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Geothermal 3-D modeling Hamburg and surrounding areas: Temperature prediction and reservoir simulation

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We present results from steady-state and transient 3-D thermal modeling of parts of city of Hamburg and surrounding areas. The aim of this project is to provide planning criteria for deep geothermal installations.

A 3-D geological model provides the basis for this modeling study, representing all important geological units down to the Rotliegend, particularly the salt structures. The corresponding regional numerical model extends over an area of 35 km x 28 km down to a depth of 6 km. For a reliable temperature prediction it is necessary to define precisely the thermal properties, in particular thermal conductivity. For this purpose we compiled existing borehole data, and in combination with other data from the North German basin we were able to assign representative values of thermal properties to each geological unit. An undisturbed temperature log of the deep "Allermöhe" borehole (3.2 km) as well as other temperature logs in the area could be used for model calibration. These data agree well with the steady-state simulations, using the derived thermal properties. Thus, this regional model allows to reliably predict temperatures for any target area or reservoir within the model domain. The model results also show the significant influence of the salt structures due to their comparable high thermal conductivity: at reservoir depths horizontal temperature variations of more than 35 K are possible.

In a next step two locations were chosen for an exemplary reservoir modeling, simulating a geothermal doublet. Using smaller scaled models whose boundary conditions were adapted from the regional models, the transient coupled heat and flow simulations illustrate the geothermal potential of possible reservoirs. Model variations were performed, regarding different hydrological properties, as well as different technical parameters such as the distance between production and injection, pump rate, and injection temperatures. Because of the sparse permeability data, variations within the reservoir could only be considered by average values. Nevertheless, the transient simulations show that the target horizon represents an appropriate reservoir, keeping up necessary production temperatures in the long run.