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Predicting the lithosphere-scale thermal field for the Beaufort-Mackenzie Basin (Arctic Canada)

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Anomalies in the present-day temperature distribution of the Beaufort-Mackenzie sedimentary basin correspond with specific tectonic domains and major fault zones, indicating that heat transport by fluid flow and advection might be an important process in the basin (Chen et al., 2008). On the other hand, the poly-phase history of the basin has produced a complex stratigraphic architecture and density distribution (Sippel et al., submitted), arguing for a wide range of thermal conductivities which would also complicate the thermal structure. We calculate the 3D conductive thermal field for lithosphere-scale models of the Beaufort-Mackenzie Basin, thus taking one step towards a quantification and localization of heat transporting processes in this petroliferous region.
Pre-requisites for our thermal calculations are the construction of a 3D-consistent structural model of the basin and the assignment of appropriate physical properties and boundary conditions. A crust-scale model was constructed based on an extensive compilation of available data (including seismic and well information) complemented by 3D isostatic and gravity modelling (Sippel et al., submitted). The Mesozoic-Cenozoic sedimentary part of the model comprises seven units (mainly sandy shales) which reflect successive tectono-stratigraphic phases and generally tend to be less compacted, and thus less thermally conductive, towards the north. 3D gravity modelling indicates that the continental crust below the sediments is split into a lower crystalline unit (2850 kg/m^3) and an upper crustal layer of lower average density (2720 kg/m^3) mostly representing Late Proterozoic-Palaeozoic (meta-) sedimentary rocks. Furthermore, gravity modelling confirms the presence of oceanic crust (2900 kg/m^3) in the northern, distal parts of the basin, underlain by an oceanic mantle (3250 kg/m^3) that is less dense than the continental mantle (3300 kg/m^3). The upper boundary condition for the thermal modelling is related to the basin's location within the Arctic permafrost of which the thickness, and hence the depth of 0°C-isotherm, is well known throughout most of the study area. The 1300°C-isotherm is set as the lower boundary condition which leaves different published depth distributions of the corresponding lithosphere-asthenosphere boundary to be tested. For the calibration of the modelling results, we can resort to temperature data from more than 250 wells and depths of up to 5000 m. We present different thermal models and comment on their specific (mis-)fits with the observed temperature distribution in the study area.

Chen, Z., Osadetz, K.G., Issler, D.R. and Grasby, S.E., 2008. Hydrocarbon migration detected by regional temperature field variations, Beaufort-Mackenzie Basin, Canada. AAPG Bulletin, 92(12): 1639-1653.
Sippel, J., Scheck-Wenderoth, M., Lewerenz, B. and Kroeger, K.F., submitted. A crust-scale 3D structural model of the Beaufort-Mackenzie Basin (Arctic Canada). Submitted to Tectonophysics.