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Shallow and deep control on the thermal structure of basins as inferred by 3 D numerical models – an example from the North East German Basin

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Numerical simulations are carried out to characterize the regional thermal structure of the North East German Basin (NEGB) and its interaction with the basin-scale active fluid system. The aim of the study is to provide deeper insights on the relevant processes influencing the hydrothermal setting of the basin in a way that will help to constrain the potential geothermal resources and reserves of the NEGB. The present study principally focuses on estimating the undisturbed regional thermal field by means of three dimensional lithospheric thermal models. It provides understanding of the thermal signature of the diffusive processes as driven by the interaction of the spatial distribution of thermal rock properties and corresponding layers' geometry and thickness as well as proper information to be used in more complex numerical studies of the coupled fluid and heat flow to attempt a hydrothermal interpretation of the basin. A detailed model describing the distribution with depth and geometry of the main stratigraphic layers is used to properly constrain the lithologically dependent thermal rock properties. Based on this geological model the three dimensional present-day regional conductive geothermal structure of the basin is simulated. The resolution of the model about 4 km enables a detailed representation of the different salt structures affecting the basin thus providing possible explanations to the observed 'anomalous' shallow temperature and subsurface heat flow distribution as locally modified by deep rooted salt diapirs and/or pillows. Attention is also toward a quantification of the influence of different crustal and shallow mantle configurations on the lithospheric-scale thermal structure as well as their surface manifestations. The model results suggest a close correlation between the thermal and heat flow distribution and the complex interaction of thermal rock properties and layers' thicknesses. Small wavelengths (up to a few kilometers) variations in the shallow thermal and heat flow fields are mainly influenced by the respective thickness and geometry of the salt layer, the burial depth of the top of the salt as well as the heat budget of the salt overburden. In contrast, the long wavelength character of the near surface heat flow and temperature distribution is hardly affected. The surface thermal manifestation of the deeper structures may or may not overprint these shallow and short wavelength anomalies, depending on the adopted crustal and lithospheric mantle configurations. Different crustal and shallow mantle scenarios may lead to different lithospheric thermal configurations with important implications in the rheological behavior of the lithosphere thus influencing deformation styles and fluid regimes with depth.