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Shallow and deep controls on the thermal structure of basins - predictions from data-based large-scale 3D models

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The long term availability and the large extent of geothermal heat make it an attractive source for a sustainable supply of energy. However, exploitation of geothermal energy requires a quantitative resource assessment that must integrate the main physical transport mechanisms involved. To understand the thermal regime on a basin-scale, we perform 3D numerical simulations of conductive heat transport processes for the Central European Basin System (CEBS). The CEBS covers the northern part of Central and Western Europe. The long-lasting evolution of this basin system has resulted in deposition of more than 12 km thick sediments including a layer of Upper Permian (Zechstein) salt. In response to salt movements, the present-day structure of the CEBS is strongly complicated by salt structures which were triggered by several tectonic events. Our results provide new insights on the major controlling factors of the thermal field and indicate that lithosphere-scale factors are superposed with effects resulting from the spatial interaction of thermal rock properties of the sedimentary layers in the basin. A detailed model describing the geometry of the main stratigraphic layers and their lithology-dependent thermal rock properties is used to simulate the present-day regional conductive geothermal structure of the basin in 3D. We assess the sensitivity with respect to contrasting thermal rock properties in the sediment fill and with respect to the influence of different configurations of the crystalline crust and lithospheric mantle. We find that 3D conductive models predict observed temperatures amazingly well. Small wavelength variations (up to a few kilometers) in the shallow thermal field are mainly influenced by the thickness and geometry of the salt layer present in the succession. Salt diapirs and walls are characterized by both positive thermal anomalies and increased heat flow at the surface. In addition, the chimney effect of the highly conductive salt is counteracted by the insulating effects of sediments with lower thermal conductivities within salt-rim synclines. In contrast, the long wavelength character (> 50 km) of the surface heat flow and the temperature distribution at depth is controlled by the configuration of the crystalline crust and upper mantle beneath the basin system.