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The deep geothermal potential of Berlin (Germany) – Predictions from 3D structural and thermal modelling

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In the light of an aspired reduction of CO_2 emissions for Germany's capital Berlin, one possible alternative for meeting the city's growing energy demands lies in deep geothermal energy. To minimise exploration risks, a profound knowledge about the subsurface temperature distribution is indispensable. We present a 3D structural model that is used for thermal modelling and thus correlates calculated subsurface temperatures with geothermally relevant structures in the deep subsurface of Berlin – an ideal base for improving the probability of finding adequate geothermal reservoirs.

Berlin is located in the eastern part of the North German Basin which is filled with several thousand metres of Permian to Cenozoic sediments containing hot and water bearing aquifers to potentially be used as hydrothermal reservoirs. To characterise the geological underground, the 3D structural model integrates stratigraphical, petrophysical and well-log based information from local boreholes as well as stratigraphic trends from (seismic data based) regional 3D models. The model differentiates 21 geological units: 17 Permian-Cenozoic sedimentary layers, pre-Permian sediments, upper crust, lower crust and the lithospheric mantle. Based on this 3D geological model complemented by databased lithology-dependent thermal properties, two groups of numerical thermal simulations have been carried out: calculations of the steady-state conductive thermal field and simulations of coupled fluid and heat transport.

The 3D thermal models predict large lateral variations in temperatures that are validated by high-precession temperature logs. These variations are mostly caused by three specific geological layers and their physical properties: the Permian Zechstein salt with its markedly high thermal conductivity and strong thickness variation (171-3442 m); the crystalline upper crustal layer with its high radiogenic heat production and decreasing thickness from east to west; and the Tertiary Rupelian aquitard that locally hampers the downward flow of colder groundwater and thus induces the greatest differences in temperatures between the purely conductive and the coupled fluid and heat transport models. The 3D models deliver temperature maps for constant depth levels (down to 6 km) and for the varying depths of geothermally relevant reservoirs (e.g., 15-95°C at the top of the Triassic Middle Buntsandstein and 85-139°C at the top of the Permian Sedimentary Rotliegend). Furthermore, the models include predictions on which geological units are cut by economically interesting isotherms.