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# Evaluation of the paleoclimatic effect in the exploration of subsurface temperatures: a case study from the Groß-Buchholz borehole (North German Basin)

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Temperature-depth models developed in geothermal exploration are usually constrained by values of observed surface heat flow and the thermal conductivity of rocks. In several areas, in particular in the northern hemisphere, regional geothermal studies have shown that the subsurface temperatures and temperature gradients may be overprinted by the long term paleoclimatic effect of glacial and interglacial periods. This effect generally yields, for depths < 1.500 - 2.000 m, a measured present day near-surface heat flow, which is lower than the undisturbed terrestrial heat flow from greater depths.
The North German Basin (NGB) was affected by several glacial periods, but a quantification of the paleoclimatic effect on the shallow subsurface temperature field through the observation of changes in heat flow along a borehole profile was still pending. This is mostly because of the lack of drill cores and consequently the lack of laboratory measurements of rock thermal parameters. Here we present such an evaluation for the Groß-Buchholz borehole (GT1) (total depth: 3.900 m) located in the Hannover area by using a high-precision temperature log and a calculated thermal-conductivity profile by applying the approach of Fuchs et al. (2015), which is based on the interpretation of standard petrophysical well logs.
Our observations show significant changes in mean heat-flow density along the borehole: a value of 63 mW/m$^2$ at depth between 100 and 500 m, 78 mW/m$^2$ at depth between 500 m and 1.100 m, and 84 mW/m$^2$ for depths > 1.100 m. The latter value is regarded as heat flow, which is not affected by paleoclimate and thus representing the background terrestrial heat flow. The reduction in heat flow due to the paleoclimatic effect corresponds to values of 21 mW/m$^2$ (100 – 500 m) and 7 mW/m$^2$ (500 – 1.100 m), respectively. In terms of temperature gradients, paleoclimate causes a reduction of approx. 11.9 °C/km and of 4.3 °C/km for the respective depths intervals. Below 1.100 m, disturbances in temperature gradients seem very small (on average -0.2 °C/km).
The observed reduction in heat flow towards shallower depth in the NGB is in good agreement with values determined in northern Poland (up to 20 mW/m$^2$; Torun-1 well, Majorowicz et al., 2008) and with values observed in the northern onshore part of the Danish Basin (20 – 30 mW/m$^2$; Balling, 2013, and references therein).
Our results clearly indicate that in the NGB, paleoclimatic perturbations have to be considered when heat-flow studies are performed at shallow depth, and the heat-flow values are applied as thermal boundary conditions on models that predict temperatures for greater depth. In general, the presented workflow allows a substantiation of the presented results at any borehole location in the basin where standard well log data and sufficient temperature information is available. This includes temperature logs as well as a series of corrected bottom-hole temperatures or temperatures from drill-stem tests.

References:

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