January 16, 2019

Distributed Temperature Sensing (DTS) measurements made in Brady observation well 56-1 conducted on August 24, 2018.

Christopher B. Kratt, Thomas I. Coleman, Scott W. Tyler, Herbert F. Wang, Douglas E. Miller, Kurt L. Feigl

This submission is a follow-up to Distributed Temperature Sensing (DTS) measurements made in Brady observation well 56-1 during the PoroTomo field experiment conducted in March, 2016. The measurements in this data set were made on August 24, 2018 over an approximately 20 hour period. The fiber-optic cable extends to the bottom of the well at 367 m below the wellhead. Measurements were made with a Silixa XT DTS interrogator configured to continuously record in each file a sixty-second average of stokes and anti-stokes readings on a single channel with a bottom hole U-bend. The 2016 data were collected using a Silixia Ultima with 12.5 cm spatial sampling, whereas the XT spatial sampling interval is 25 cm with a temperature resolution of 0.03 °C. Raw, uncalibrated data were converted to a single .MAT file using code provided by CTEMPs https://ctemps.org/data-processing. The binary Matlab file containing processed Silixa XT data is read using the Matlab statement "load('Brady_25Aug2018_ch1.mat')", which contains the arrays below. Arrays with 2361 rows represent the channels and arrays with 1210 columns represent the one-minute samples.

Name	Size	Bytes	Class	Attributes
datetime	1x1210	9680	double	column
distance	2361x1	18888	double	rows
AntiStokes	2361x1210	22854480	double	
Stokes	2361x1210	22854480	double	
tempC	2361x1210	22854480	double	
ans	1x1	168666	struct	
tref_int	1x1210	9680	double	

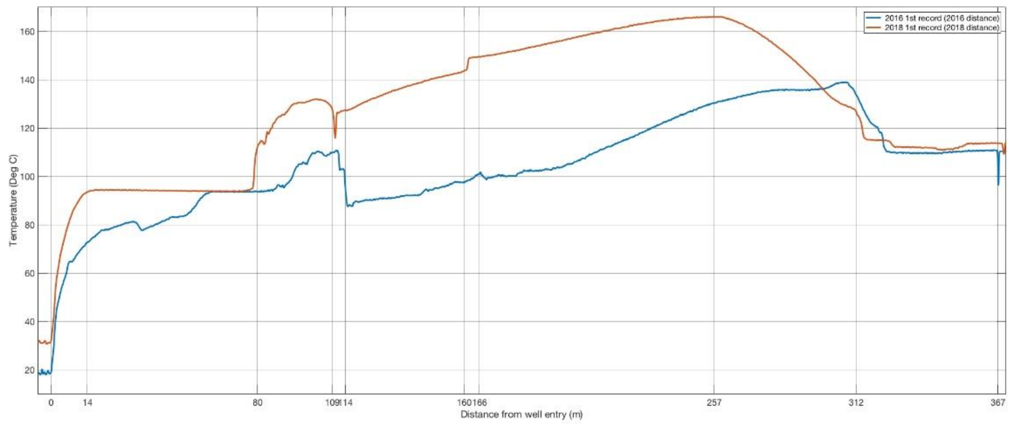

Figure 1. Thermal profiles in Well 56-1 in March 2016 and August 2018 referenced to recorded distance from well entry.

These are the first records in each set of data from the 2016 and 2018 DTS surveys. Channel indices corresponding to well entry point and downhole turnaround splice are clear in both recordings. When DTS recordings are saved, an array of physical distances is created by multiplying channel index by a distance increment calculated as the product of optical delay-time increment times an assumed two-way group speed of light in the fiber. Figure 1 shows an apparent discrepancy in total distance that stems from slightly different effective refractive index values being used by software in the DTS instruments for the two surveys. The discrepancy is an artifact of the software difference. For interpretation, it is suggested that a common uniform sampling in the borehole section (between well entry and turnaround) is appropriate.

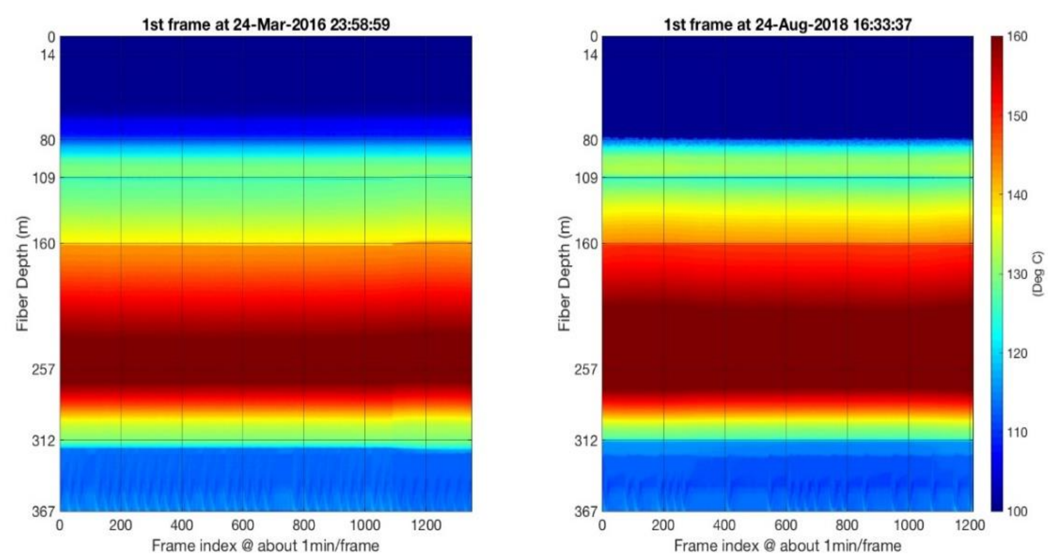

Figure 2. Thermal profiles in Well 56-1 in March 2016 and August 2018 versus time over approximately 20 hours (1200 minutes).

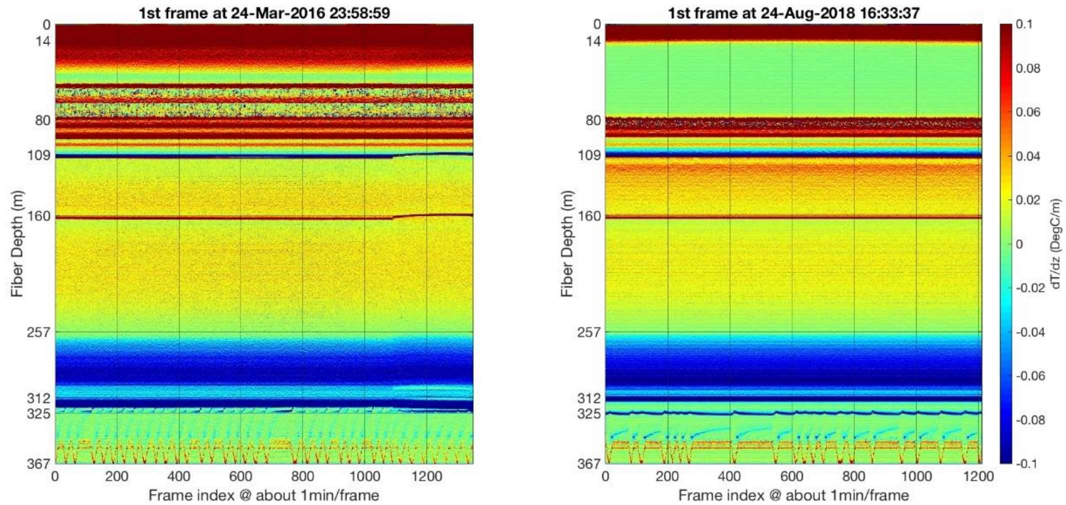

Figure 3. Thermal gradient profiles in Well 56-1 in March 2016 and August 2018 versus time over approximately 20 hours (1200 minutes).

Figures 2 and 3 show Temperature T(z,t) and Temperature depth gradient dT/dz(z,t) , for comparable, roughly 20-hour, periods. For 2018, that is the entire recording period. For 2016 it is the final day's recording. There is evident overall agreement. In the 2016 panels, thermal boundaries at 109m, 160m, and near 312m show fluctuations that were correlated to changes in reservoir pressure resulting from a plant shutdown on 24 March 2016. No fluctuation is seen at these depths in the 2018 data, suggesting that the irregularities are stable under normal plant operations, as was the case during the 2018 recording period.

The 2018 data shows a larger zone of constant temperature (93 degC) between 14m and 80m, presumably related to steam condensation and responsive to surface temperature and state of fill outside the well casing. (Patterson 2017).

Most notable is a quasi-regular repeating thermal exchange process that is evident in both recordings between 325m and 367m (roughly the perforated zone). In 2016 the repetition period was (eventually) stable at about 30 min/cycle. In 2018 there are 20 cycles during the 20 hour recording. (Miller, et al 2018) compared DTS with DAS recordings and found detectible local acoustic signal (presumed to be flow noise) associated with the process.

References

Patterson, J. R., M. Cardiff, T. Coleman, H. Wang, K. L. Feigl, J. Akerley, and P. Spielman (2017), Geothermal reservoir characterization using distributed temperature sensing at Brady Geothermal Field, Nevada, The Leading Edge, 36, 1024a1021 - 1024a1027.

D.Miller, T. Coleman, X. Zeng, J. Patterson, E. Reinisch, H. Wang, D. Fratta, W. Trainor-Guitton, C.Thurber, M. Robertson, K. Feigl, and The PoroTomo Team (2018), DAS and DTS at Brady Hot Springs: Observations about Coupling and Coupled Interpretations, 43rd Stanford Workshop on Geothermal Reservoir Engineering (2018)

Acknowledgements

We would like to thank John Akerley and Ormat for assistance in the field.