# On the development of enhanced geothermal gradients in the southwestern Northwest Territories

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## Summary (All headings should be Arial 12pt bold, DELETE SECTIONS THAT ARE NOT USED)

The southwestern Northwest Territories (NWT) has elevated geothermal gradients of up to 50°C/km and has been studied for its economic potential (Figure 1) (Grasby et al., 2011). Although much is known about the hydrocarbon and mineral potential of the area, not much is known about why this area presents such unusual thermal patterns. The area includes the Liard Basin in the west and the Great Slave Plain in the east, both part of the Western Canada Sedimentary Basin (WCSB) (Figures 1 and 2). We aim to evaluate how the geologic history of the basin, in particular through burial, uplift and erosion, possibly led to the development of the geothermal anomaly. We use low-temperature thermochronology to constrain the thermal history of the region. Preliminary interpretations include: (1) Cretaceous, Triassic and Carboniferous strata from westernmost Liard Basin experienced higher maximum burial of 160–240°C (Figure 2), and (2) Cambrian strata from the easternmost Great Slave Plain experienced lower maximum burial of 160°C or less (Figure 2). To constrain the tectono-thermal history of the region, thermal history modeling will be performed together with a reassessment of the region's geothermal gradients.

## Theory / Method / Workflow

The process of rapidly moving hot rocks from greater depth towards the surface can develop geothermal anomalies by creating an isothermal imbalance. This process is complex and is usually not directly associated with the development of geothermal anomalies, such as those associated with young magmatism (e.g., Mount Meager) (Grasby et al., 2011). To study the upper crustal processes such as exhumation and burial of rocks, we use low-temperature thermochronology. Thermochronological methods are used because of their ability to constrain the time when rocks last experienced temperatures between 55-75°C (apatite (U-Th)/He method, AHe) and 160-240°C (zircon (U-Th/He methods, ZHe) (Farley et al., 2002; Reiners, 2004). To constrain the thermal history and exhumation patterns across the study region, we collected both basement and sedimentary rocks, from outcrops and boreholes (Figure 2). In the Liard Basin, we collected Devonian, Carboniferous, Triassic and Cretaceous strata from undeformed and deformed parts of the basin. In the Great Slave Plain we collected Cambrian strata and Precambrian basement rocks (Figure 2).

## Results, Observations, Conclusions

In the Liard Basin, Carboniferous strata show a pattern of westward decrease in ZHe dates. These western samples yield dates that are similar and/or younger than the time of deposition, indicating

burial to temperatures between 160–240°C. The eastern samples present dates that are similar and/or older than deposition, suggesting lower burial temperatures between 160–200°C. The Cretaceous strata present similar ZHe date trends, implying burial temperatures between 160–200°C. In the eastern undeformed part of the Liard Basin, ZHe dates from Cretaceous strata all pre-date deposition, limiting burial and heating to temperatures <160°C. The date trends observed suggest that samples located in the west and at deeper stratigraphic levels experienced greater burial, likely due to Cordilleran fold-and-thrust belt development and basin sedimentation.
In the Great Slave Plain, Cambrian strata yield ZHe dates that pre-date deposition, suggesting that the strata experienced temperatures between 80–160°C, possibly up to 200°C. This is consistent with previous work that limits maximum burial in the area to 2.8 km during the Devonian and 1.3 km during the Cretaceous (Ault et al., 2013). Basement samples yield younger cooling ages than the overlying strata. Thermal history modeling will be performed to evaluate the thermal history of the basin for different strata and across the basin. Ultimately, these results will show if rapid exhumation can explain the high geothermal gradients in southwestern NWT.

## Novel/Additive Information

Our study will provide the first thermal history models for the southwestern NWT, hence enabling the definition of a basin-wide model that will incorporate the burial and exhumation history patterns of the region. To better constrain the correlation of the histories with the geothermal patterns, we will reassess geothermal gradient data and combine them with stratigraphic information to derive updated maps and cross-sections of the study area. The new maps will have higher spatial resolution than previous maps, allowing for a detailed evaluation of the distribution of thermal patterns in the area. Geothermal gradient maps will be generated by combining bottom hole temperature (BHT) data and drill-stem test temperature (DST) data. Due to the relatively low reliability of BHT data, maps will be constructed taking into account such characteristics, by weighting more reliable data over less reliable data (Waples and Ramly, 1995).

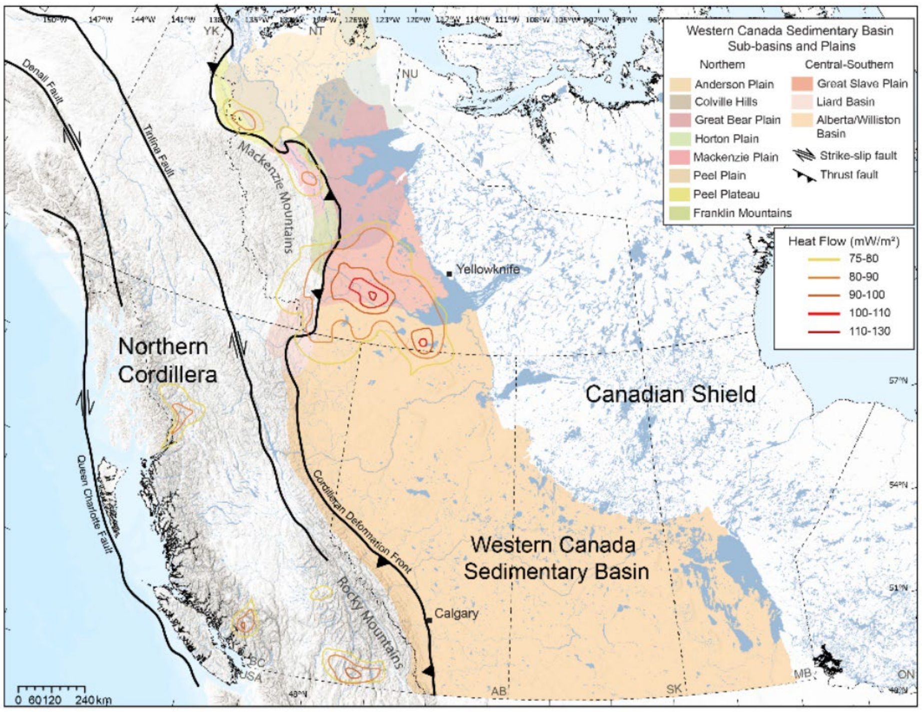


Figure 1. Sub-basins of the Western Canada Sedimentary Basin and schematic outline of heat flow patterns in western Canada (modified from Grasby et al., 2011).

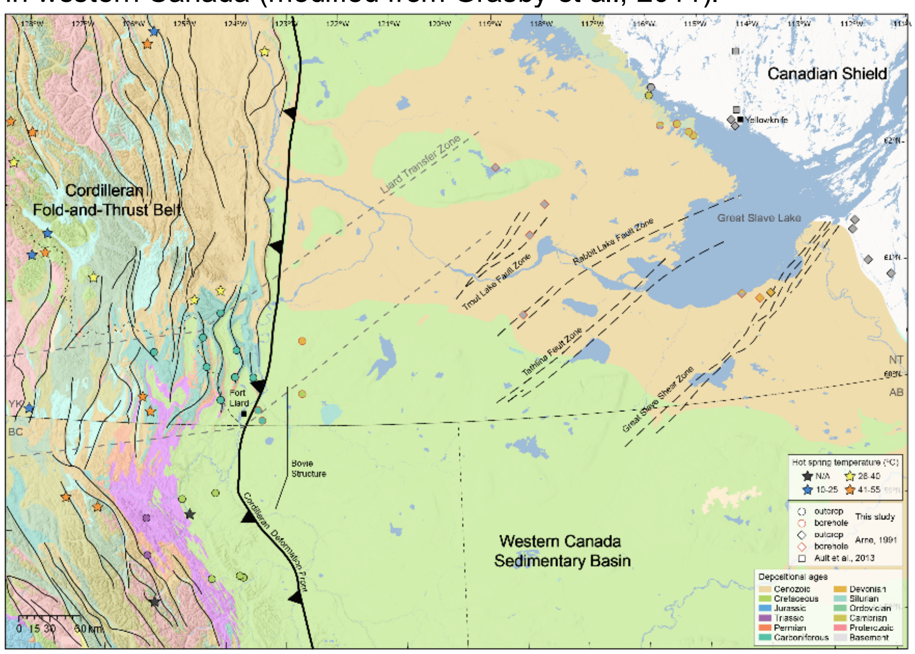


Figure 2. Geologic map of the study area. Sample locations of this study are represented as dots and are color-coded by depositional age. Sample location of other thermochronological studies are marked as diamond (Arne, 1991) and square (Ault et al., 2013). Main structures through the Paleozoic-Mesozoic strata are marked with solid lines, and basement structures with dashed lines.

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