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3D structure and conductive thermal field of the Upper Rhine Graben

Jessica Freymark (1,2), Judith Sippel (1), Magdalena Scheck-Wenderoth (1,2), Kristian Bär (3), Manfred Stiller (1), Johann-Gerhard Fritsche (4), and Matthias Kracht (4)

(1) Helmholtz-Centre Potsdam GFZ German Research Centre for Geosciences, Potsdam, Germany, (2) Faculty of Georesources and Material Engineering, RWTH Aachen, Aachen, Germany, (3) Institute of Applied Geosciences, TU Darmstadt, Darmstadt, Germany, (4) Hessian Agency for Nature Conservation, Environment and Geology (HLNUG), Wiesbaden, Germany

The Upper Rhine Graben (URG) was formed as part of the European Cenozoic Rift System in a complex extensional setting. At present-day, it has a large socioeconomic relevance as it provides a great potential for geothermal energy production in Germany and France. For the utilisation of this energy resource it is crucial to understand the structure and the observed temperature anomalies in the rift basin. In the framework of the EU-funded "IMAGE" project (Integrated Methods for Advanced Geothermal Exploration), we apply a data-driven numerical modelling approach to quantify the processes and properties controlling the spatial distribution of subsurface temperatures.

Typically, reservoir-scale numerical models are developed for predictions on the subsurface hydrothermal conditions and for reducing the risk of drilling non-productive geothermal wells. One major problem related to such models is setting appropriate boundary conditions that define, for instance, how much heat enters the reservoir from greater depths. Therefore, we first build a regional lithospheric-scale 3D structural model, which covers not only the entire URG but also adjacent geological features like the Black Forest and the Vosges Mountains. In particular, we use a multidisciplinary dataset (e.g. well data, seismic reflection data, existing structural models, gravity) to construct the geometries of the sediments, the crust and the lithospheric mantle that control the spatial distribution of thermal conductivity and radiogenic heat production and hence temperatures.
By applying a data-based and lithology-dependent parameterisation of this lithospheric-scale 3D structural model and a 3D finite element method, we calculate the steady-state conductive thermal field for the entire region. Available measured temperatures (down to depths of up to 5 km) are considered to validate the 3D thermal model.

We present major characteristics of the lithospheric-scale 3D structural model and results of the 3D conductive thermal modelling of the URG and adjacent areas. We show that the Variscan crystalline crustal domains with their different radiogenic heat production influence the regional thermal field, while a thermal blanketing effect due to thick thermally low-conductive sediments causes higher temperatures in the central and northern URG. In contrast, local salt domes result in colder temperatures in parts of the southern URG.