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Interactive comment on "Laurentide Ice Sheet basal temperatures at the Last Glacial Cycle as inferred from borehole data" *by* C. Pickler et al.

J.A.M. Majorowicz

majorowicz@shaw.ca

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Pickler et al., (2015) report on thirteen temperature-depth profiles ($\geq$ 1500 m) measured in boreholes in eastern and central Canada inverted to determine the ground surface temperature histories during and after the last glacial cycle. The sites are located in the southern part of the region covered by the Laurentide Ice Sheet.

Temperature log of 2.35 km deep Hunt well near Fort McMurray in north-eastern Alberta (see Figure 1 for the location) is located at the shallow part of the platform with top of the basement at 0.5km (Jones et al., 1985). This deep high precision equilibrium log, is also in the region previously covered by the Laurentide Ice Sheet. The results of measured geothermal gradient and thermal conductivity with depth (z) show increase of heat flow (HF) with z (Majorowicz et al. 2012). These logs in this deepest

well in granites of the western part of the Precambrian craton show the importance of knowledge of heat production (HP) with depth (z) in explaining HF(z) variation with depth.

Here I show comparison of estimate of ground surface temperature with assumed constant HP(z), (see Fig. 2) by Majorowicz et al., (2012) vs. later ones (Majorowicz and Safanda, 2015) after precise HP(z) became known (see Fig.3). Gamma spectrometry log done in the granitic part of the well in 2013 was used to calculate HP(z) from determination of practical concentration units of weight ppm for uranium and thorium and weight percent for potassium and knowledge of granitic rock density (z), (Majorowicz et al., 2014).

The new reconstruction of surface temperature history based on newer data on HP (z) (Majorowicz et al. 2014) based on spectral gamma logs allowed Majorowicz and Safanda (2015) reconstruction of heat flow change with depth due to HP contribution with depth z. The new HP production model explains significant part of the observed HF (z).

The new (Majorowicz and Safanda, 2015) with HP(z) data, estimates of the ground surface paleo-temperatures obtained from the Hunt well temperature log by FSI (Functional Space Inversion) and by the upward extrapolation from the depth of 2250 m (Fig. 3) are quite consistent, but by 2 - 3 K higher than the previous preliminary estimates by Majorowicz et al. (2012a), when constant HG (z) assumed (Fig. 2). The new reconstruction indicates that the average surface temperature of the 100 kyr glacial cycles is around 0 °C, the average of their glacial part up to -2 °C and the minimum values reached during the last glacial maximum some 20 kyr ago could be as low as -3 °C. The temperature amplitude between the last glacial maximum and Holocene Optimum might amount to 10 – 12 K. These results for the Northern Alberta part of the Laurentide Ice Sheet generally agree with other evidence on paleo-temperatures at the base of this ice sheet inferred from borehole temperature data from wells to the east in Manitoba, Ontario and parts of western Quebec, Canada as reported by Pickler et al., (2015).

Conclusions

The above reported examples show that without a precise knowledge of HP(z) it is impossible to deduct cause of heat flow variations with depth, otherwise interpreted entirely as a result of surface climate change. Pickler et al., (2015) fail to show any evidence of HP (z) variability. In the wells they examine, also thermal conductivity measured on core samples are few. There is no sufficient data to determine HP (z) as no spectral logs reported. It adds to uncertainty in their interpretation of the paleo-climatic signal and of the amplitude between the last glacial maximum and Holocene Optimum and Present.

References

Jones, F., Lam, H., and Majorowicz, J.: Temperature distributions at the Paleozoic and Precambrian surfaces and their implications for geothermal energy recovery in Alberta: Canadian Journal of Earth Science, 1985, 22, 1774-1780.

Majorowicz, J., Chan, J., Crowell, J., Gosnold W., Heaman, LM„ Kück, J., Nieuwenhuis. G., Schmitt, D.R., Unsworth, M.J., Walsh, N., Weides, S.: The first deep heat flow determination in crystalline basement rocks beneath the Western Canadian Sedimentary Basin, Geophysical Journal International, 2014, online first, doi: 10.1093/gji/ggu065.

Majorowicz, J., Gosnold, W., Gray, A., Safanda, J., Klenner, R., and Unsworth, M.: Implications of post-glacial warming for northern Alberta heat flow-correcting for the underestimate of the geothermal potential, GRC Transactions, 36, 2012. GRC1030303.

Majorowicz, J., Šafanda, J.: Effect of postglacial warming seen in high precision temperature log deep into the granites in NE Alberta, Int. J.Earth Sci. 2014. 1–9.

Pickler, C., Beltrami, H., and Mareschal, J.-C.: Laurentide Ice Sheet basal temperatures at the Last Glacial Cycle as inferred from borehole data, Clim. Past Discuss., 11, 3937-3971, doi:10.5194/cpd-11-3937-2015, 2015.

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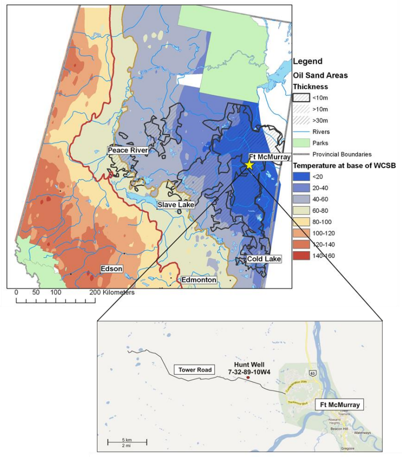

Figure 1. Well location.(WCSB stands for Western Canadian Sedimentary Basin).

Fig. 1.

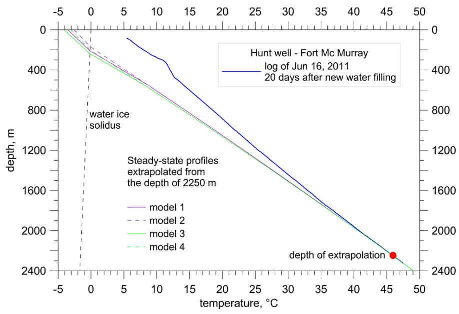

Figure 2. Precise equilibrium condition temperature depth temperature continuous logs in wells AOC GRANITE 7-32-89-10, hereafter referred to as the Hunt Wellin equilibrium condition (log 6 of June 2011). Models 1-4 are based on assumed constant HP(z). Extrapolations of the close-to-steady-state T-z profiles from the depth of 2250 m based on the heat flow below 2.2km is 51mW/m^2.

1. -5.6 °C for ($A_{granite}$ = 3 μW/m^3, $k_{sediment}$ = 2.4 W/(m.K))
2. -4.1 °C for ($A_{granite}$ = 3 μW/m^3, $k_{sediment}$ = 2.7 W/(m.K))
3. -6.6 °C for ($A_{granite}$ = 4 μW/m^3, $k_{sediment}$ = 2.4 W/(m.K))
4. -4.9 °C for ($A_{granite}$ = 4 μW/m^3, $k_{sediment}$ = 2.4 W/(m.K))

Fig. 2.

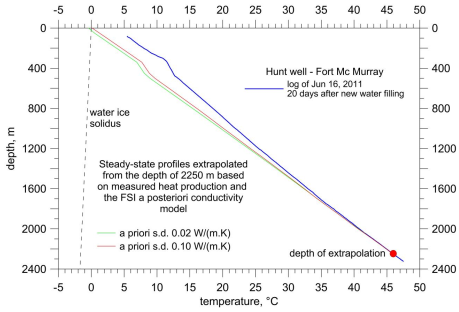

Figure 3. Extrapolations of the close-to-steady-state T-z profiles from the depth of 2250 m based on the new heat production HP (z) model based on spectral gamma log and the a posteriori FSI conductivity model for s.d. 0.02 W/(m K) and 0.5 W/(m K), respectively. Heat flow below 2.2km is 51mW/m^2.

Fig. 3.