geoconvention
Virtual Event
September 13 - 15
2021

Preliminary Results of a Temperature Log Using a Deep Disposal Well in the Western Canada Sedimentary Basin

Katherine Y. Huang[1], Catherine J. Hickson[1], Yannick Champollion[2]
[1]Alberta No. 1 [2]HydroGeo+ Inc

Summary

The Alberta No. 1 conventional geothermal project is located south of the city of Grande Prairie within the Municipal District of Greenview. The company recently conducted a detailed temperature log on a SECURE ENERGY idle disposal well close to the project site. The goal was to determine the regional thermal gradient and temperatures within the project's target formations, understand heat flow within the lowermost sequences, and compare results from oil and gas temperature data. The log yielded a temperature profile from surface to over 4000m depth and recorded a Borehole Temperature (BHT) of 117.9 °C. The upper portion of the well (surface to 2867.5 m) calculated a gradient of 32.5 °C/km, while the lower portion (2867.5 m to 4035.5 m) calculated a significantly lower gradient of 21.1 °C/km. The abrupt change in gradient appears to represent the transition between the Jurassic and Triassic formations. At this transition, lithology changes from sandstone and shale sequences to more carbonate-dominated sequences. The results also suggests that there may be convective heat flow through these more porous limestone and dolomite units. In addition, the geothermal log exhibits small-scale variations in the thermal gradients likely related to lithology changes.

Theory / Method / Workflow

The temperature log was assessed to explore the relationship between downhole thermal gradients and lithology. Details on how the log was conducted can be found in a separate abstract titled 'Comparing Temperature Data from Oil and Gas and Geothermal Logs – An AB No.1 Case Study'.
The data from the log going up the wellbore were used, as there were minimal calibration errors compared to the log going down the wellbore.
First, thermal gradient was calculated using the simple equation:

$$Thermal\ Gradient = \frac{Temperature}{Depth} * 1000$$

where temperature is in °C, depth is in m, and thermal gradient is in °C/km. Thermal gradients were then calculated for moving averages for 20 m, 50 m, and 100 m intervals. The moving average gradients were then plotted with depth. A decrease in thermal gradient was visually apparent at approximately 2867.5 mGL for all three plots. A line of best fit was calculated for the portion of the well above this gradient change and below.
To correlate the temperature log with lithology, formation tops were chosen based on raster logs (density-neutron, gamma, and resistivity), which were downloaded from geoSCOUT. Next, each formation was characterized by summarizing the lithological descriptions from the raster logs into general lithologies, such as shale, sandstone, and limestone. Finally, temperature was plotted with depth and correlated with formations and lithology.

Results, Observations, Conclusions

The temperature and lithology logs are shown in Figure 1. The thermal gradients for upper portion of the well (surface to 2867.5 mGL) and lower portion of the well (2867.5 mGL to 4035.5 mGL) are 32.5 °C/km and 21.1 °C/km, respectively. The BHT at total depth was 117.91 °C. The average geothermal gradient for this well is 29.1 °C/km which exceeds the average gradient of 23.9 °C/km previously reported for the area (Huang et al., 2020).

The gradient shift occurs at the approximate interface between the lower Jurassic sandstone and shale-dominated formations and the upper Triassic carbonate formations. Specifically, the gradient changes around the dolomite and limestone-dominated Charlie Lake Formation.

These results confirm that temperatures within our target formations will exceed the threshold temperature of 100 °C that is required to efficiently generate power. The results also validate the existence of temperatures sufficient for direct use applications much shallower in the region.

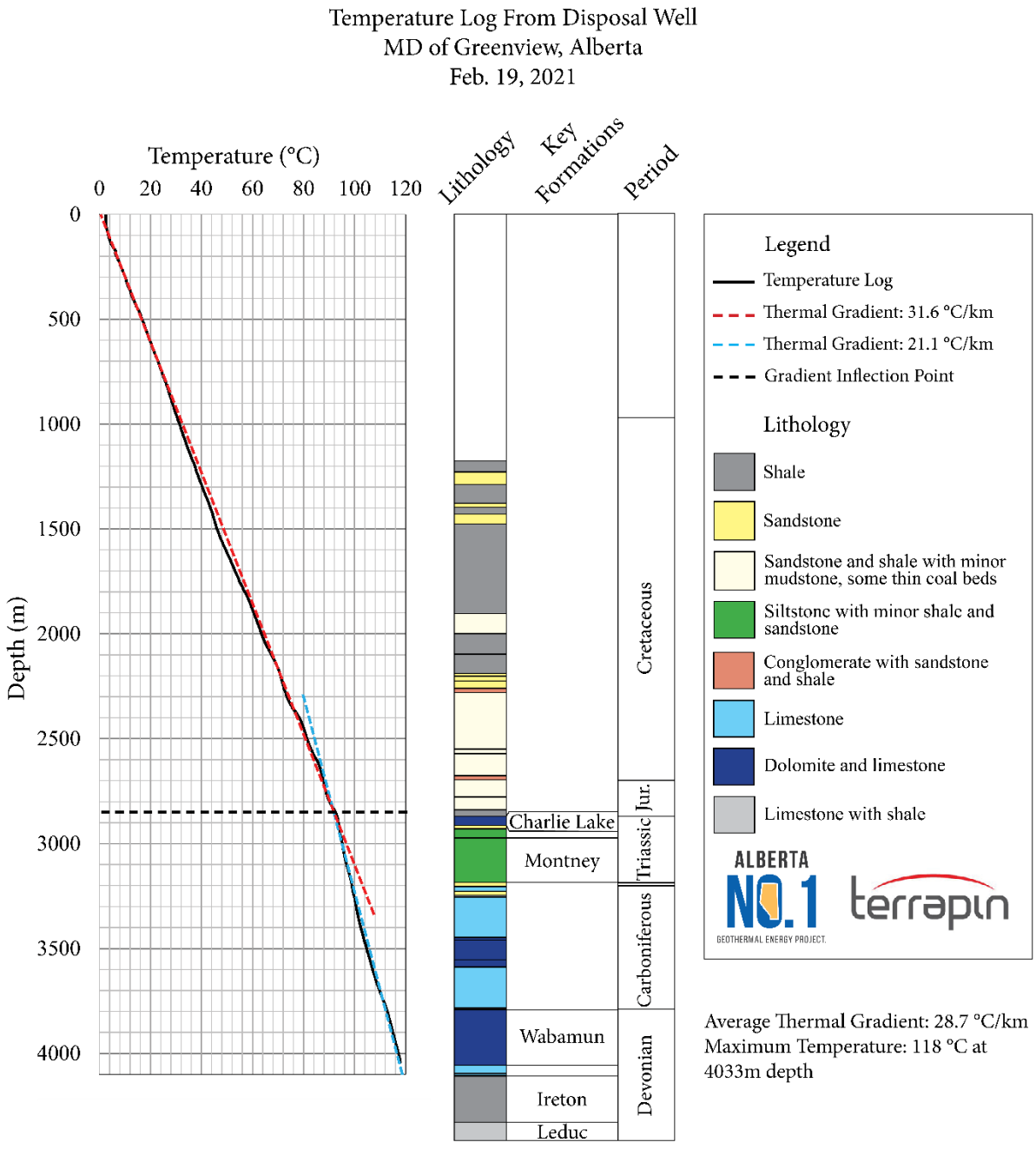

Figure 1. Temperature profile with depth and lithology log showing notable formations. The shift in thermal gradient occurs at the boundary between the Jurassic and Triassic, at the Charlie Lake Formation.

Acknowledgements

We are grateful for the collaboration with SECURE ENERGY to access the wellbore for logging. We would also like to acknowledge Voltage Wireline Inc. for conducting the temperature log. Geological consulting for selecting formation tops was performed by Darrell Cotterill (Parallax Resources).
The project manager and major shareholder of the Alberta No. 1 project is Terrapin Geothermics. The Alberta No. 1 project is partially funded by the Emerging Renewable Power Project from Natural Resources Canada.

References

Huang KY, Hickson CJ, Cotterill D, Champollion Y. Geothermal Assessment of Target Formations Using Recorded Temperature Measurements for the Alberta No. 1 Geothermal Project. Applied Sciences. 2021; 11(2):608. https://doi.org/10.3390/app11020608