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Surface heat flow and lithosphere thermal structure of the larger Luxembourg area as a basis for the evaluation of its geothermal potential

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The evaluation of the geothermal potential and the type of geothermal use necessitates knowledge of the subsurface temperature distribution in combination with hydraulic properties (e.g. porosity, permeability and hydraulic conductivity). In the larger Luxembourg area, only a few subsurface temperature data are available restricted to shallow depth. This paucity in data required to assess the thermal regime to drillable depths by modeling. The thermal model was constrained by surface heat flow and the lithosphere-asthenosphere boundary (LAB) characterized by the 1300°C isotherm. A surface heat-flow value of 75 $\pm$ 7 (2σ) mW m^{-2} was determined in central Luxembourg, which corroborates most values known from adjacent areas. The conceptual geological model for thermal modeling has a high resolution in the upper 15 km due to a wealth of geological data, while refraction seismic data and xenoliths provide petrological constraints for the lower part of the model down to the crust/mantle boundary. Thermal rock properties assigned to geological units are based on a large set of laboratory data, complemented by some literature data for the lower parts of the crust. The thermal structure is investigated by calculating 2-D steady-state thermal models along three crustal cross sections developed for the study area assuming a purely conductive lithosphere. The location of the LAB at 100 km depth, as typical for the Ardennes, provides the best fit with the measured surface heat flow of about 75 mW m^{-2}. This LAB model provides temperatures at 5 km of 115–118°C on average and of about 600°C at the Moho. The resulting mantle heat flow in this model is 39–40 mW m^{-2}. A reduced lithosphere thickness of 50 km as typical for the Eifel area to the east results in an increase of surface heat flow to 97 mW m^{-2} and of the mantle heat flow to 65 mW m^{-2}, respectively. If heating from the Eifel plume had reached the surface yet, temperatures at 5 km would be about 20°C higher (and about 300°C at the Moho) along the German-Luxembourgish border than in the 100-km-lithosphere model. The high Moho temperature in the Eifel also is documented in upper mantle xenoliths. Due to the uncertainties in surface heat flow from the Eifel region, which may be affected by advective components of heat transport by fluids, the timing of the lithosphere heating by the Eifel plume remains unresolved. However, considering the lapse time of heat transfer through the lithosphere and the start of the thermally induced uplift 10-20 Ma ago, it is not expected that the heat pulse has heated the entire crust and can be observed by surface heat-flow measurements.