Influence of fluid flow and heat transport on predictions of geothermal potentials in sedimentary layers of Hesse (Germany)

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For the sustainable utilization of deep geothermal resources it is essential to predict the exploitable potential thermal energy from the subsurface. One main parameter influencing the geothermal potential is the reservoir temperature that may vary locally or regionally in response to fluid flow and heat transport processes.

This study aims at combining highly complex 3D thermo-hydraulic numerical simulations of heat transport and fluid flow with predictions of the geothermal potential for the application case of a hydrothermal doublet. Quantifying the influences of conductive, advective and convective heat transport mechanisms on the thermal field and moreover on the predicted heating power requires fundamental numerical investigations. We use the Federal State of Hesse in Germany as study area where heat transport processes have been quantified in recently published studies. There, the heterogeneous geology consists of outcropping Variscan Crust and up to 3.8 km and 1.8 km thick sedimentary deposits of the Upper Rhine Graben and the Hessian Depression, respectively. This geological complexity is expressed by areas of different hydraulic and thermal configurations: in the flat, but tectonically active Upper Rhine Graben high heat flow from below the graben sediments is in contrast to the variable topography of the Hessian Depression with low heat input from the Rhenohercynian Basement.

The heating power in the three reservoir units (I) Cenozoic, (II) Buntsandstein and (III) Rotliegend is only predicted to be high in the Upper Rhine Graben. There the reservoir temperature is high enough and varies between 50 °C in the convective thermal model of the Cenozoic reservoir and 170 °C in the conductive thermal model of the Buntsandstein reservoir. Predicted low temperatures in the Hessian Depression lead to negligible low heating power, but as production mass flux is above ~6 kg s⁻¹ investigations should continue to assess the geothermal potential for other applications like seasonal energy storage or low enthalpy geothermal utilization.