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The effects of regional fluid flow on the deep thermal field - a case study from the Federal State of Hesse (Germany)

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Geothermal energy utilization for electric power generation was planned in the Federal State of Hesse at two sites. The first one in the northern part of the Upper Rhine Graben (south Hesse) has been drilled in 2016 but flow rates and temperatures were well below expectations. The reasons for local reduction of porosity and permeability in the reservoir compared to what is known from outcrop analogue studies and other sites in the middle Upper Rhine Graben, are still a matter of discussion and illustrate the need for a possibility to predict such processes and thereby minimize the drilling risks.
The aim of this study is to understand the influence of regional hydrothermal processes on the local geothermal configuration of reservoirs. We address the question if and how the regional fluid and heat flow influences the local reservoir behavior and if we can improve predictions. Therefore, a 3D structural model of Hesse is used as a base for coupled 3D hydrothermal simulations of the deep fluid and heat transport. The model is 6 km deep and the processes are simulated with the commercial software FEFLOW©. As the model boundary is following the Hessian border and crossing the Upper Rhine Graben, lateral boundary conditions for fluid flow were extracted from an uncoupled fluid flow model covering the whole Upper Rhine Graben.
First results show higher temperatures in southern Hesse (northern part of the Upper Rhine Graben) and lower temperature in northern Hesse (Hessian Depression). Moreover, the simulations show that the regional flow is divided into two regions. In the southern part of Hesse Rotliegend sediments of the Saar-Nahe basin and up to three kilometers thick Cenozoic deposits of the Upper Rhine Graben build a thick aquifer. In the northern region, the Buntsandstein of the Hessian Depression forms an up to 1.4 km thick aquifer. In the southern region, thermal water is uprising forming local geothermal anomalies and resulting high temperatures provide favorable conditions in target horizons in depths below 1.5 km for geothermal utilization. In contrast, in the Hessian Depression groundwater recharge causes reduced temperatures in the target horizons which are too low for geothermal power generation.
In further work local more detailed models covering only the southern part of Hesse, will help to predict locations or settings favoring upwelling of deep hot water, which are the target for geothermal exploitation. The regional model of Hesse which is presented here will provide the necessary boundary conditions.