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Temperature Mapping of Select Devonian Formations in Alberta

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Background

This presentation reports the results and findings of a subsurface temperature mapping project conducted by the Alberta Geological Survey. Alberta's long history of petroleum exploration has resulted in a wealth of temperature data, from various sources and of varied quality. While temperature measurements from drill stem tests and annual pool surveys are considered higher quality, temperature measurements recorded from wireline logs as bottom hole temperatures (BHT) often record the temperature of drilling mud in the wellbore, which has not equilibrated with the formation temperature and requires correction to be representative of in-situ conditions.

Methodology and Results

To maximize the amount of BHT data available for mapping, a temperature correction method based on a derivation of the Harrison correction (Harrison et al., 1983) was used to calibrate uncorrected BHTs with more reliable temperature measurements acquired from drill stem tests, and annual pool surveys. A culled temperature dataset from Nieuwenhuis et al. (2015) was used to provide temperature measurements from drill stem tests and annual pool surveys. The new data and updated methodology resulted in an Alberta-calibrated Harrison correction equation that can be used to estimate the formation temperature in BHT measurements:

$$Tc(°C) = -13.6586 + 0.01806x - 0.000002555x^2$$

where Tc = the temperature increase to equilibrium and x = depth in metres.

This temperature correction was applied to previously unutilized BHT temperature data and then merged with pre-existing temperature data from Nieuwenhuis et al. (2015). The resulting temperatures were statistically culled to remove any outliers in the data. As a result, an updated subsurface temperature database for the Alberta basin was created. This correction resulted in an increase in over 100,000 temperature measurements from BHT's (Figure 1) and a final subsurface temperature database of over 200,000 temperature measurements.

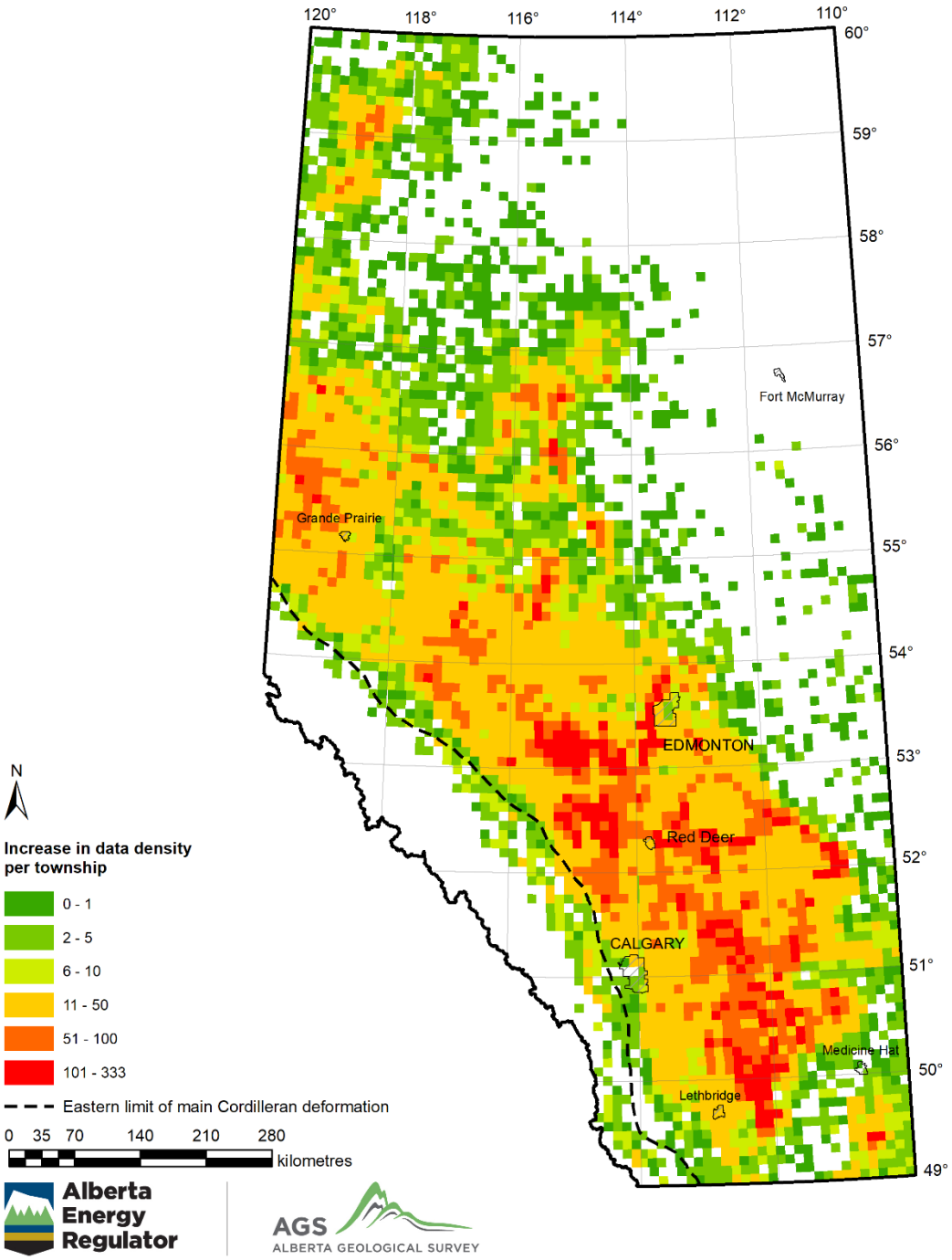

Figure 1. Corrected BHT data per township added to the temperature database used to create the temperature model and subsequent formation-scale maps.

A 3D subsurface temperature model was generated using the new database and the Geological framework of Alberta (Alberta Geological Survey, 2021) was used to produce 2D temperature maps for some of Alberta's deeper sedimentary formations that may be targeted for future geothermal exploration and development.

Temperature maps were created for, in descending stratigraphic order: 1) Wabamun Group, 2) Winterburn Group, 3) Leduc Formation, 4) contiguous Swan Hills and Slave Point formations, 5) Watt Mountain Formation, 6) Sulphur Point Formation, and 7) Keg River Formation.

An example showing the type of temperature map created is shown for the Leduc Formation in Figure 2.

In addition, the temperature at the top of the Precambrian crystalline basement (base of the sedimentary succession) was also mapped and a thermal gradient map was produced using the temperature at the top of the Precambrian and the depth to the top of the Precambrian.

The methodology and data from this study was also used to create GIS products displaying the distribution of formation temperature as ASCII grids, and generate point cloud model data as tabular data sets.

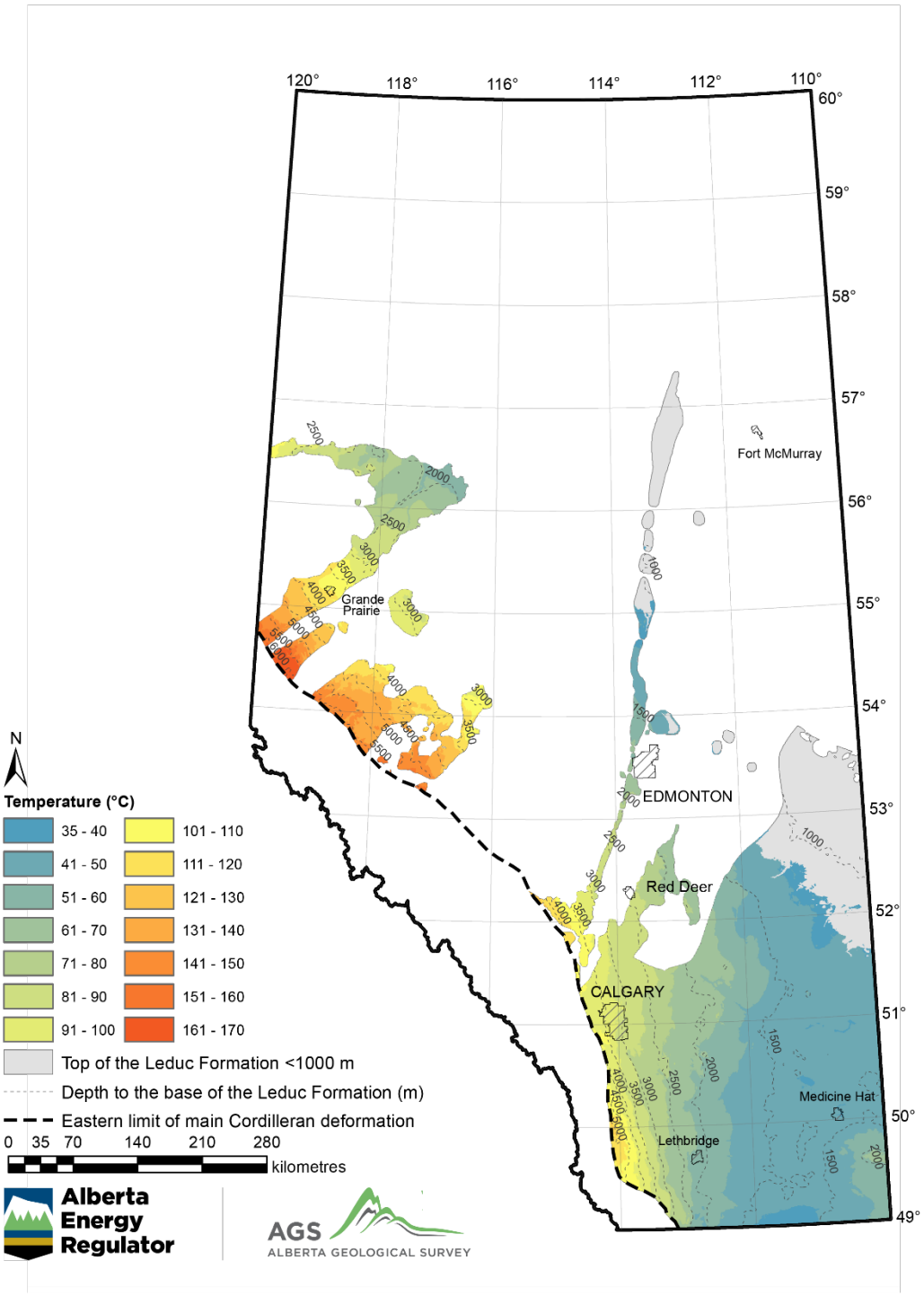

Figure 2. Temperature at the base of the Leduc Formation.

References

Alberta Geological Survey (2021): Geological Framework of Alberta, Version 3 (interactive app and map, methodology, model, dataset, story maps, web maps); Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Interactive Application, URL <https://gfa-v3-ags-aer.hub.arcgis.com> [December 2021].

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