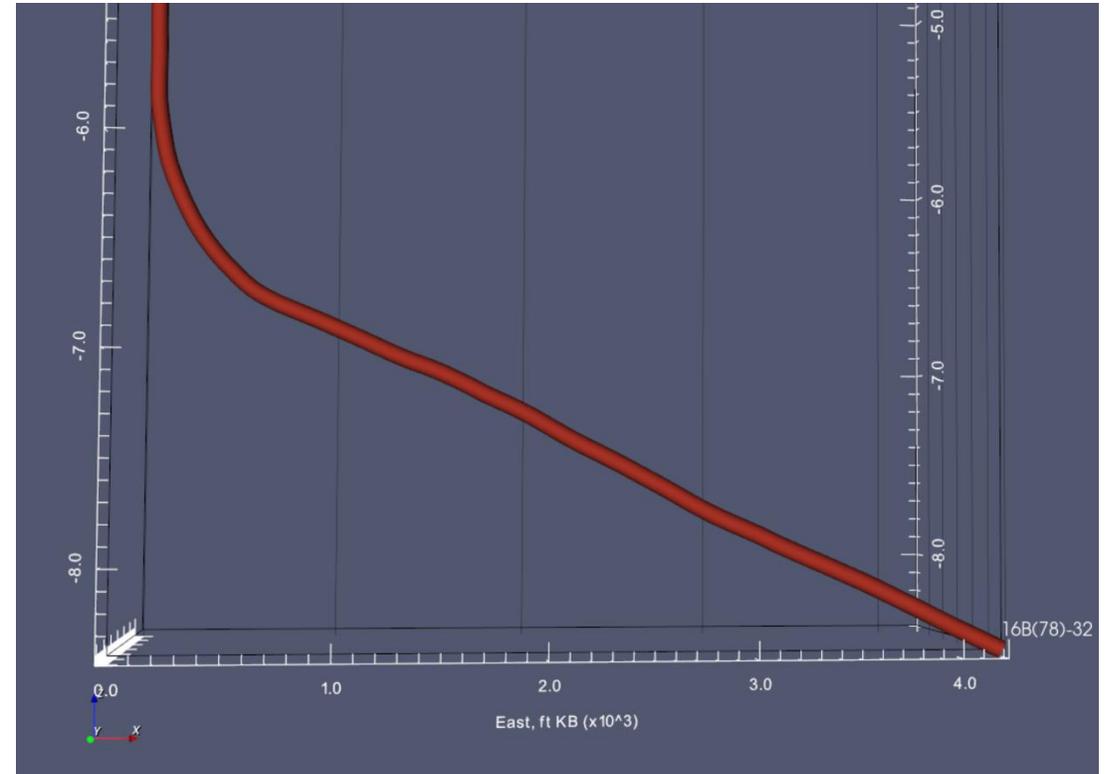
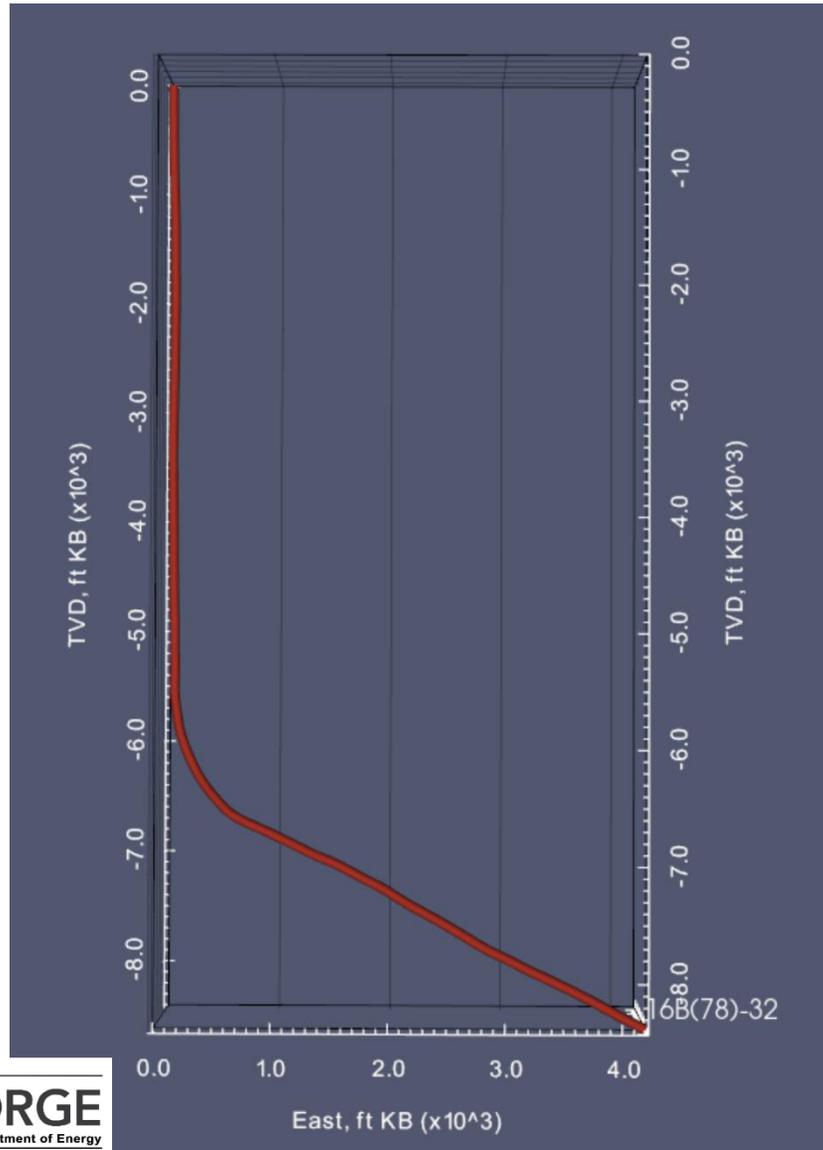
Monitored well



Monitored well



Monitored well





Measurements type and target

Information on measurements type and acquired signals

Measurements type

- Monitoring target:
 - Strain and temperature changes on the monitored well
- Measurements:
 - Rayleigh Frequency Shift
 - (from reference time and depths) strain change
 - Rayleigh frequency shift, profile time to profile time, strain change rate ($dRFS/dt$)
 - Brillouin absolute strain
 - Brillouin center frequency converted to strain
 - DTS
 - Raman based temperature measurements

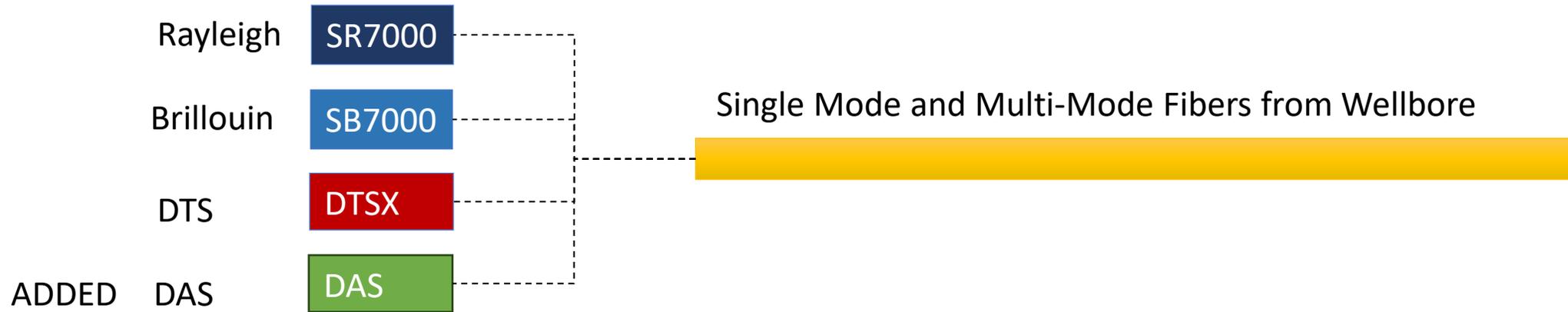


Fiber connection scheme

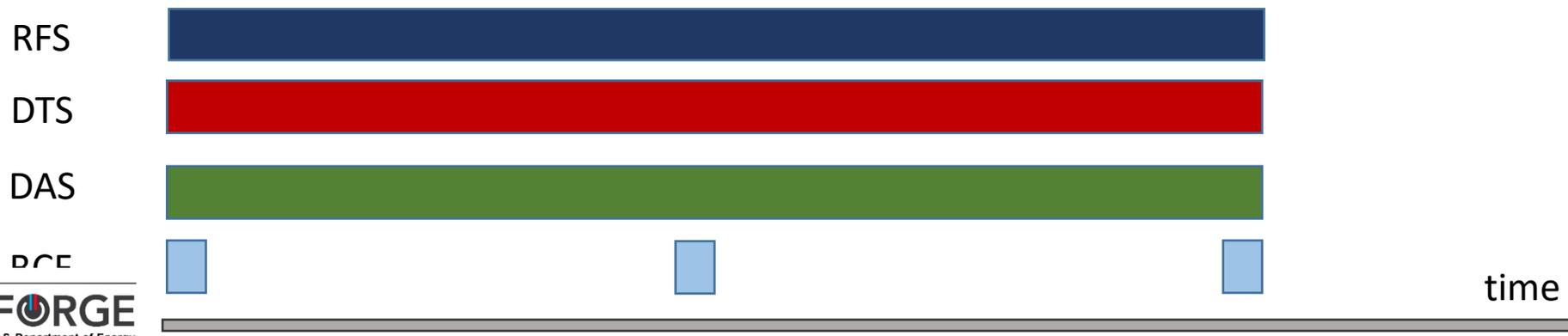
Connection of NBX instruments to permanent wellbore fibers

Connection scheme

- Instruments are connected to the different SM and/or MM fibers
 - Continuous acquisition of DTS, RFS, and DAS was achieved during the survey time



Measurements types and sensing pattern over time



Fibers

- The following fibers were used during data acquisition:

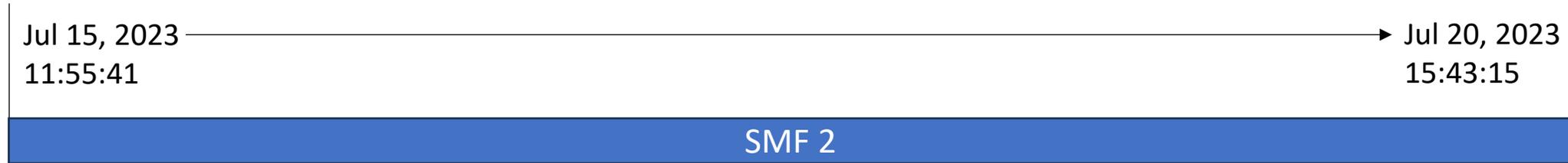
Table 3. Fibers used during acquisition

Name	Type	IOR	Length
SMF 1	SM	1.4782	10,108.46
SMF 2	SM	1.4782	10,108.46
MM 2	MM	1.4790	10,108.46

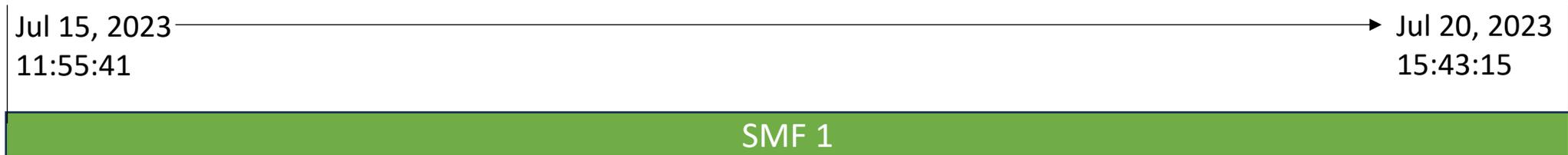
Fiber connections and measurements sequence



RFS/BCF measurements



DAS measurements



DTS measurements



Depth calibration

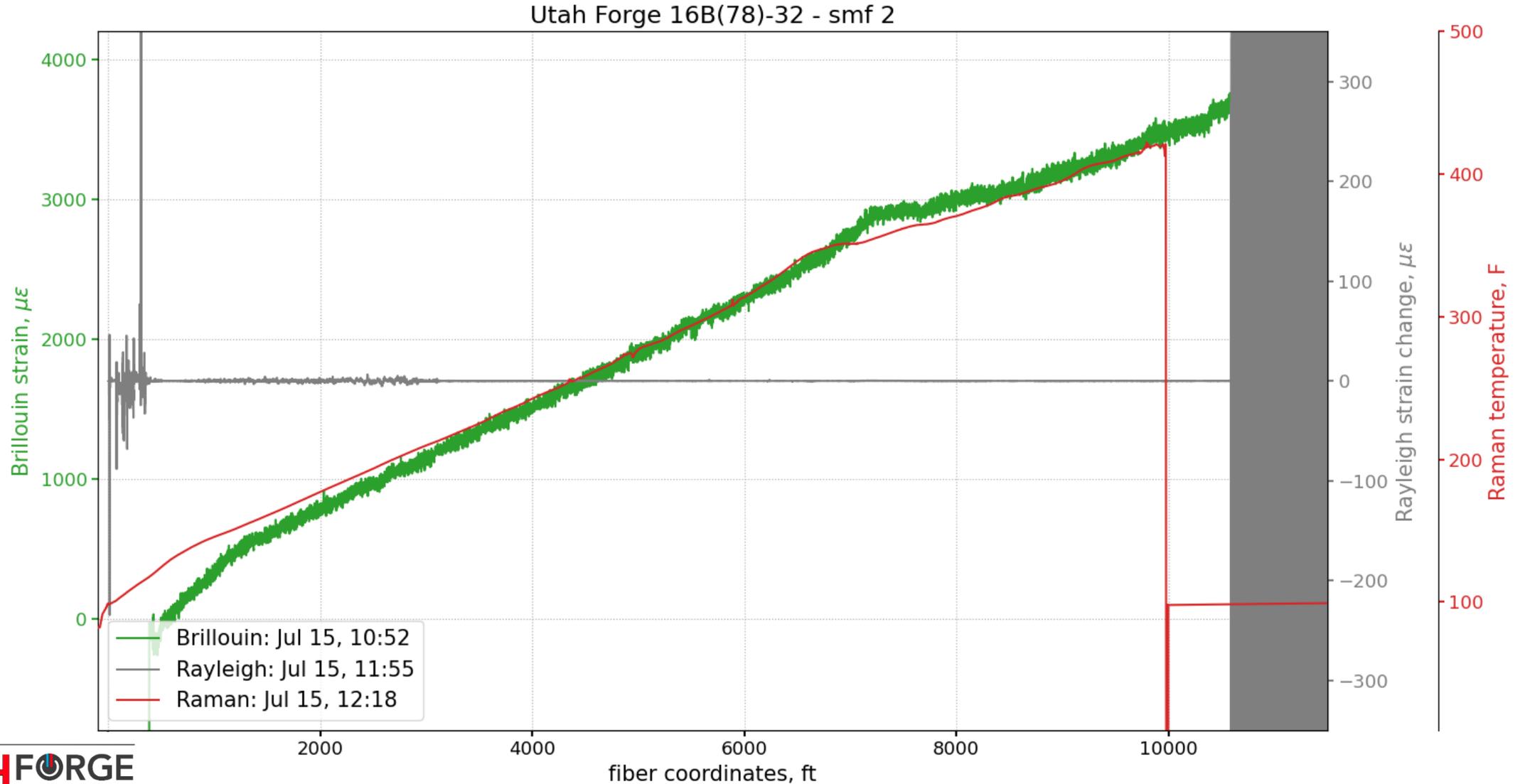
This Section contains the depth mapping of the fiber optics on monitored wells.

Depth calibration between fiber optic measurements and well measured depth features is an essential and critical component of fiber optic data processing.

Depth calibration marking – ice test

- Ice test was used to detect the location
- The location of the ice is X ft above the
- KB is the elevation reference for this project and report

SMF 2 – fiber coordinates (Original Lengths, no calibration)

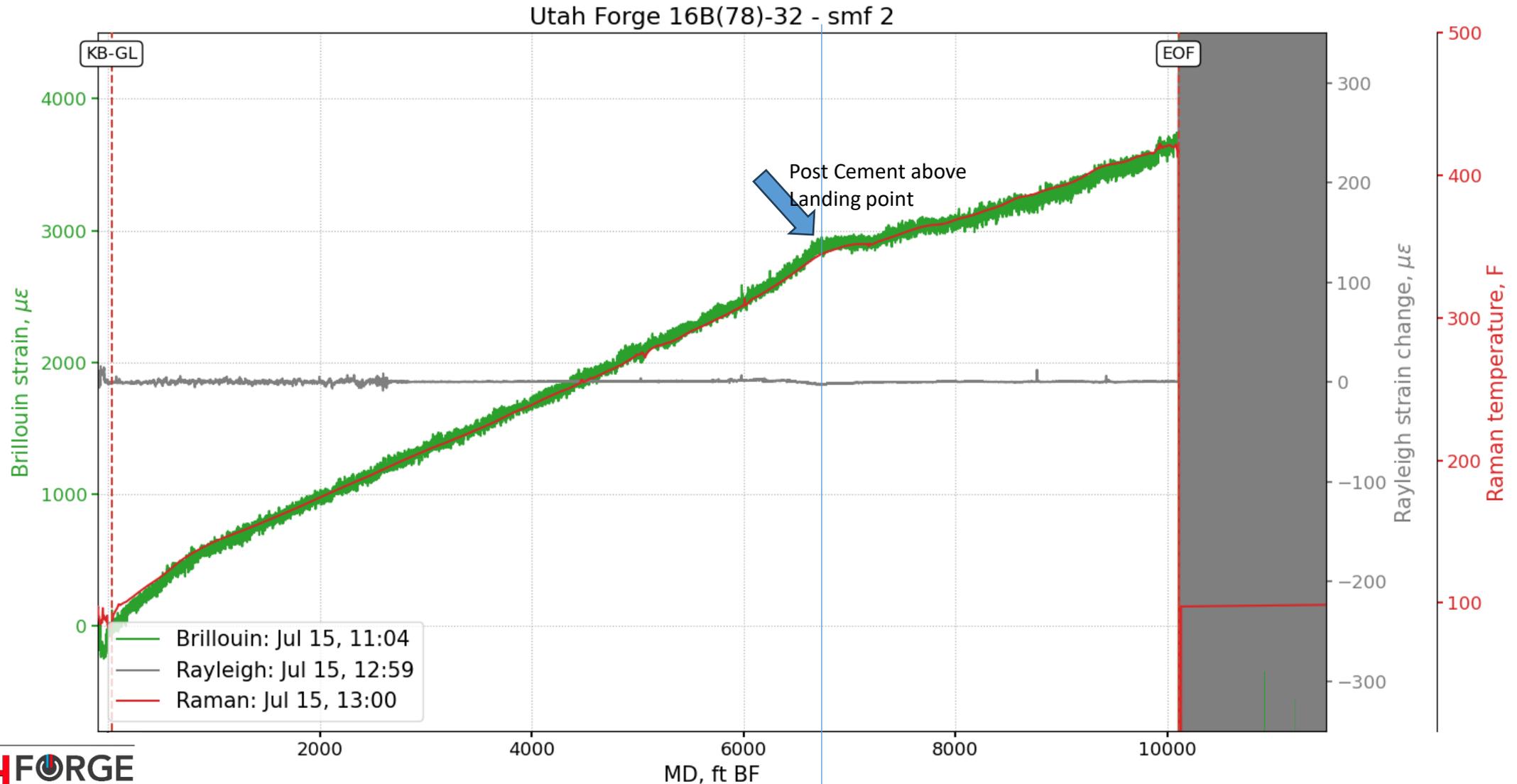


Depth calibration findings from Neubrex workflow and data



- Final measured depth of the fiber termination = **10,108.46 MD, ft KB**
- KB = **31.0 ft MD**
 - Casing tally report
 - Reference location: GL
- **Depth Contraction coefficient (SMF 2/MMF 2):**
 - RFS = 1.0000
 - BCF = 1.0000
 - DTS = 1.0027
- **Offset Correction Distances (SMF 2/MMF 2):**
 - RFS: 470.94 ft
 - BCF: 501.57 ft
 - DTS: 392.96 ft

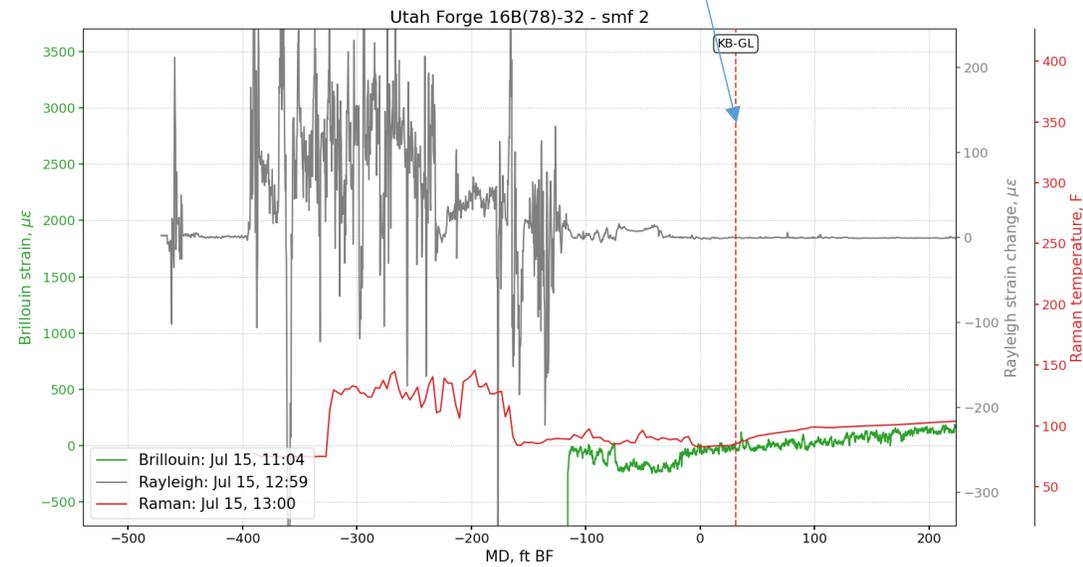
SMF 2 – depth calibrations applied to BCF, RFS, and DTS



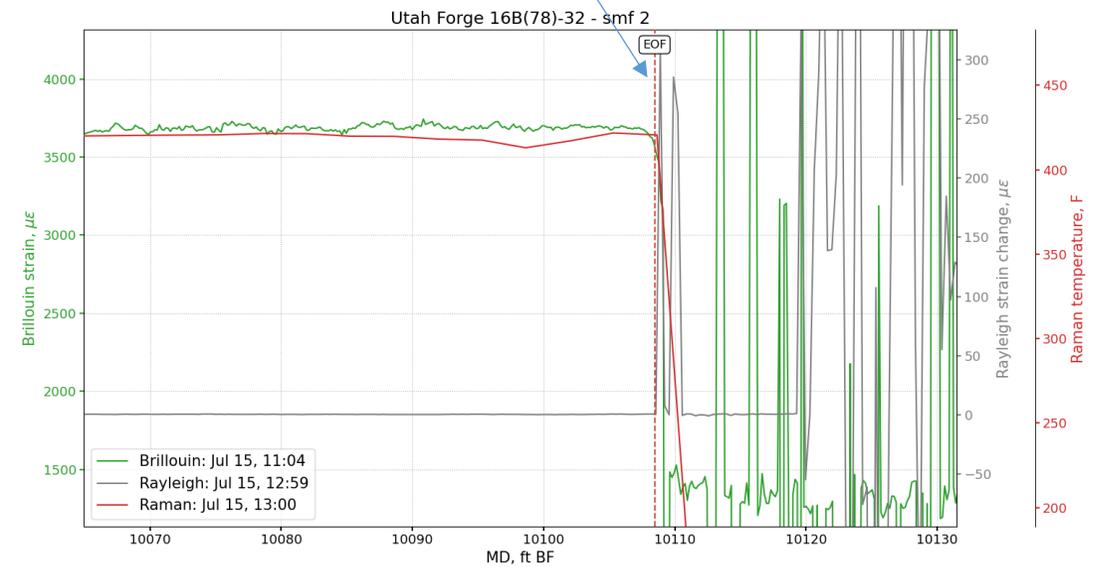
SMF 2 – Depth calibration at Wellhead and Termination



wellhead and GL



termination



Brillouin, Rayleigh, and Raman signals distributions



Summary of Depth Calibration – Fiber to Well MD Results



- The following offsets were determined and are used in all subsequent plots to convert fiber coordinates to Well MD coordinates
- Conversion method:
 - scaling factor is applied first, then offset applied

Well 16B – SMF 2/MMF 2

Data type	Offset, ft	Scaling factor
Brillouin	501.57	1.0000
Rayleigh	470.94	1.0000
DTS	392.96	1.0027

Well 16B – SMF 1

Data type	Offset, ft	Scaling factor
DAS		1.0000

Measurements

Summary of measurements using RFS, DTS, and BCF

RFS = Rayleigh Frequency Shift fiber optic measurement

DTS = Distributed Temperature Sensing fiber optic measurement

 illouin Center Frequency fiber optic measurement

Interrogator Unit acquired data parameters



- RFS acquired over entire period of survey
 - Time step between full well interrogation: 30 seconds
- BCF acquired at specific periods of time during survey period
 - Time duration of full well interrogation: 18 minutes
 - Ensures control of total strain and helps to validate temp distribution of DTS
- DTS acquired over entire period of survey
 - Time step between full well interrogation of DTS: 5 min
- Measurements are done **on separate SM and MM** fibers during entire survey period
 - Depth registration performed on each individual fiber to ensure registration

Well 16B(78)-32 – data gaps



- The following data gaps are registered

Table 1. DTS data gaps on well 16B(78)-32

No.	Start	End	Duration
1	Jul 19, 2023, 18:42:11	Jul 19, 2023, 19:23:29	0:41:18

- No data gaps in RFS data sets



Engineers Observer (OB) Logs

Observation Notes of Neubrex Field Engineers in the field during operation.

OB Log (1/3)



Date	Time	Event	Event Details
10-Jul-23	7:51	Mobilize / Travel	Depart shop
	21:15	Mobilize / Travel	Arrive Moriarty NM
11-Jul-23	10:05	Mobilize / Travel	Depart Moriarty NM
	20:39	Mobilize / Travel	Arrive Las Vegas NV
12-Jul-23	7:22	Mobilize / Travel	Pick up Dana at airport. Depart for location
	13:30	Mobilize / Travel	Arrive at location. Meet with Alan Reynolds to discuss spotting of equipment and rig up.
	14:20	Rig up	100 amp plug purchased for job will not be used. Heading to Milford UT to source plug for generator power.
	14:56	Rig up	Plug sourced. Heading back to location
	15:26	Rig up	Arrived at location. Wire up pig tail.
	15:50	Rig up	Pig tail wire up. Spot equipment and start rig up.
	18:16	Rig up	All equipment rigged up. Cooling down IU's . Waiting on fiber connection from Baker.
	18:30	Depart	Depart location for Milford UT.
	18:55	Arrive	Arrive at hotel. Check in.
	20:48	Note	Hanger landed. On standby at hotel.
13-Jul-23	22:42	Note	Start circulation to cool wellbore prior to pumping cement
	0:00	Rig up	Power up IU's and warm up lasers.
	0:30	Acquisition	SB will not pass calibration. Will start collecting SR data. Start troubleshooting with Japan Engineering.
	1:10	Acquisition	Start acquisition SR checks.
	2:14	Acquisition	Start acquisition DTS
	2:28	Acquisition	Start SR readings on SM2
	3:58	Acquisition	Stop SR. Swap SM2 to SB and start acquisition.
	5:58	Acquisition	Stop SB. Swap SM2 to SR and start acquisition.
	6:09	Safety Meeting	Dana attends safety meeting for cement job.
	6:32	Cement	Circulation of fluids stopped at 0505am to rig up cement iron
	6:38	Cement	0538 about to start pressure testing iron
	6:51	Cement	0551 pumping 50 bbl spacer
	6:53	Cement	Now starting lead cement at 0553
6:57	Cement	Start 630 bbls lead @13.8 ppg	
7:10	Note	Note for feature identification. They noticed a lot of 'loss' on the intermediate casing cement so they will be extremely interested in the cement top and any dynamics around it. The mechanism of the loss is unknown.	
7:17	Note	Intermediate casing at 4837 / KOP 5500 / Landing point 7000 / KB 31 / TD 10213 / Hanger 2.86 above ground level	
7:57	Cement	Cement leading edge almost to bottom	



OB Log (2/3)



Date	Time	Event	Event Details
	8:07	Cement	Cement is now making the turn at bottom and starting up the annulus
	8:40	Cement	1/2 way up annulus to intermediate shoe and all looks good. No indication of losses yet
	8:52	Cement	Stopped pumping momentarily to switch tanks
	9:03	Cement	0803 opening valves on new tank for cement
	9:05	Cement	0805 spinning pumps
	9:09	Cement	Mixing cement and water.
	9:14	Cement	0813 pumping restarted
	10:57	Cement	ToC at 2100 MD now
	11:25	Cement	Cement is to surface. Still pumping plug down
	12:00	Depart	Wayne and Dana depart for Milford UT. Will remote monitor.
		Note	On going discussion about where ToC is. Current evaluation is ToC 535'. May top off casing in the morning.
14-Jul-23	6:35	Note	At the toe as well comes back into the 435 degree F range as cement cures and we go back toward normal geothermal gradient in the slant well already. Curing evolution looks good to me
	10:42	Offset Data	Ice on fiber cable RKB at 10:42
	12:14	Offset Data	458 feet offset
	12:15	Acquisition	Stop acquisition. Cut cable on rig floor. Partial rig down to move DAQ
	13:34	Depart	Leaving location. Evo Zero in the books. Back Tomorrow to reconnect.
	15:37	Processing	Server3 online with Lyve Drive NES.S.0039 from hotel. Data ready for processing
15-Jul-23	6:30	Depart	Depart hotel for location.
	6:50	Arrive	Arrive at location.
	7:35	Rig up	Arrived on location.... trailer is spotted.... sourcing a generator now
	8:01	Rig up	Generator moved. Connected to trailer. Powered up and cooling IU's
	9:01	Rig up	Status update....we are rigged up waiting to make fiber connection at wellhead. They are pressure testing the Stack at the moment
	10:08	Rig up	Setup DAS
	11:37	Acquisition	Start SB readings on SM2/ Start DTS
	12:00	Acquisition	Start SR readings on SM2
	12:16	Acquisition	Start DAS readings on SM1
	13:54	Acquisition	Baker gauge operational
	14:10	Depart	Wayne and Dana depart for Milford UT. Will remote monitor.
	14:30	Arrive	Arrive at hotel.
	14:45	Depart	Depart for Las Vegas NV.



OB Log (3/3) Circulation Test – Neubrex OB Logs



Date	Time	Event	Event Details
	18:15	Arrive	Arrive Las Vegas NV. Drop Dana off for flight on Sunday 7/16/23
	18:20	Depart	Depart for Pahrumph NV.
	19:30	Arrive	Arrive Pahrumph NV.
16-Jul-23	18:11	Depart	Departing Parumph NV for Milford UT
	22:54	Arrive	Arrive Milford UT
18-Jul-23	6:31	Depart	Depart for locationm
	6:59	Arrive	Arive at location. Meet with Alan Reynolds on troubleshooting Baker downhole gauge.
	8:01	Troubleshoot	Gauge fiber broken about 15' from wellhead connection. @Alan Reynolds has provided Baker armoured cable. Cable is in place... I have to splice connectors on each end
	10:00	Troubleshoot	Gauge is operational
	10:29	Note	Current offset from IU to JB at 400 feet. JB is at GL. So need to take that out then add (I think) 31 feet to any depth on fiber we see.to get MD RKB type depth from fiber.
	11:41	Depart	Depart location for Milford UT.
	12:23	Arrive	Arrive at hotel.
	18:45	Depart	Depart hotel for location. DAS data storage lagging
	19:20	Arrive	Arrive at location
	20:00	Acquisition	Stop acquisition . Moving Lyve drive for Server 3 to Power PC.
	20:49	Acquisition	All data being logged to Power PC on Lyve Drive now. Made connection to Baker SIU and logging P/T data to power PC
	21:02	Depart	Depart location for Milford UT.
	21:27	Arrive	Arrived at hotel
18-Jul-23	8:22	Depart	Depart for locationm
	8:44	Arrive	Arrive at location
	9:00	Acquisition	Start DAS recording 08:00
	12:01	Safety Meeting	Safety meeting on operation
	12:21	Safety Meeting	Safety meeting finished
	13:51	Acquisition	Pumping started @ 12:09 2.5 BPM
	14:21	Acquisition	Rate increase at 13:09 to 6BPM for the next 6 hours
	16:46	Acquisition	No returns to pit as of now
	17:57	Acquisition	Getting returns to the pit now
	20:30	Acquisition	We are producing at 8 to 10 barrels per hour and the displacement is 350 bbl
	22:53	Acquisition	Pumps shut down



SMF Optical loss analysis use SR7000 Rayleigh Instrument

Optical loss on SM fiber based on Rayleigh measurements/data.

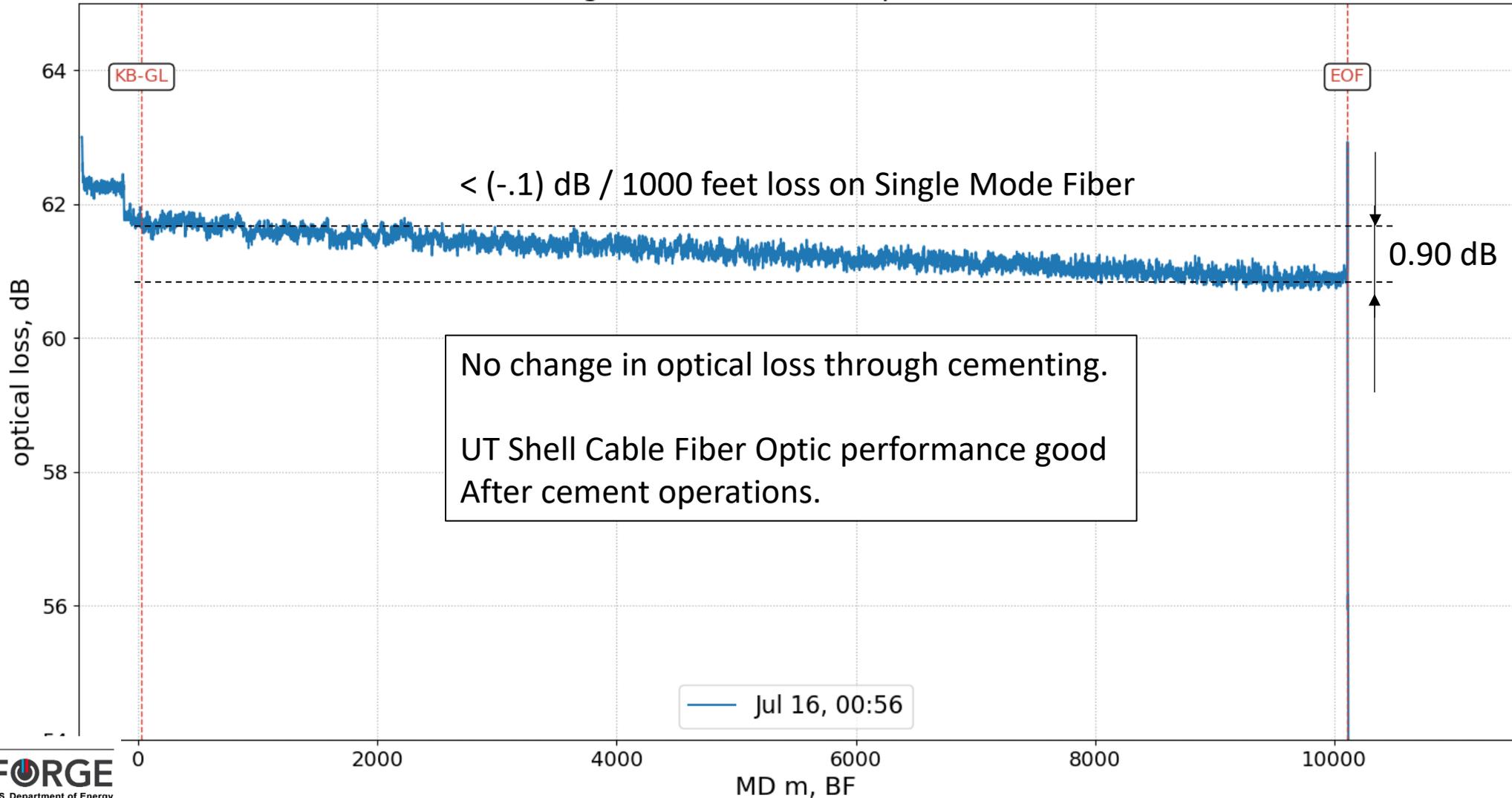
Much better optical loss resolution than hand-held OTDR

Resolution 0.67 ft.

Well 16B(78)-32 - SMF 2 – optical loss distribution



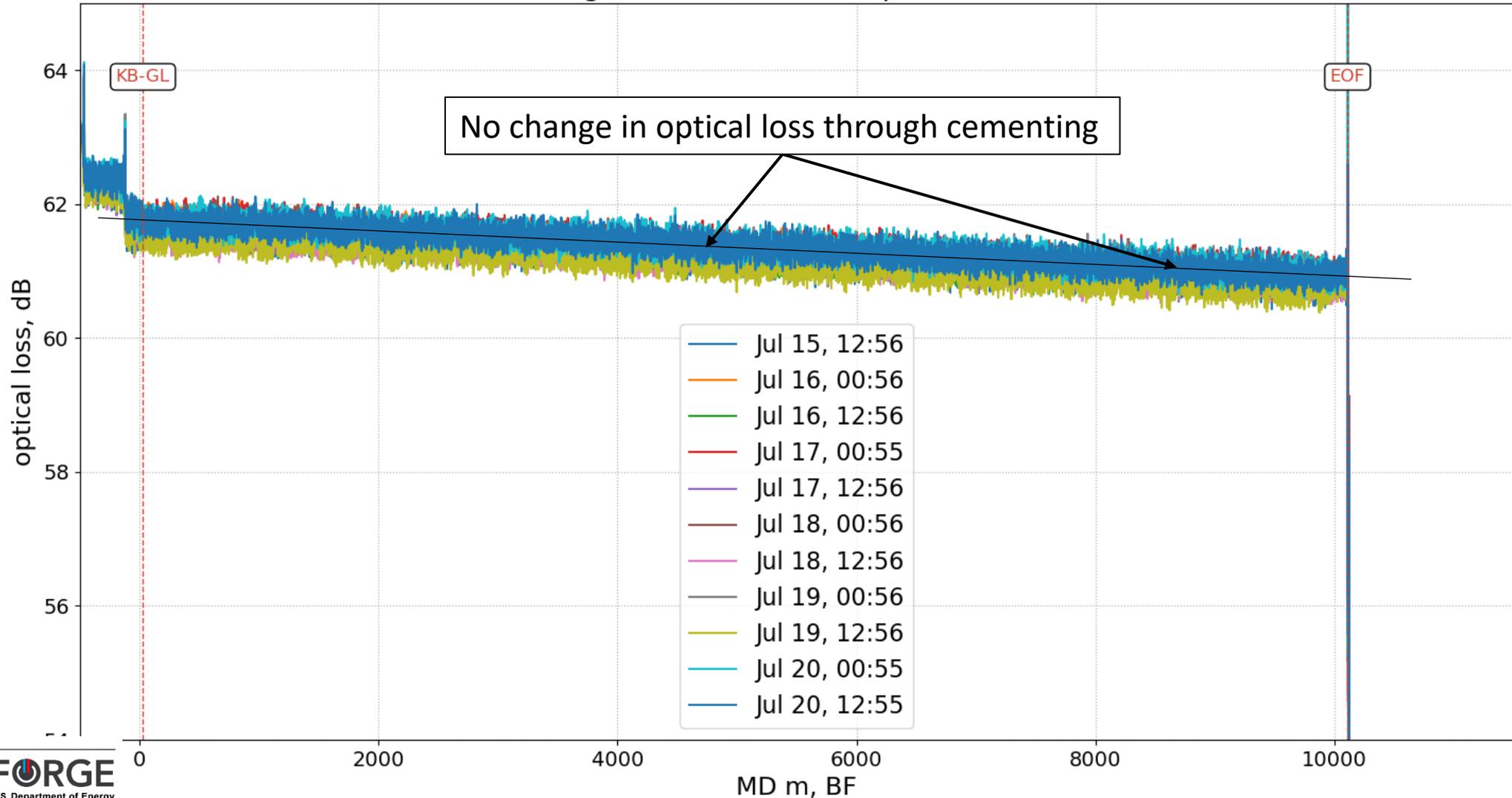
Utah Forge 16B(78)-32: RFS optical loss - smf 2



Well 16B(78)-32 - SMF 2 – optical loss distribution (step 4 h)



Utah Forge 16B(78)-32: RFS optical loss - smf 2

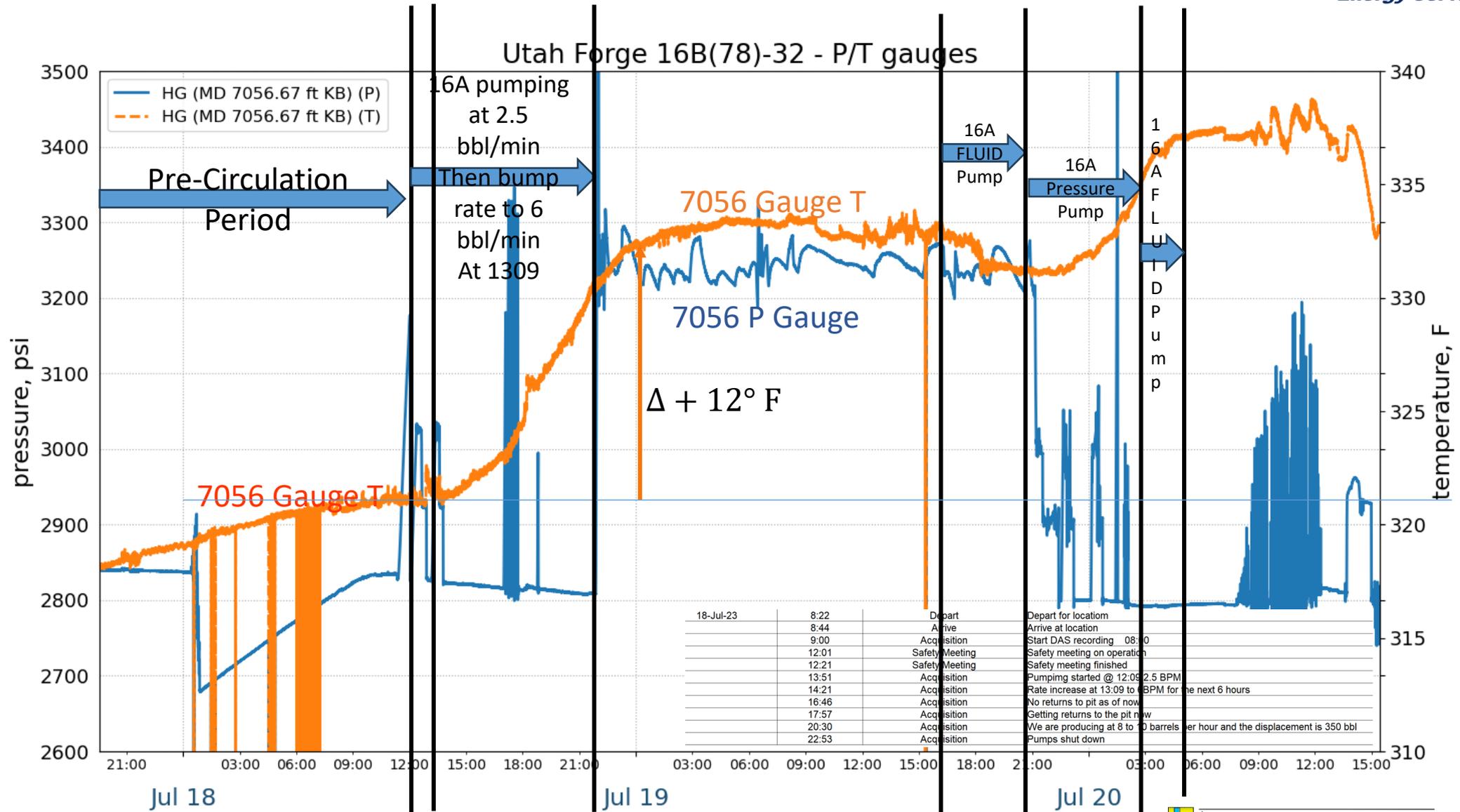




P/T gauges

Received from Operator

Well 16B(78)-32 – P/T gauges





Distributed Temperature Sensing

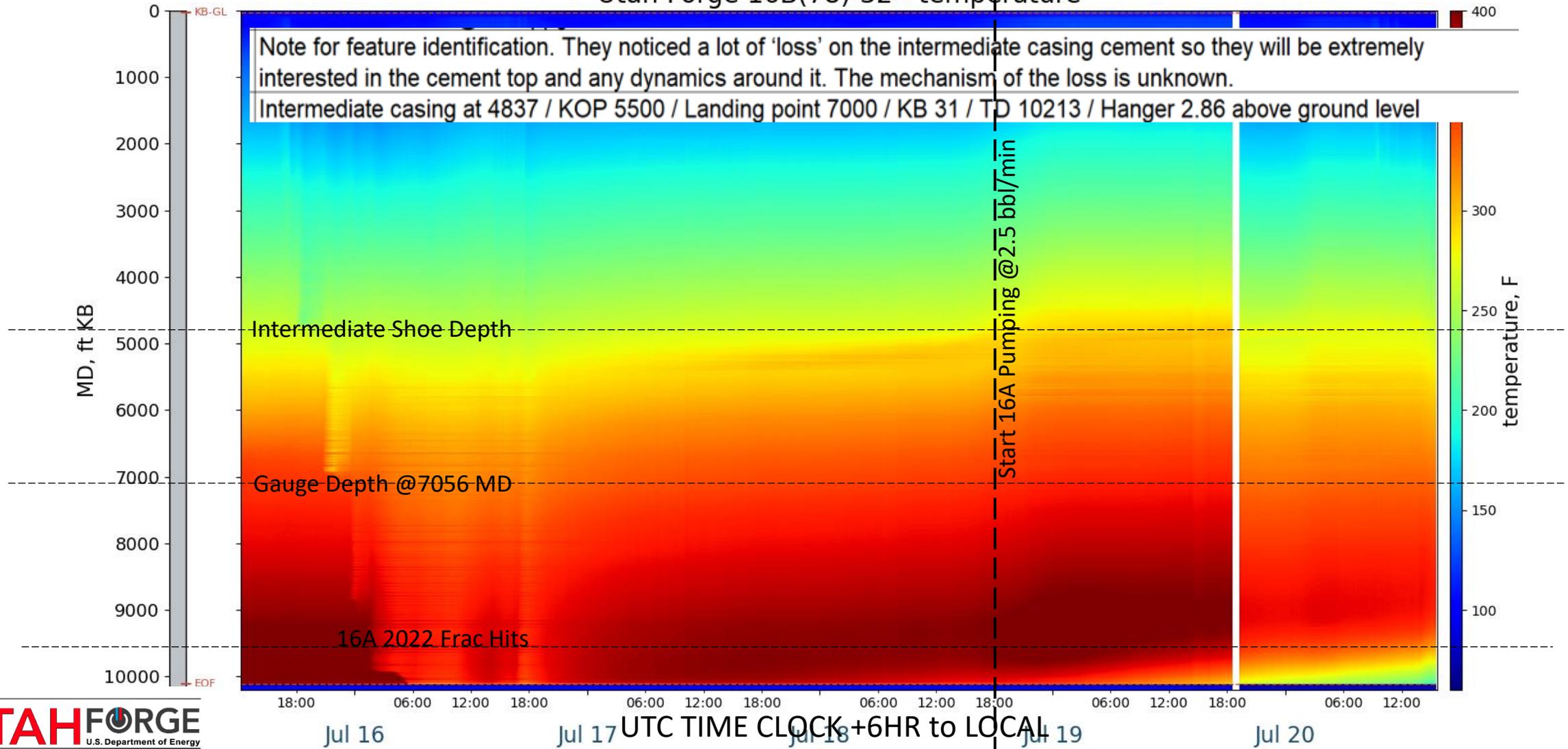
- first trace: Jul 15, 2023, 12:18:01
- last trace: Jul 20, 2023, 15:40:19
- number of traces: 1,720
- number of samples per trace: 6,332
- average temporal interval (sec): 258



Well 16B(78)-32 – DTS – waterfall – temperature overview



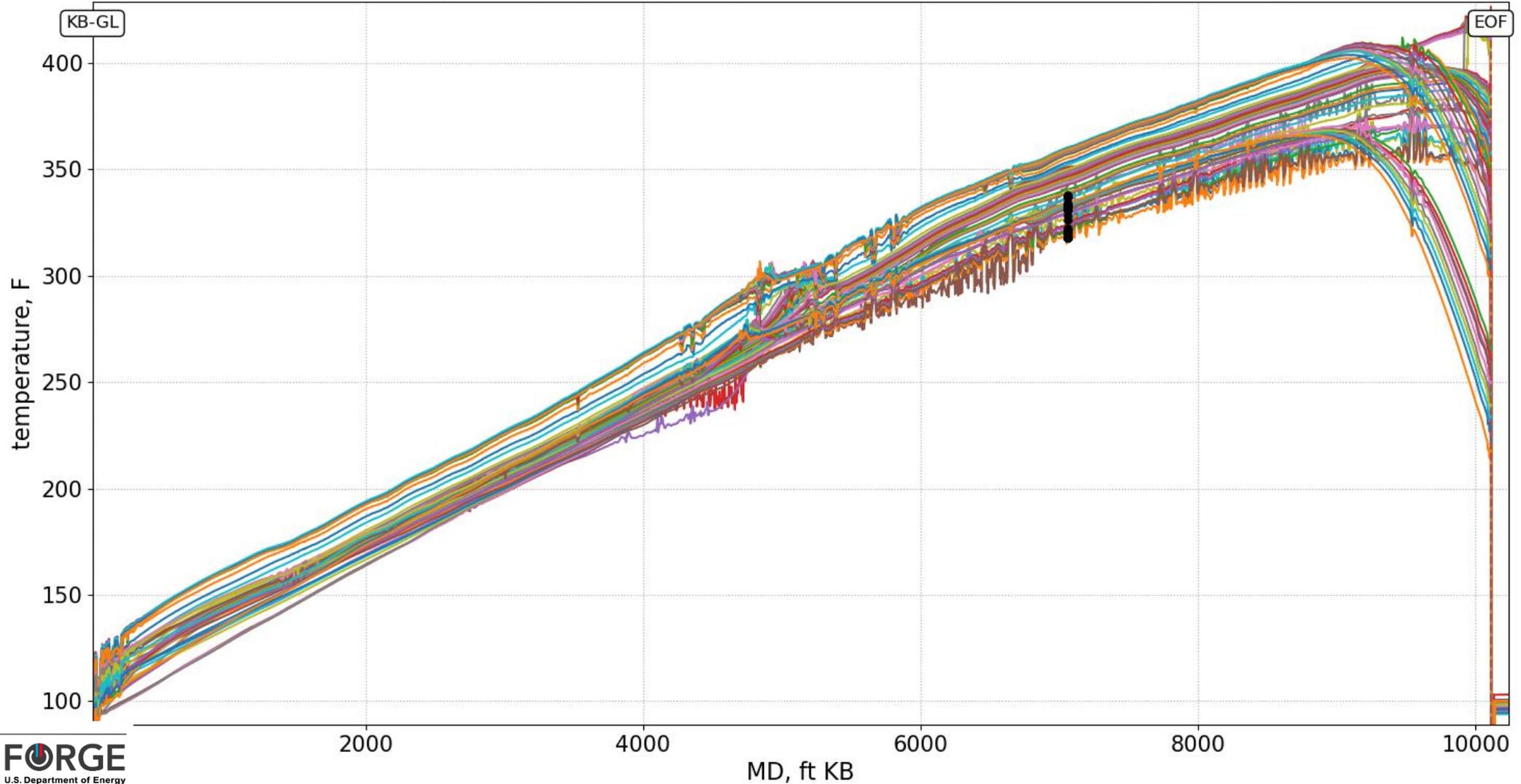
Utah Forge 16B(78)-32 - temperature



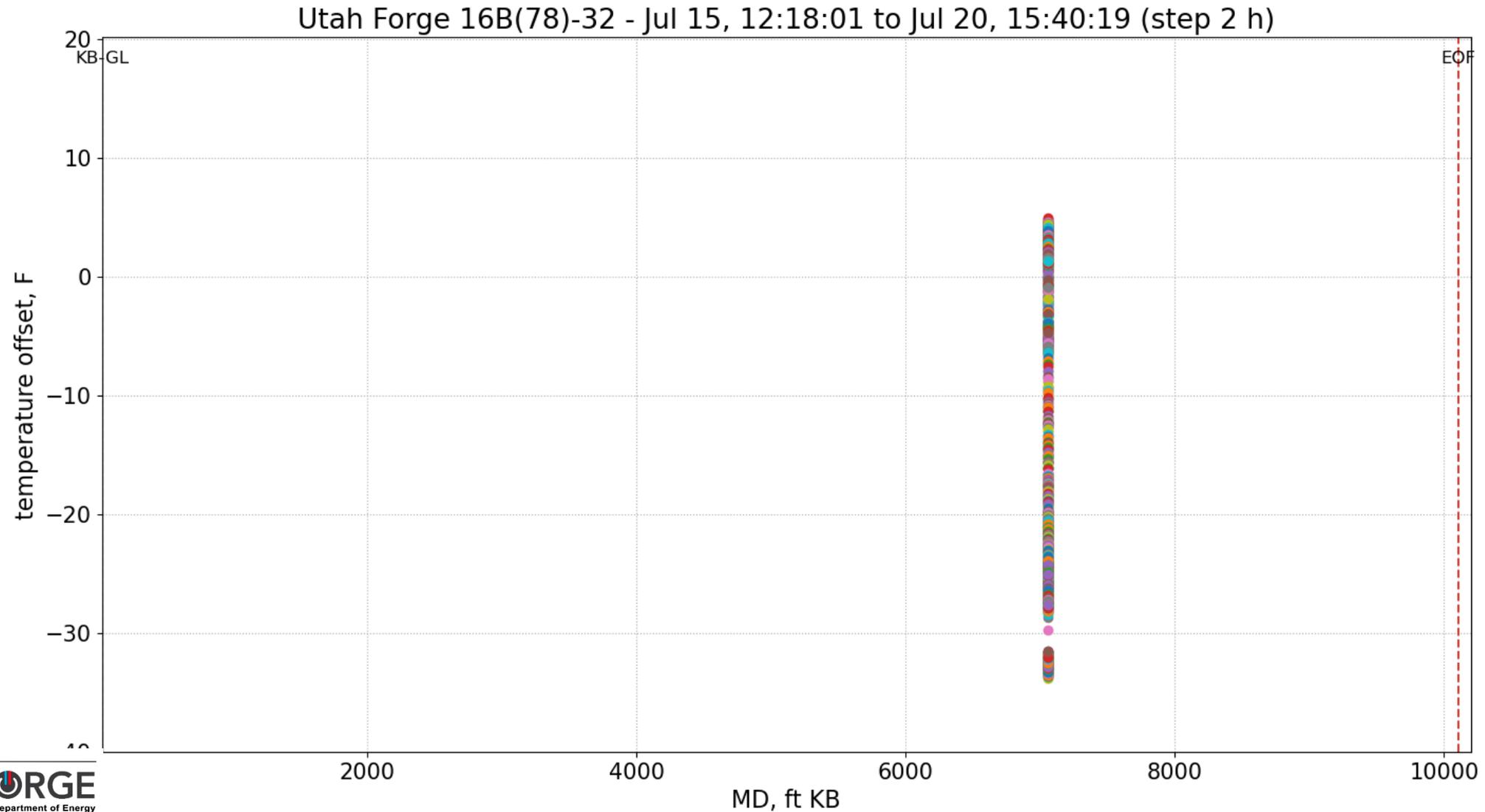
Well 16B(78)-32 – DTS – selected traces



Utah Forge 16B(78)-32 - Jul 15, 12:15:00 to Jul 20, 14:15:00 (step 2 h)



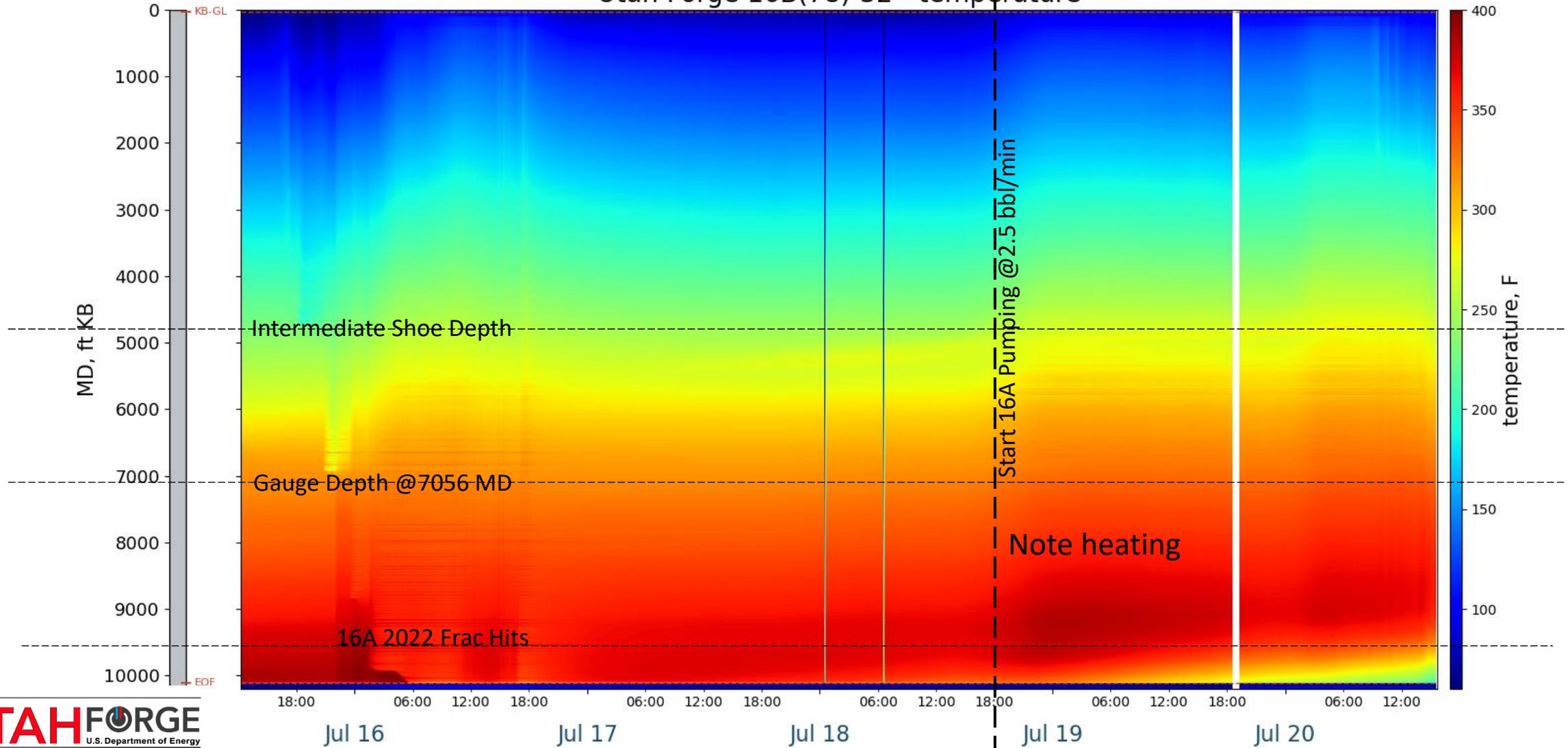
Well 16B(78)-32 – DTS – offsets to gauge



Well 16B(78)-32 – DTS – Gauge calibrated – Temp waterfall



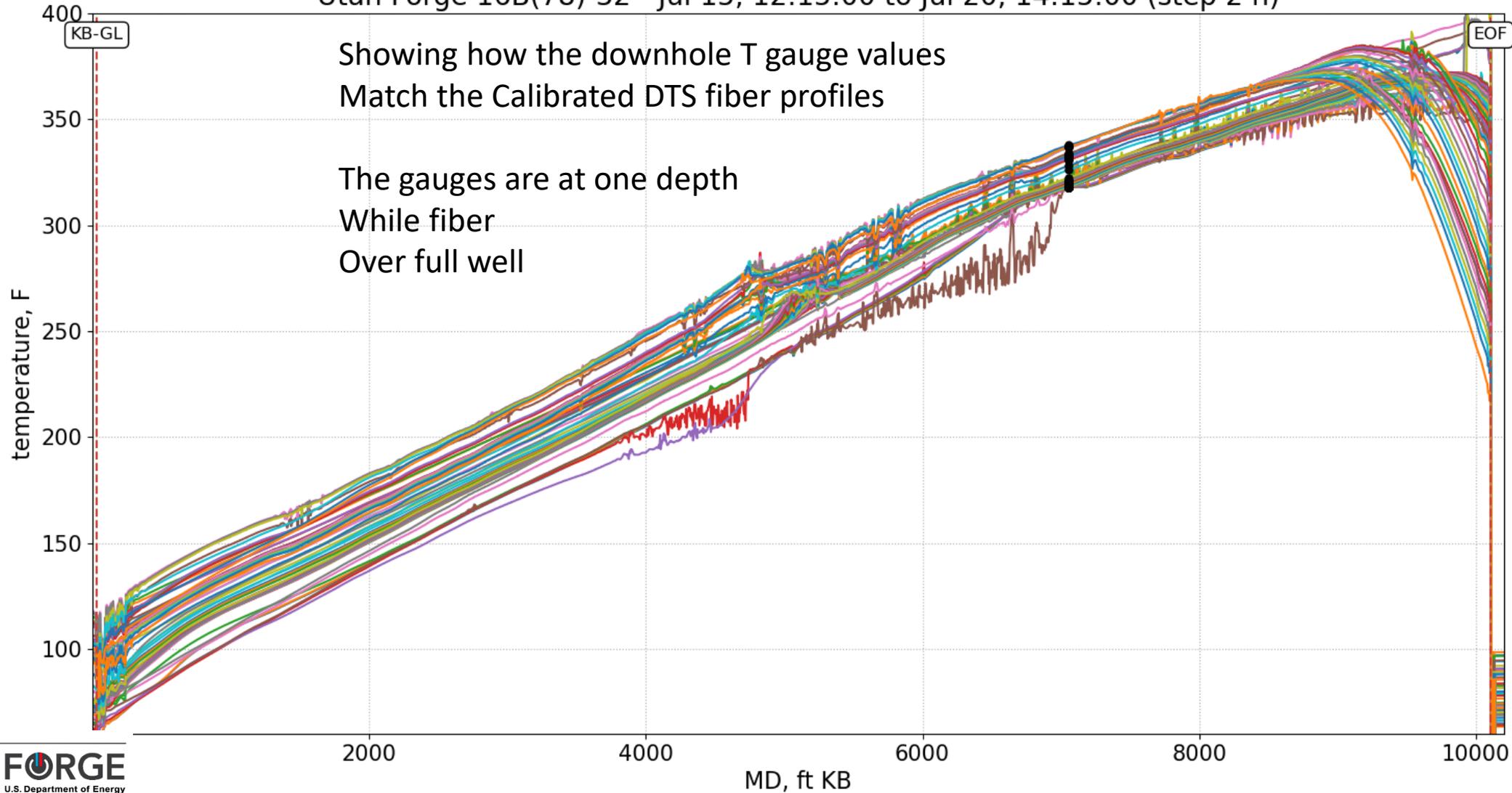
Utah Forge 16B(78)-32 - temperature



Well 16B(78)-32 – DTS – selected traces (2 h step)



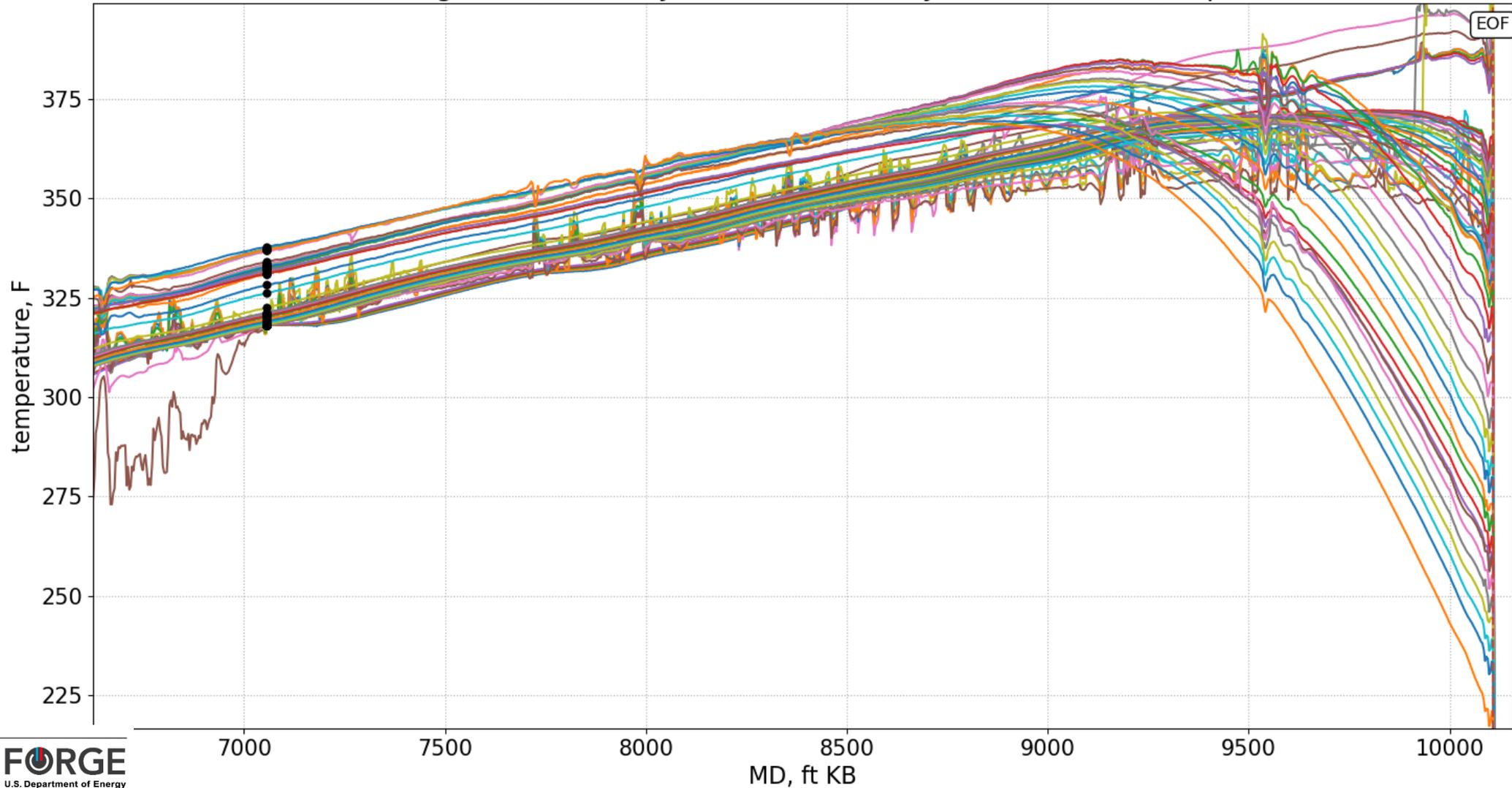
Utah Forge 16B(78)-32 - Jul 15, 12:15:00 to Jul 20, 14:15:00 (step 2 h)



Well 16B(78)-32 – selected traces (step 2 h) – zoomed in



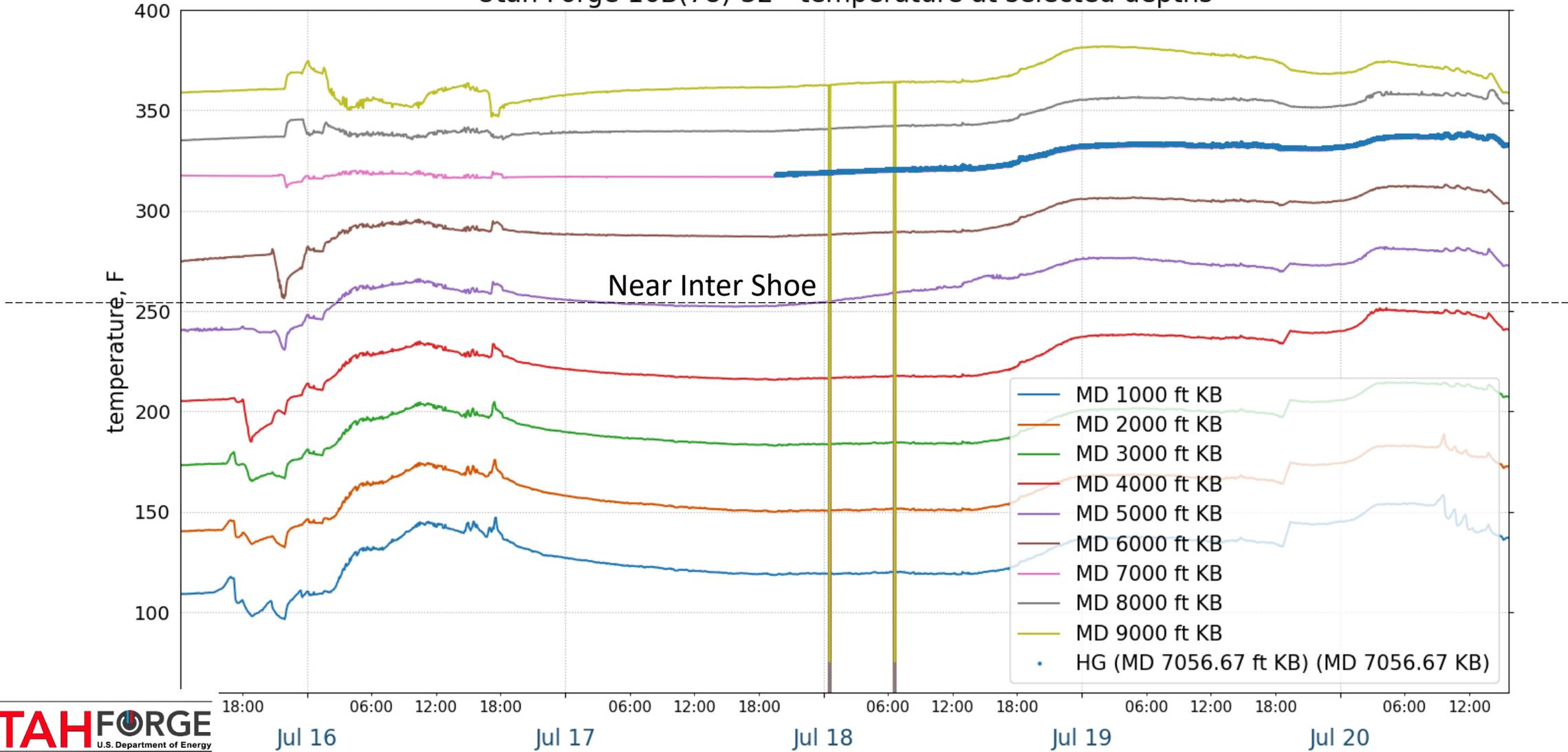
Utah Forge 16B(78)-32 - Jul 15, 12:15:00 to Jul 20, 14:15:00 (step 2 h)



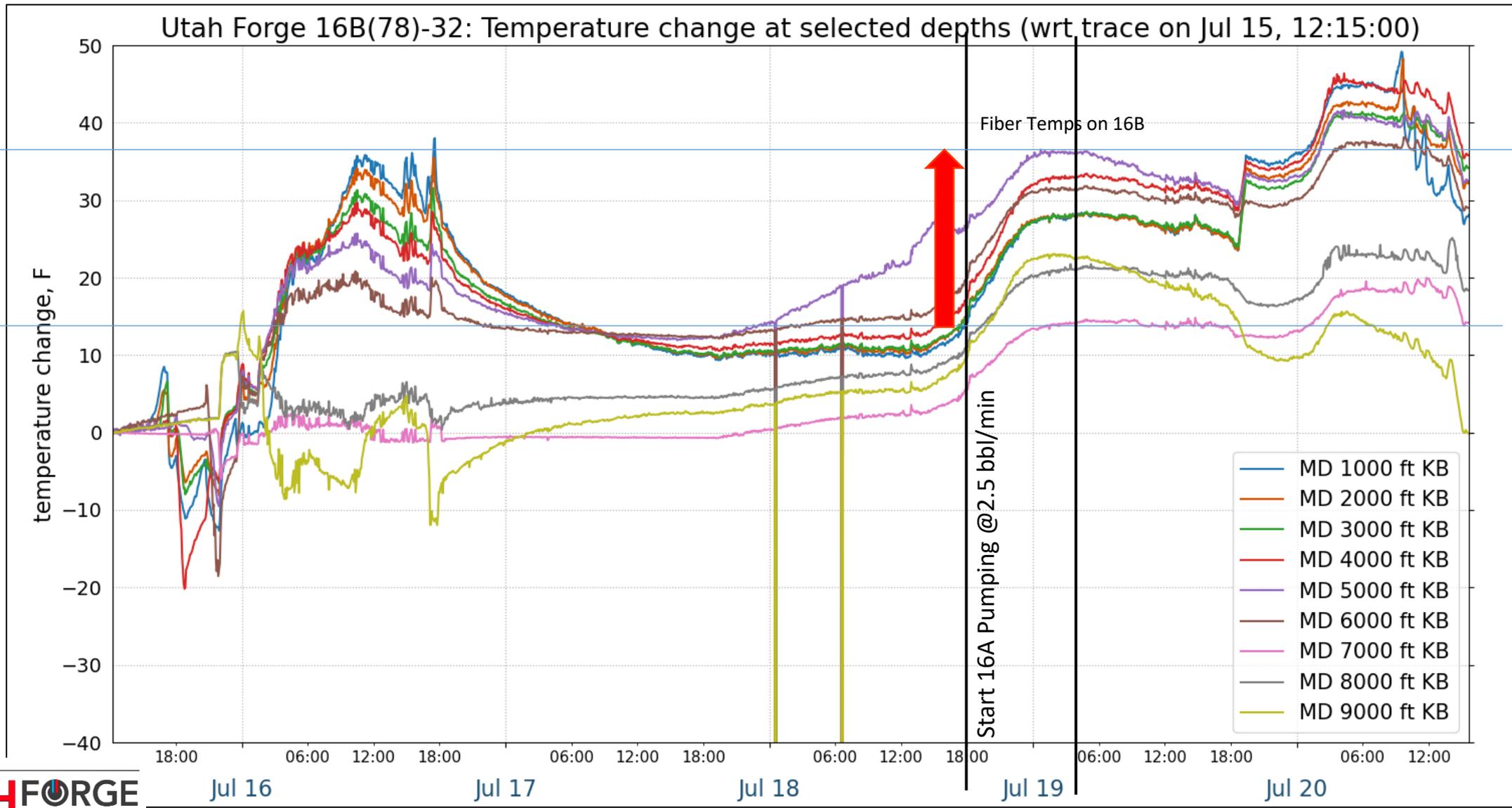
Well 16B(78)-32 – temperature at selected depths



Utah Forge 16B(78)-32 - temperature at selected depths



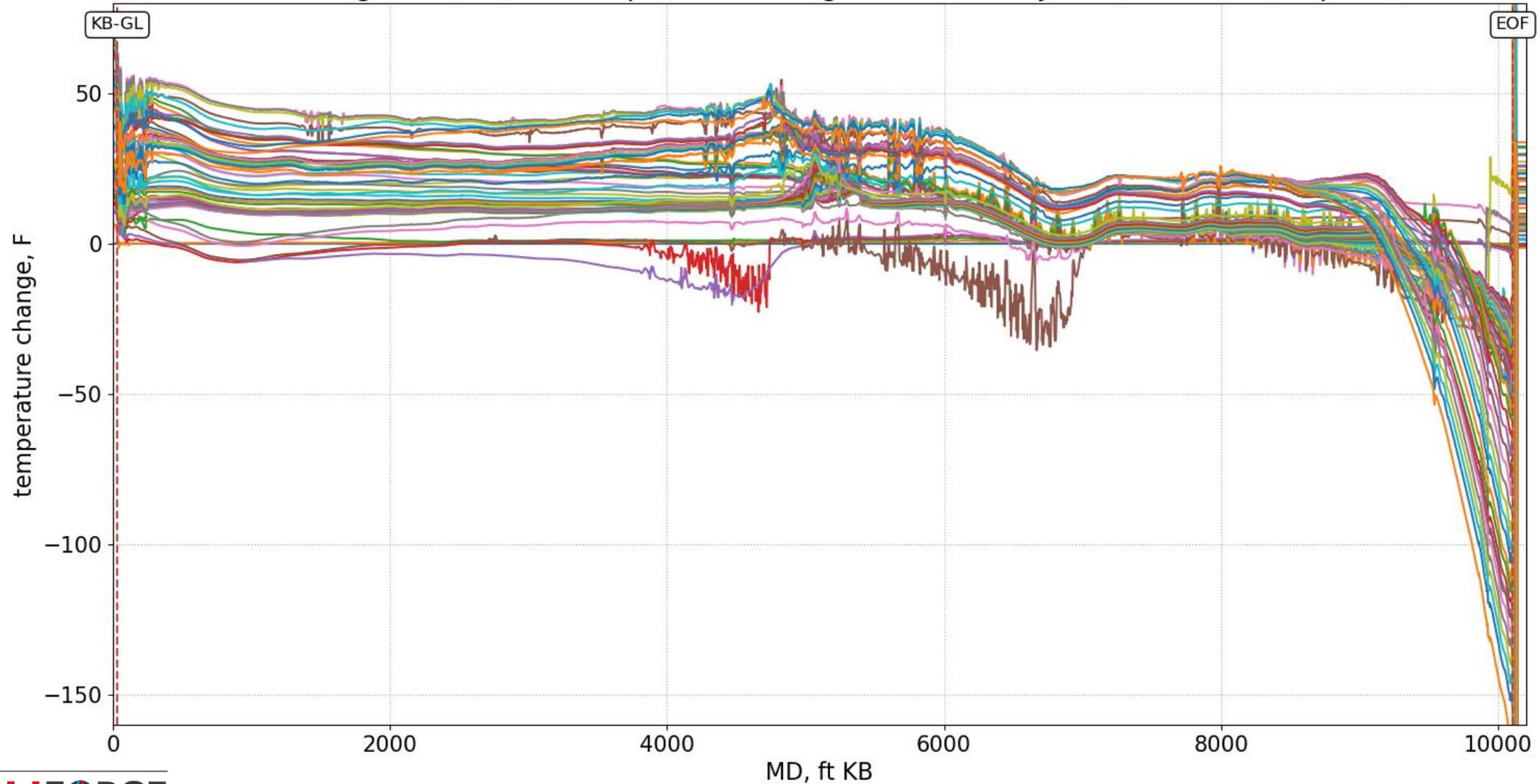
Well 16B(78)-32 – fiber DTS temperature change at selected depths



Well 16B(78)-32 – temperature change – selected traces (2 h step)



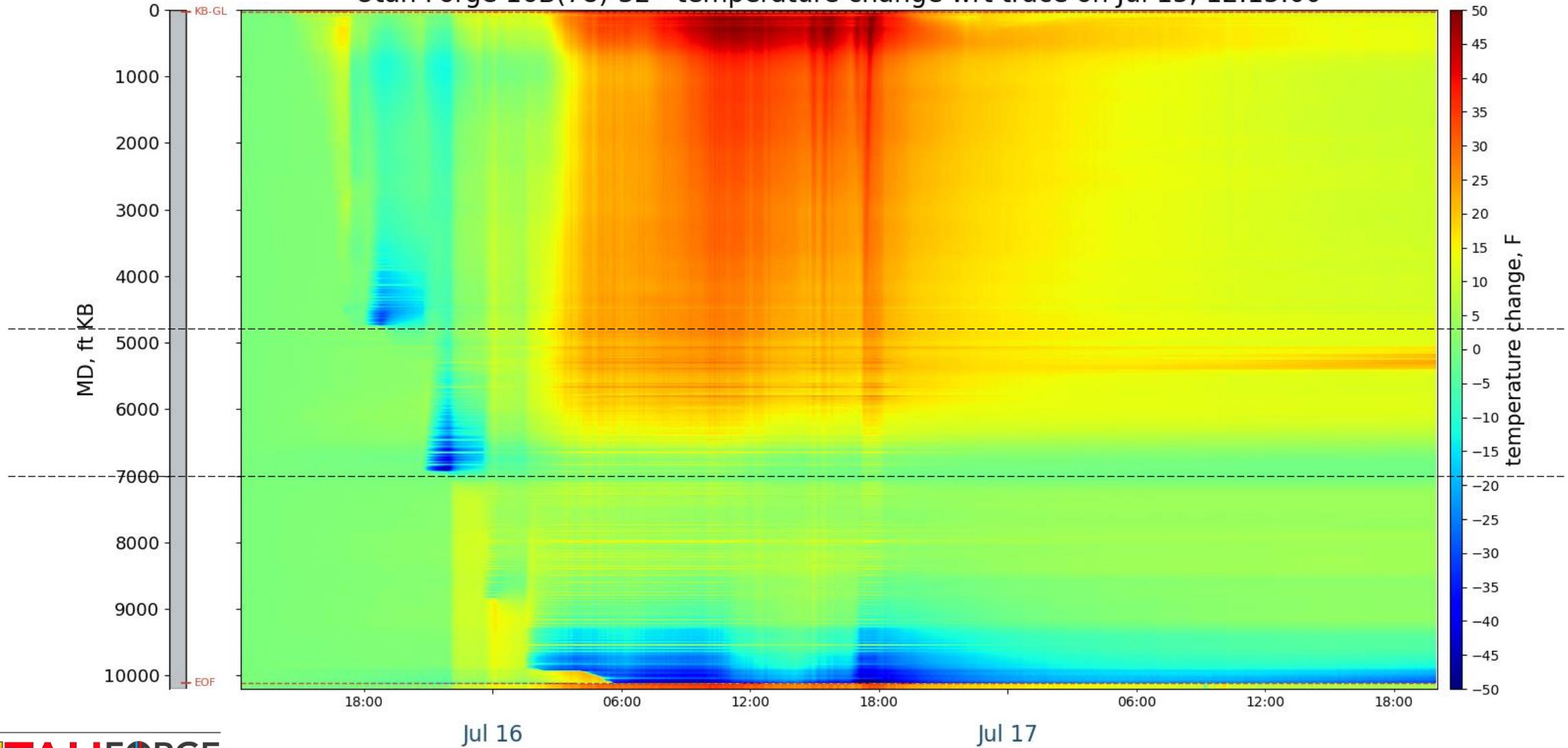
Utah Forge 16B(78)-32: Temperature change wrt trace on Jul 15, 12:15:00 (step 2 h)



Well 16B(78)-32 – temperature change – zoomed in



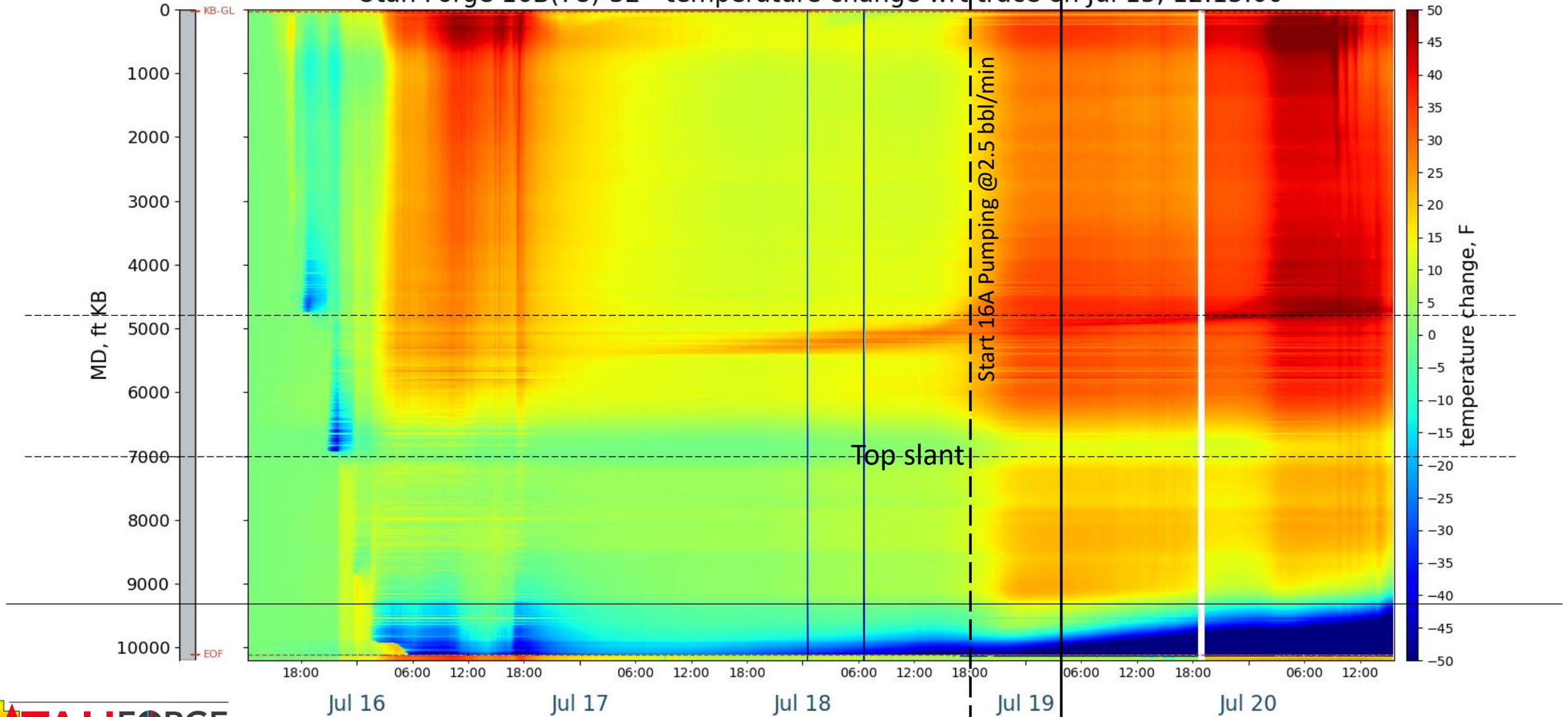
Utah Forge 16B(78)-32 - temperature change wrt trace on Jul 15, 12:15:00



Well 16B(78)-32 – DTS fiber temperature changes on 16B



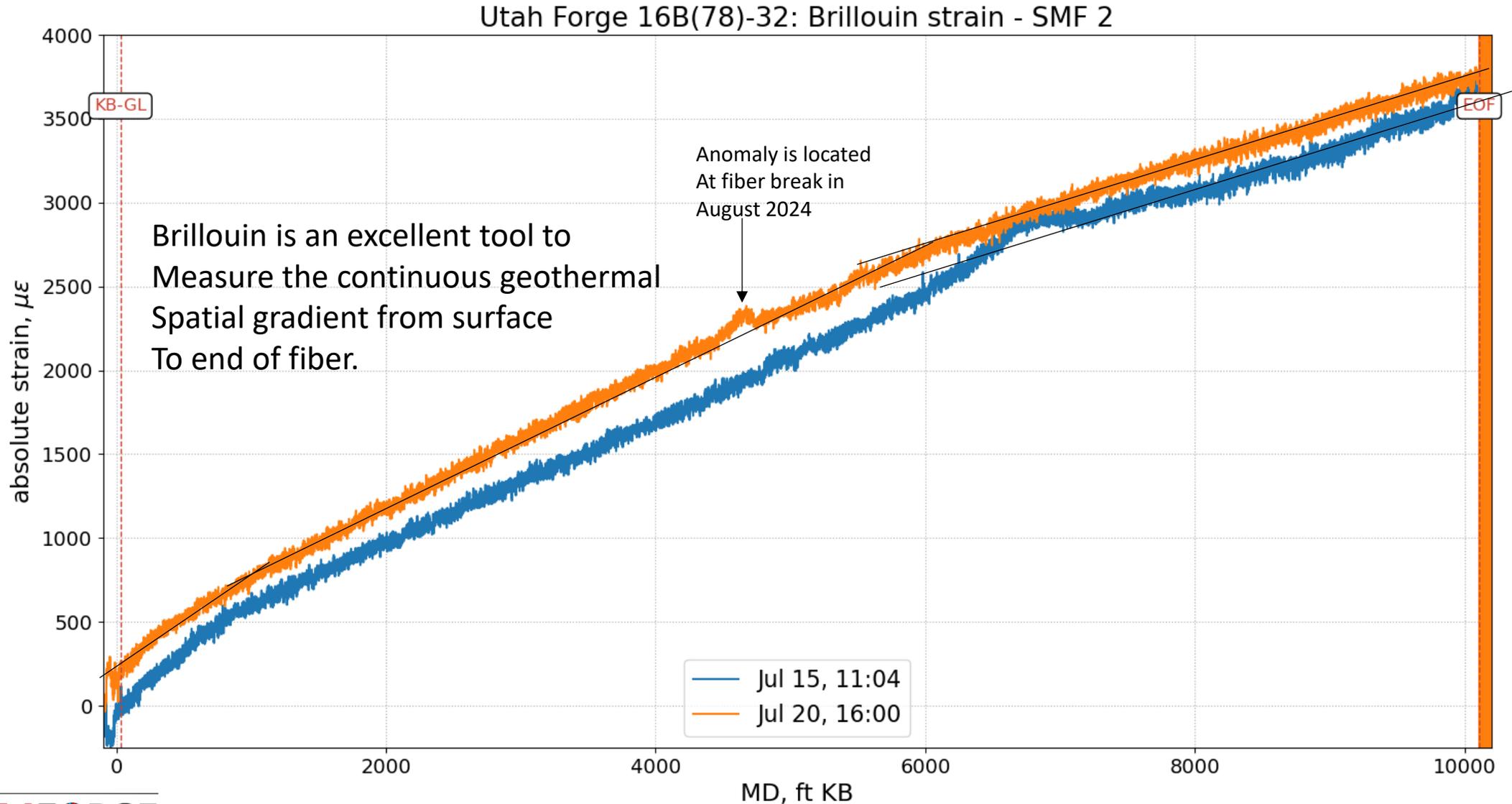
Utah Forge 16B(78)-32 - temperature change wrt trace on Jul 15, 12:15:00



Brillouin absolute total strain

- first trace: Jul 15, 2023, 10:52:09
- last trace: Jul 20, 2023, 16:12:38
- number of traces: 6
- number of samples per trace: 78,360

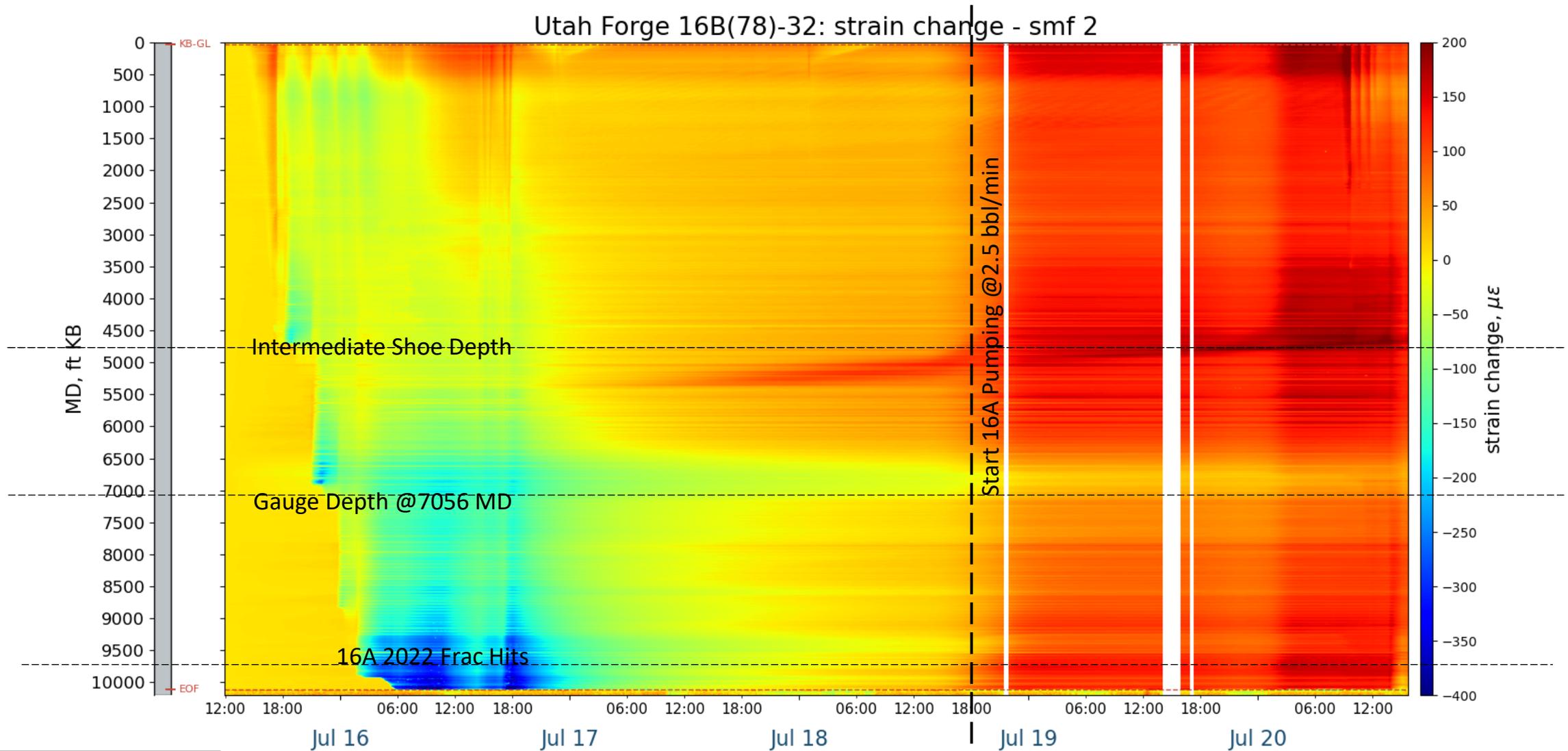
Well 16B(78)-32 – absolute strain – SMF 2 – selected traces



RFS strain change measurements

- first trace: Jul 15, 2023, 11:55:41
- last trace: Jul 20, 2023, 15:43:15
- number of traces: 6,193
- number of samples per trace: 39,181
- average temporal interval (sec): 72

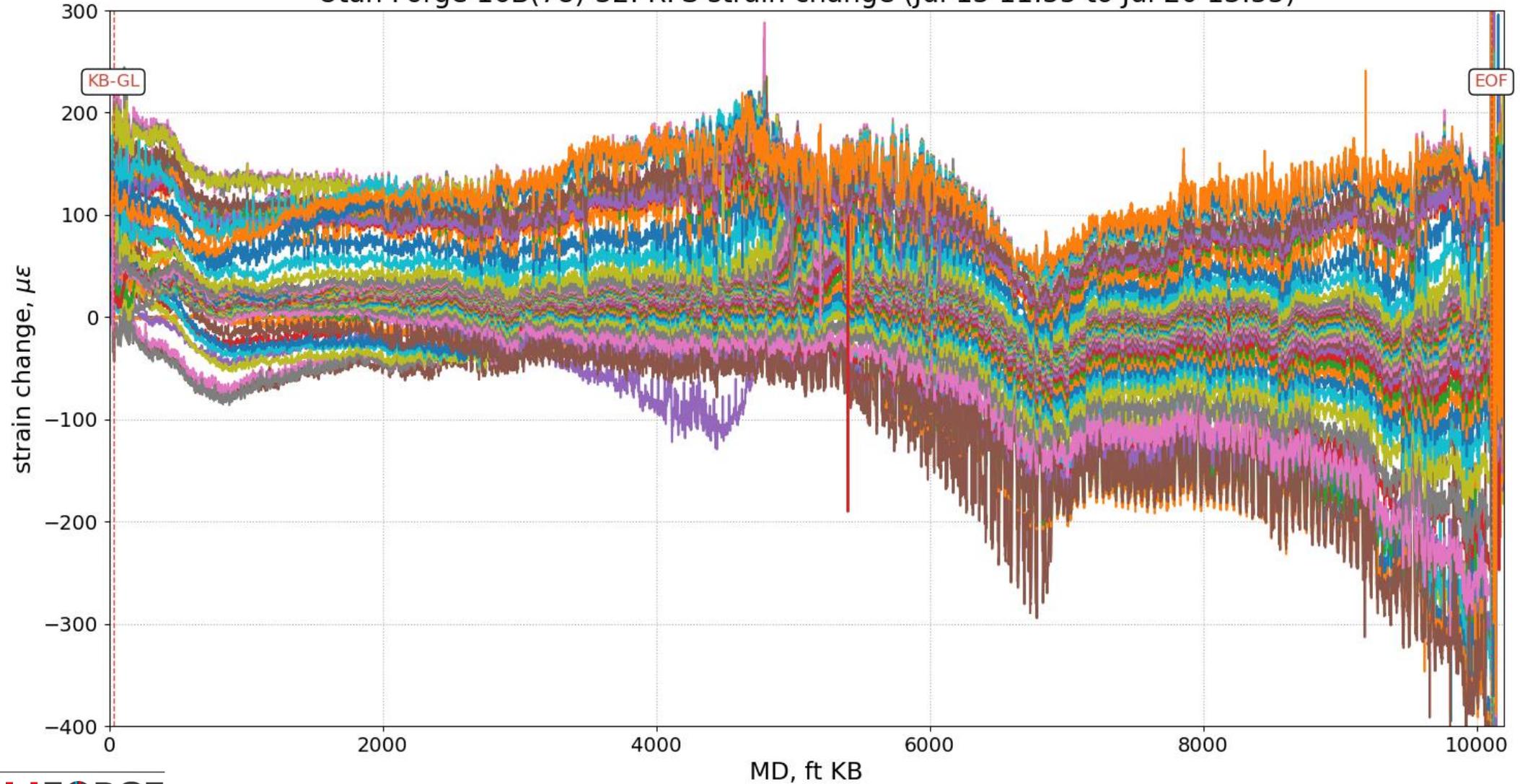
Well 16B(78)-32 – RFS strain change – SMF 2 – overview



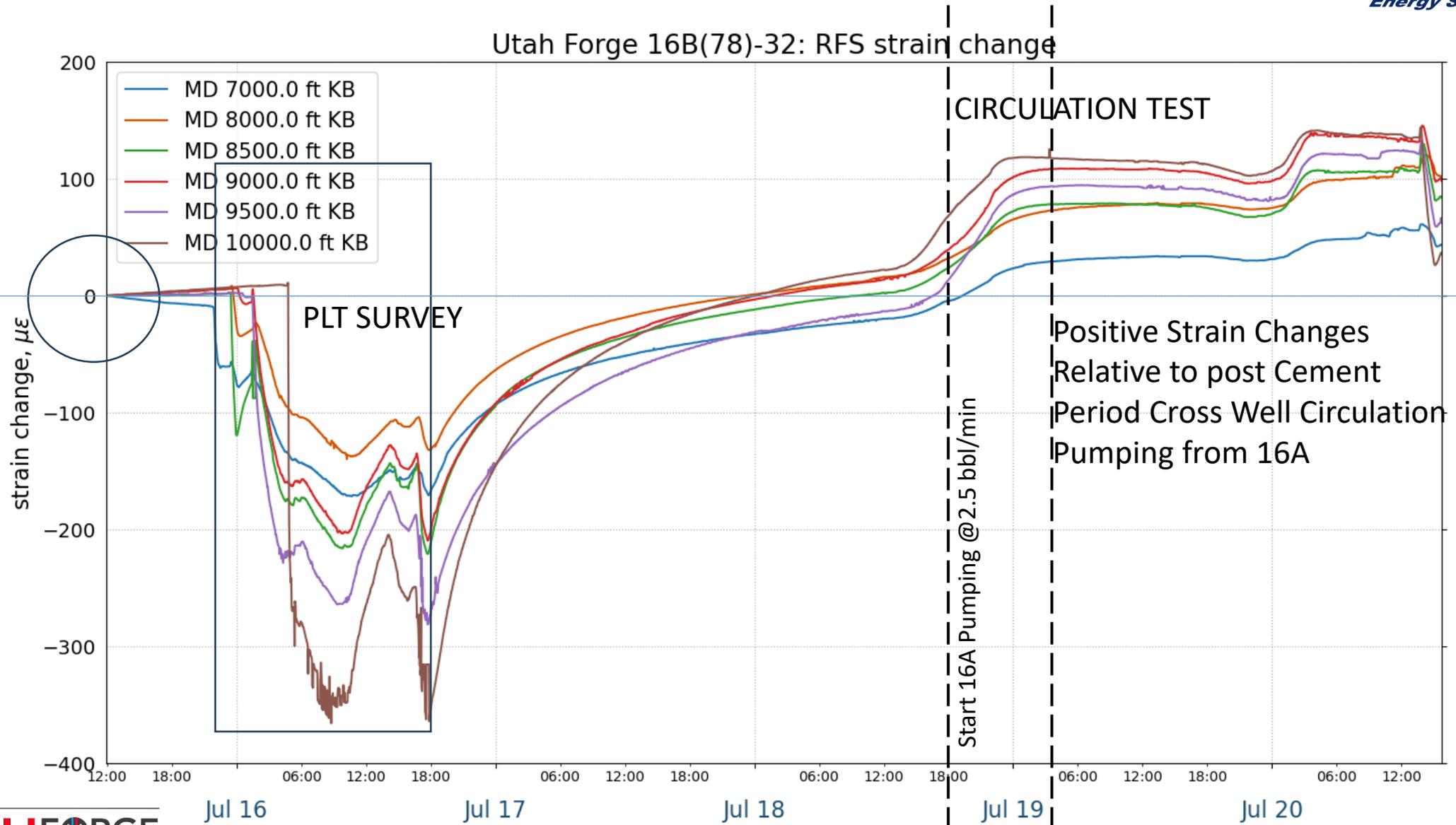
Well 16B(78)-32 – RFS strain change – SMF 2 – selected traces



Utah Forge 16B(78)-32: RFS strain change (Jul 15 11:55 to Jul 20 13:55)



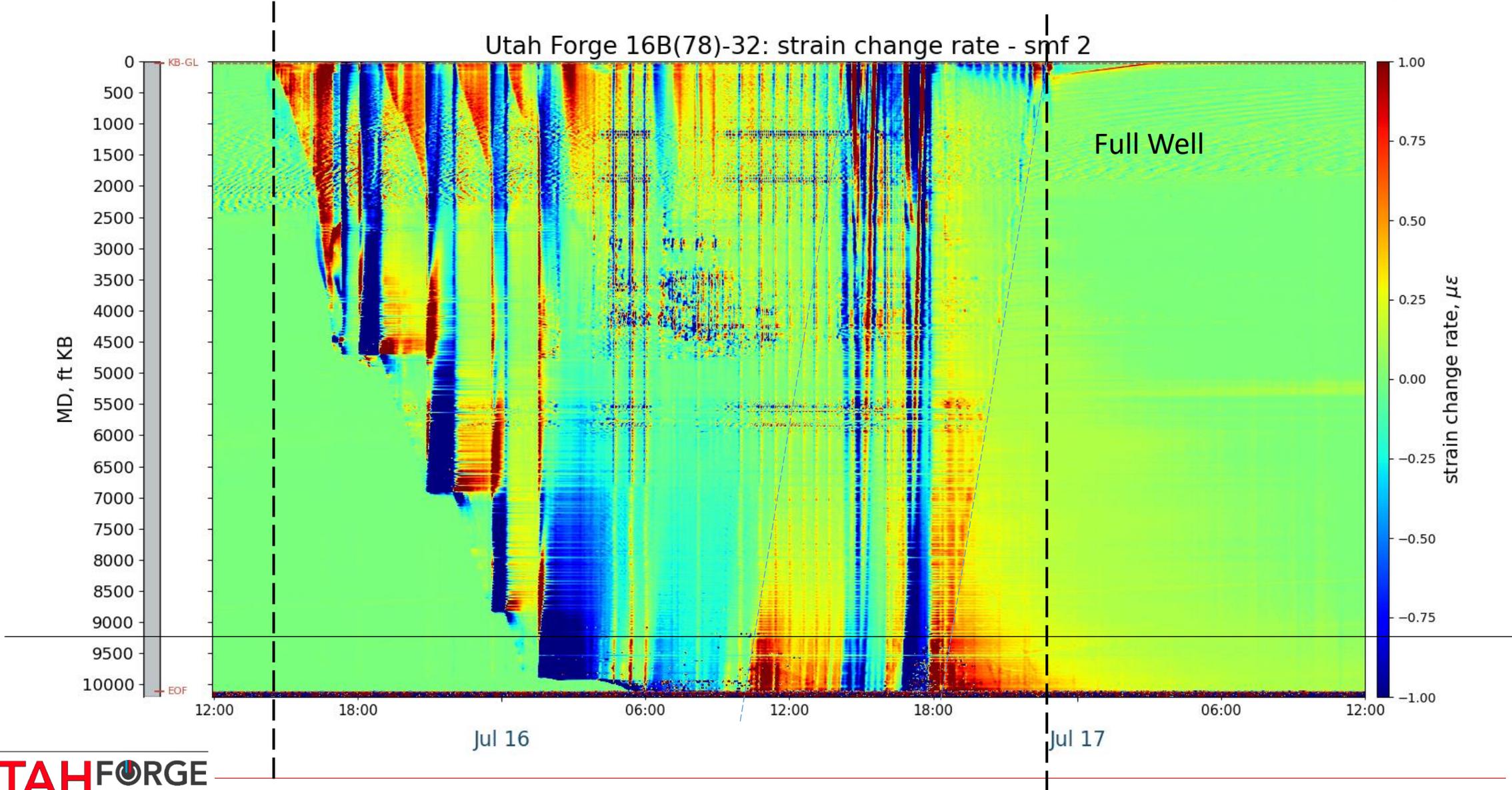
Well 16B(78)-32 – RFS strain change – selected depths



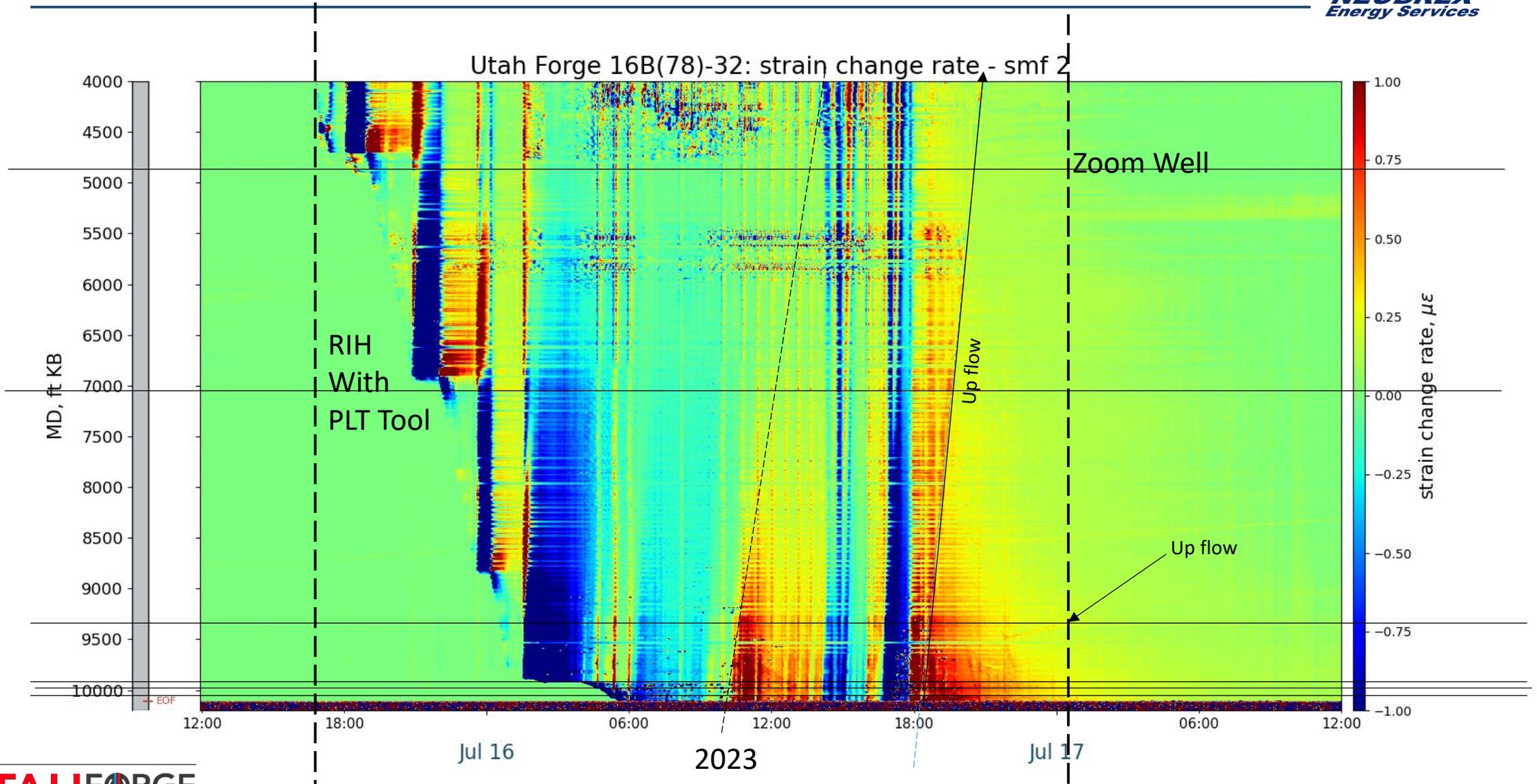
RFS strain change RATE of Change Δt interval = 72 seconds

- first trace: Jul 15, 2023, 11:55:41
- last trace: Jul 20, 2023, 15:43:15
- number of traces: 6,193
- number of samples per trace: 39,181
- average temporal interval (sec): 72

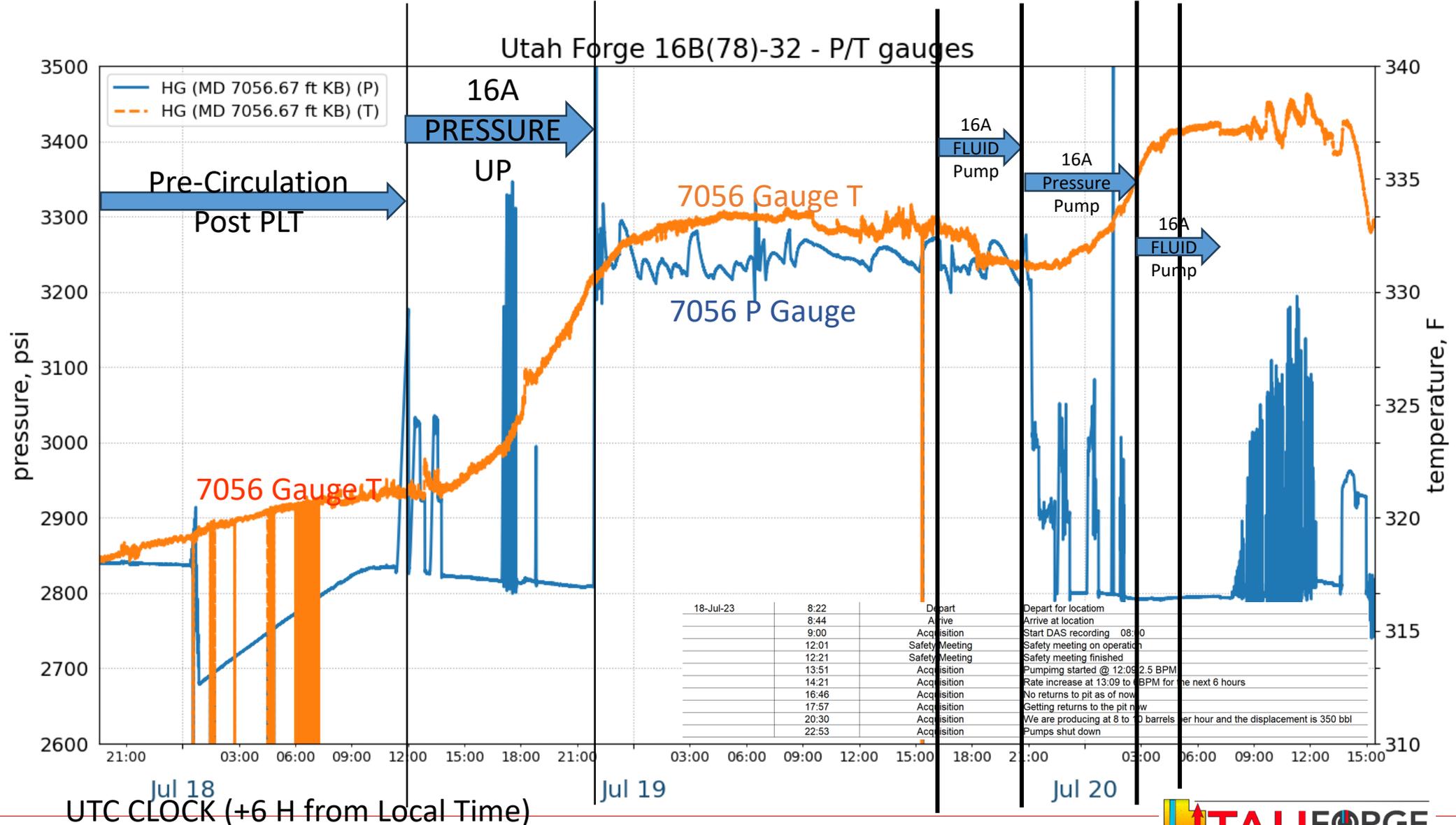
Well 16B(78)-32 – RFS strain change rate During PLT Work



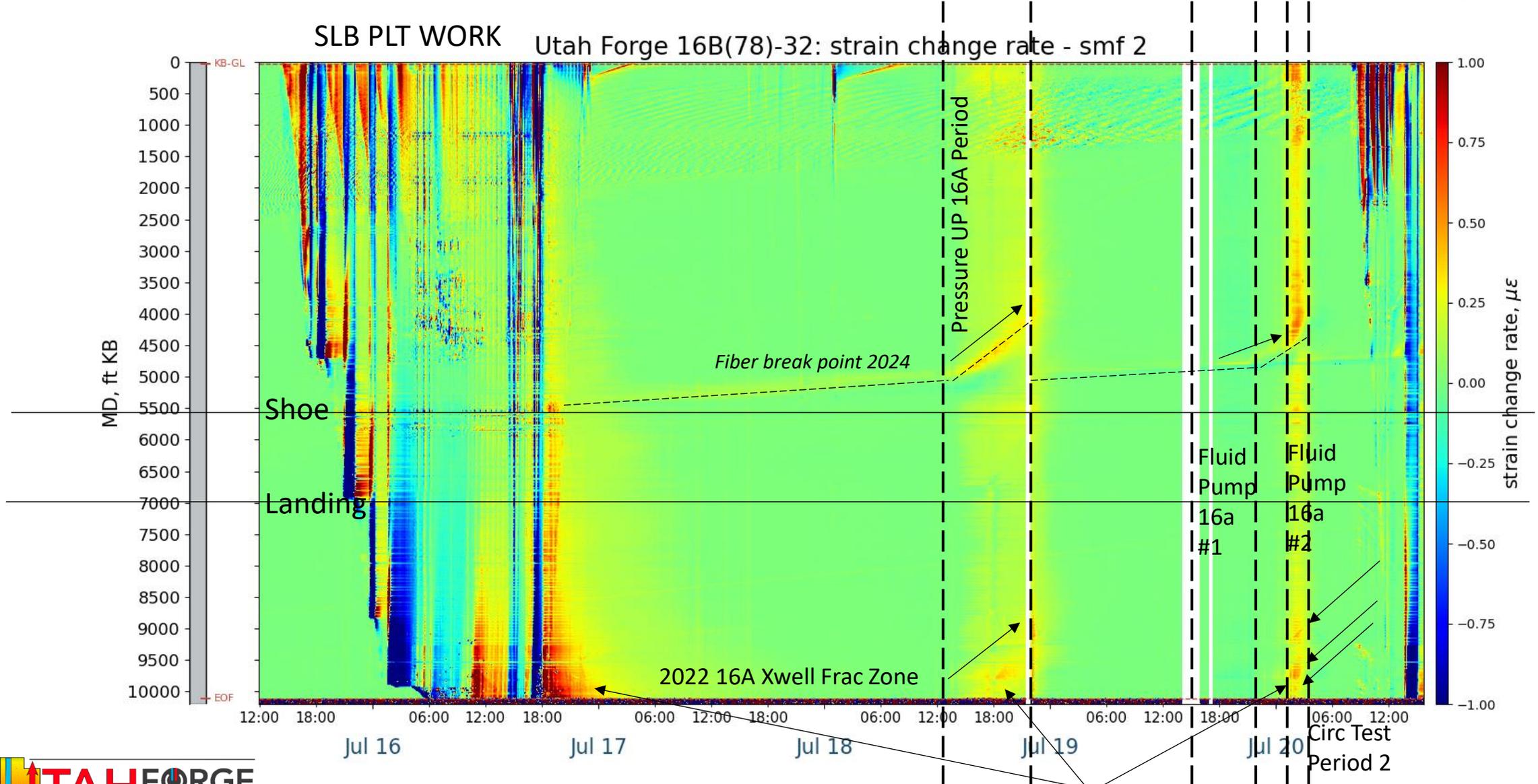
Well 16B(78)-32 – RFS strain change rate – During PLT Work



Well 16B(78)-32 – P/T gauges on 16B CIRC TEST

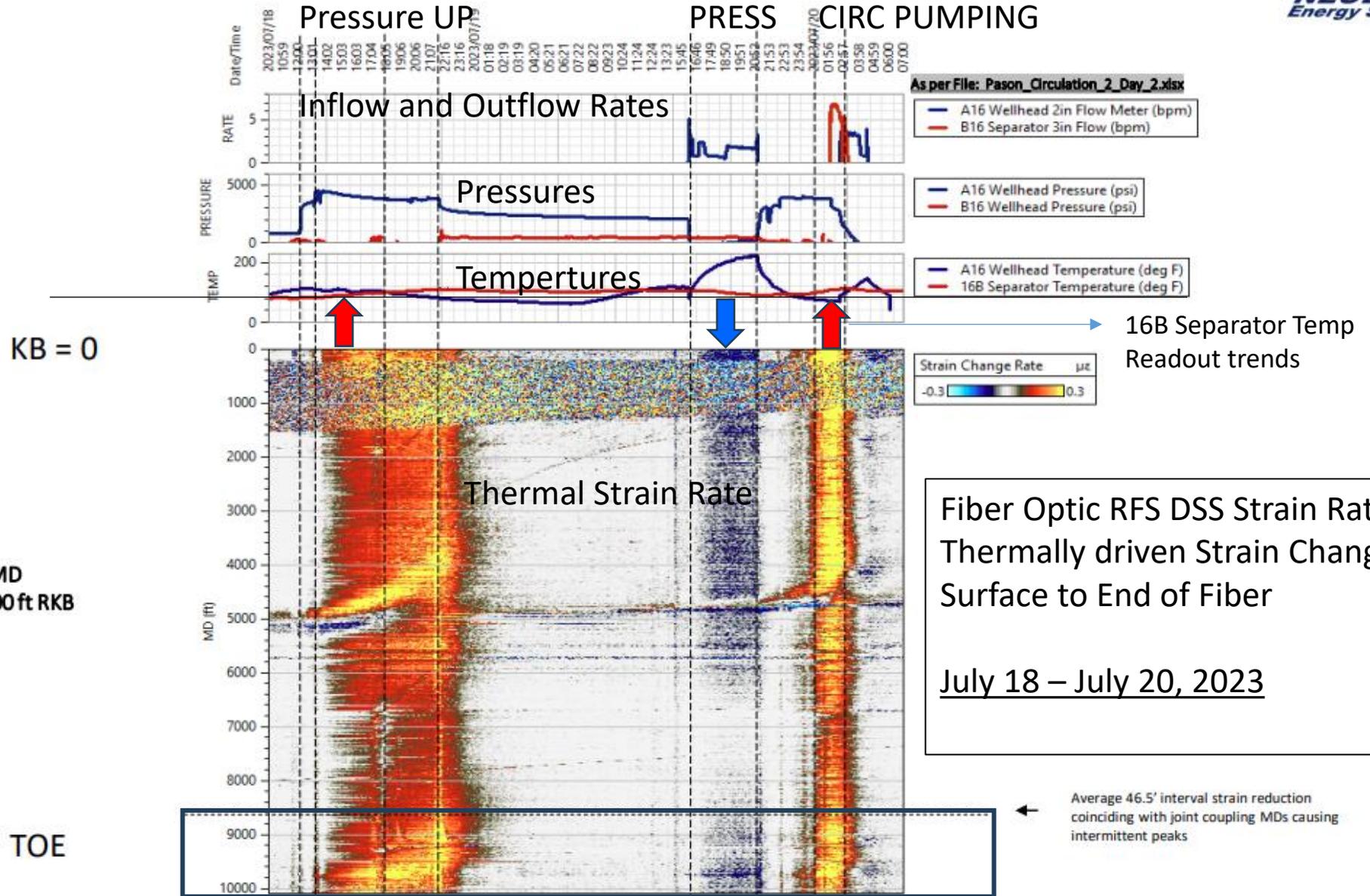


Well 16B(78)-32 – RFS strain change rate – PLT and Circ test



16B(78)-32 Fiber Well

Elizabeth Davidson
Dana Jurick
Artur Guzik

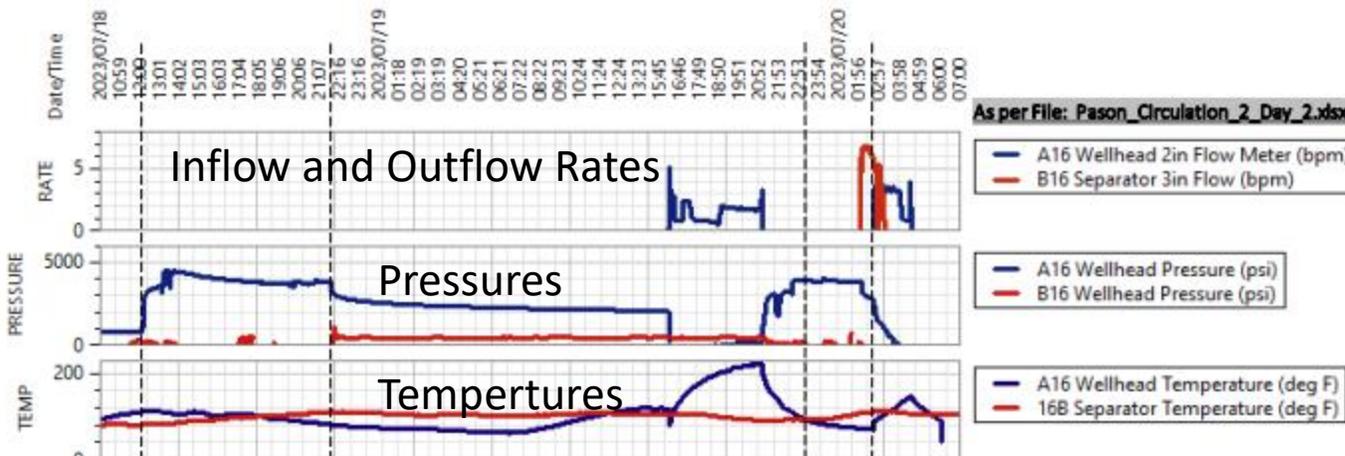


Fiber Optic RFS DSS Strain Rate
Thermally driven Strain Change
Surface to End of Fiber
July 18 – July 20, 2023

16B(78)-32 Fiber Well

Elizabeth Davidson
Dana Jurick
Artur Guzik

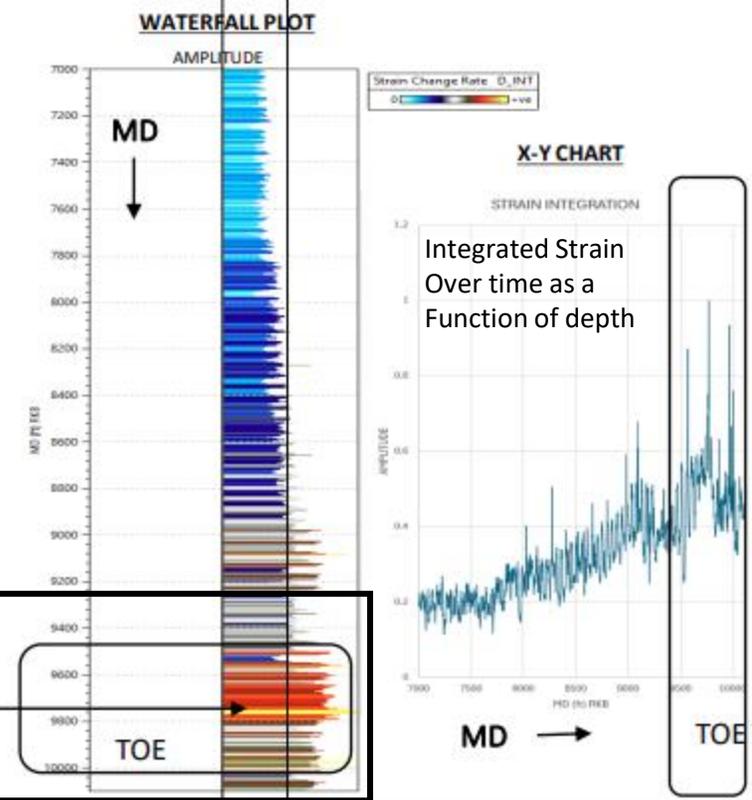
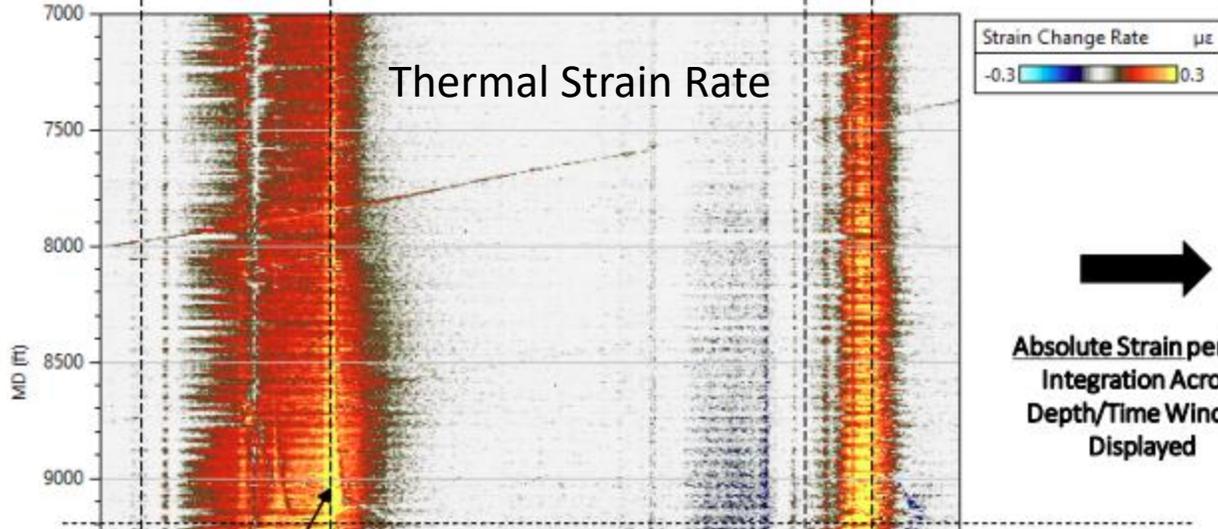
Fiber Optic RFS DSS Strain Rate
7000 MD to End of Fiber
PRE FRAC 2024 Circ Test
July 18 – July 20, 2023



Absolute Strain per MD

Integration Across Depth/Time Window Displayed
EVO_1_INT_7000-10100.csv

MD
7000-10100 ft RKB

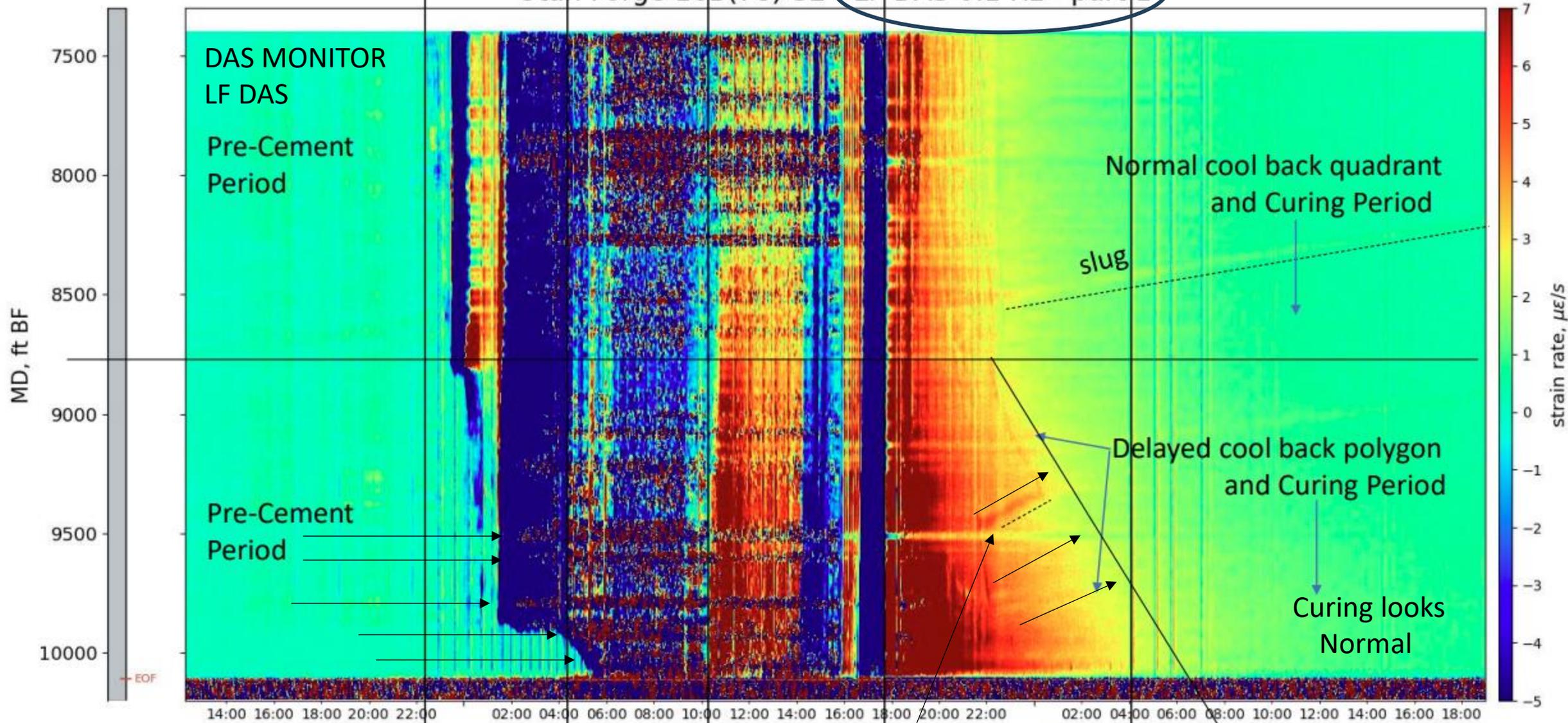


**Absolute Strain per MD
Integration Across
Depth/Time Window
Displayed**

Average 46.5' interval
strain reduction
coinciding with joint
coupling MDs causing
intermittent peaks

Hot spikes
Hot spikes

Utah Forge 16B(78)-32 - LF-DAS 0.1 Hz - part 1



End of Technical Report and Contact Information



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