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3D Modelling of the Northern Upper Rhine Graben Crystalline Basement by Joint Inversion of Gravity and Magnetic Data

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The crystalline basement of the Upper Rhine Graben presents an attractive target for deep geothermal projects due to its favourable temperatures and its high potential as a fractured and faulted reservoir system. It is already exploited at several sites, e.g. Soultz-sous-Forêts or Landau, and further projects are currently planned or under development. The crystalline units are furthermore the main source of radiogenic heat production and thus, together with the shallow Moho depth and convective heat transport along large fault zones, significantly contributing to the crustal temperature field. For these reasons, we developed the most detailed 3D geological model of the basement in the northern Upper Rhine Graben to date within the Interreg NWE DGE-ROLLOUT and Hesse 3D 2.0 projects. Due to the small number of very deep boreholes as well as seismic profiles reaching the basement beneath the locally more than 5 km thick sedimentary cover, we additionally used high-resolution magnetic and gravity datasets. In contrast to common deterministic modelling approaches, we performed a stochastic joint inversion of the geophysical data by applying a Monte Carlo Markov Chain algorithm. This method generates a large set of random but valid models, which enables a statistical evaluation of the results, e.g. concerning the model uncertainties. For a realistic attribution of the model, we used existing petrophysical databases of the region and measured the magnetic susceptibility of more than 430 rock samples. As a result of the inversion, high-resolution voxel models of the density and susceptibility distribution were generated, allowing conclusions about the composition and structure of the crystalline crust, which leads to a reduction of uncertainties and risks associated with deep geothermal drillings in the northern Upper Rhine Graben. Furthermore, our model will serve as a basis for realistic simulations of heat transport processes in the fractured basement and a meaningful assessment of the deep geothermal potential in the future.