TEMPERATURE-DEPTH PROFILES MEASURED IN THE INUIT COMMUNITY OF KUUJJUAQ, NORTHERN QUÉBEC, CANADA

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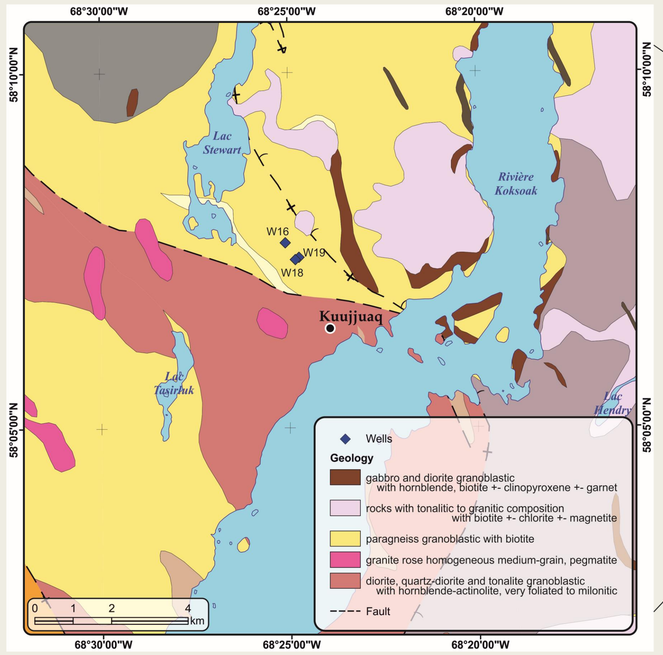
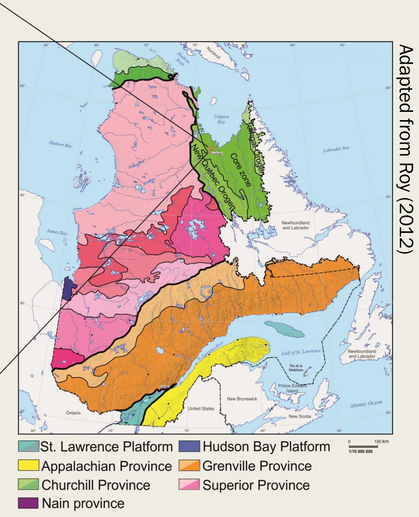
INTRODUCTION

- The area surrounding the Inuit community of Kuujjuaq is being studied to assess its geothermal energy potential to be exploited by shallow and deep geothermal systems.
- Temperature-depth profiles were measured in wells W19, W18 and W16, to estimate surface heat flow in the region and reconstruct the ground surface temperature history.

GEOLOGICAL SETTING

- The area under study is located in Core Zone of Southeastern Churchill Province. The wells were drilled in granoblastic paragneiss with biotite lithological unit.





Adapted from Roy (2012)

METHODS

- The measurements were carried out using a RBR duet probe with accuracy of ± 0.002 ºC and ± 0.25 m.
- The probe was placed in the wells 20 minutes before the beginning of the recording to ensure thermal equilibrium between the probe and the groundwater in the wells.
- The profiles were carried out in a continuous temperature logging pace of 1 m/10 sec.

Temperature corrections

- Daily and seasonal cycles (Beardsmore and Cull, 2011)

$$z = \frac{2\pi}{\varepsilon} = \sqrt{4\pi P \alpha}$$

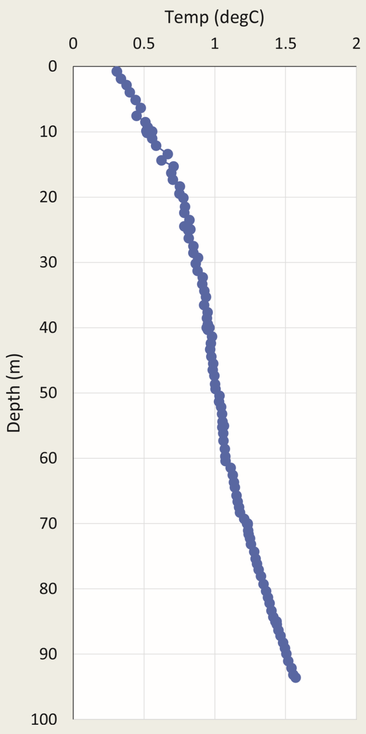
z = depth (m)
P = period of a perturbation (s)
α = thermal diffusivity (x10^{-6} m^2 s^{-1})

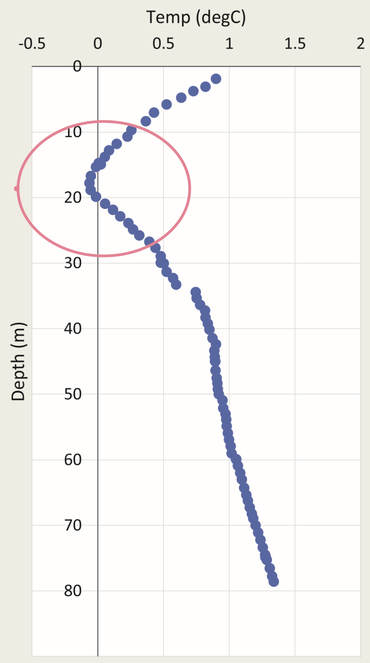
- Paleoclimatic correction (Jessop, 1990)

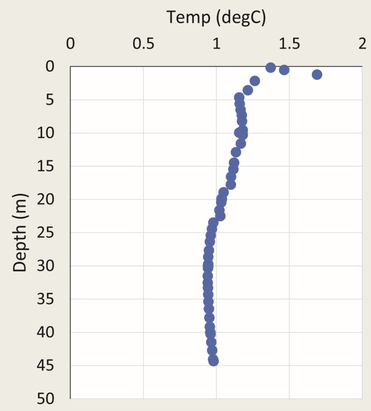
$$T = T_0 + gz + T_1\left[\operatorname{erf}\left(\frac{z}{2\sqrt{\kappa t_1}}\right) - \operatorname{erf}\left(\frac{z}{2\sqrt{\kappa t_2}}\right)\right]$$

T = temperature (ºC); T_0 = present-day average surface temperature (ºC);
T_1 = temperature step (ºC); z = depth (m); erf = error function;
α = thermal diffusivity (x10^{-6} m^2 s^{-1}); t_1 and t_2 = times of end and beginning of an ice-age

RESULTS



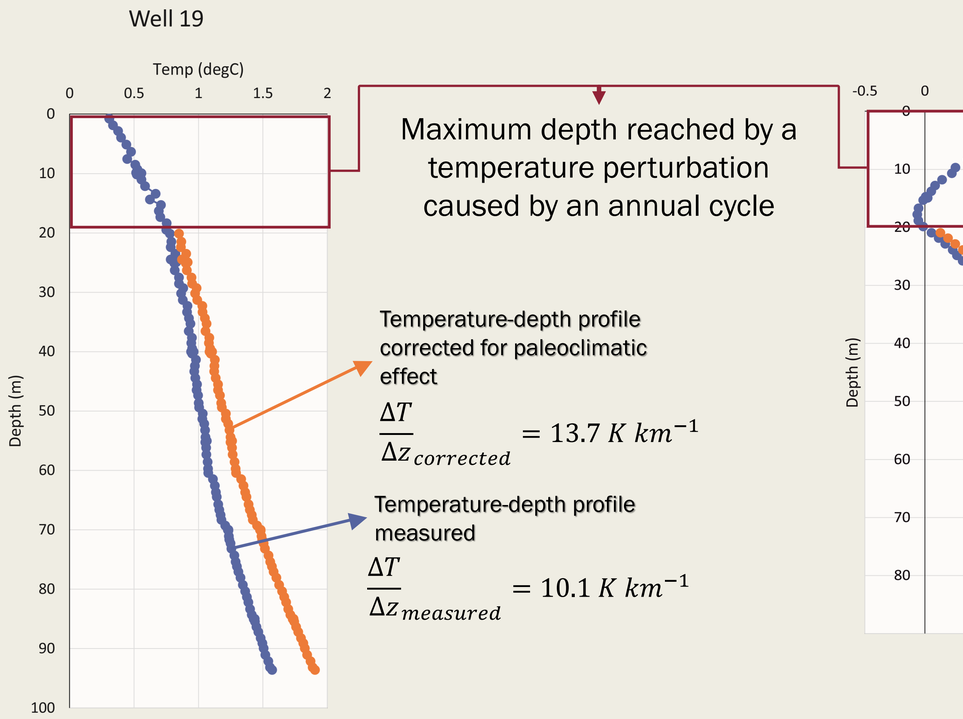


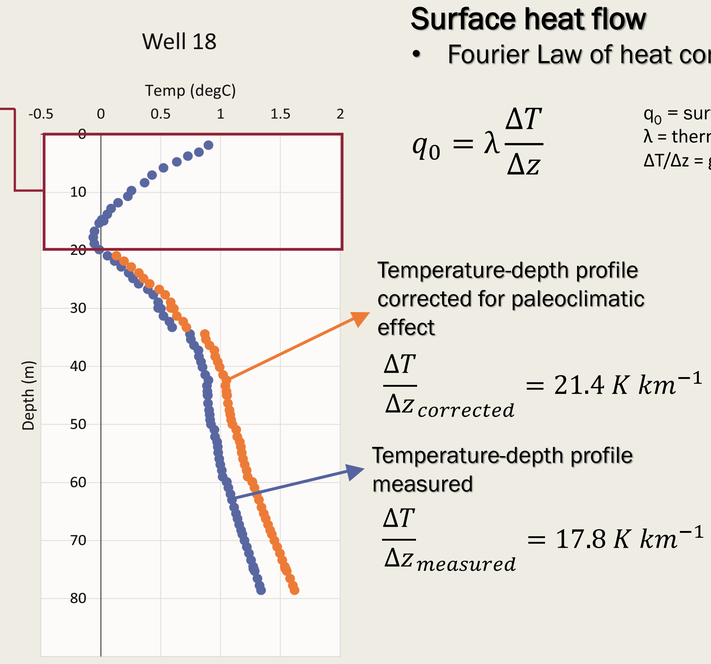


Well 19
Continuous temperature increase with depth

Well 18
Negative temperatures related with the effect of groundwater flow that prevent freezing

Well 16
Decrease of temperature with depth





Surface heat flow

- Fourier Law of heat conduction

$$q_0 = \lambda \frac{\Delta T}{\Delta z}$$

q_0 = surface heat flow (mW m^{-2})
λ = thermal conductivity (W m^{-1} K^{-1})
ΔT/Δz = geothermal gradient (°C/m)

$$\lambda_{//;\,0°C} = 3.47\ \mathrm{W\ m^{-1}\ K^{-1}}$$

- **Uncorrected surface heat flow**

$$q_{0;\,W19} = 35\ \mathrm{mW\ m^{-2}}$$

$$q_{0;\,W18} = 62\ \mathrm{mW\ m^{-2}}$$

- **Corrected surface heat flow**

$$q_{0;\,W19} = 48\ \mathrm{mW\ m^{-2}}$$

$$q_{0;\,W18} = 74\ \mathrm{mW\ m^{-2}}$$

Concluding remarks

- The wells seem to show signs of upward groundwater flow, this increase the uncertainty for heat flow estimations in the area;
- The average surface heat flow estimated for the region based on the two wells is of 68 mW m^{-2};
- The heat flow values were calculated based on thermal conductivity measured in the parallel direction of foliation;
- Due to low to moderate surface heat flow, the exploitation of deep geothermal resources is restricted to heating purposes.

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