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Geothermal Project Den Haag – 3-D models for temperature prediction and reservoir characterization

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In the framework of the "Den Haag Zuidwest" geothermal district heating system a deep geothermal installation is projected. The target horizon of the planned doublet is the "Delft sandstone" which has been extensively explored for oil- and gas reservoirs in the last century. In the target area, this upper Jurassic sandstone layer is found at a depth of about 2300 m with an average thickness of about 50 m. The study presented here focuses on the prediction of reservoir temperatures and production behavior which is crucial for planning a deep geothermal installation.

In the first phase, the main objective was to find out whether there is a significant influence of the 3-dimensional structures of anticlines and synclines on the temperature field, which could cause formation temperatures deviating from the predicted extrapolated temperature data from oil and gas exploration wells. To this end a regional model was set up as a basis for steady state numerical simulations. Since representative input parameters are decisive for reliable model results, all available information was compiled: a) the subsurface geometry, depth and thickness of the stratigraphic layers known from seismic data sets 2) borehole geophysical data and c) geological and petrographical information from exploration wells. In addition 50 cuttings samples were taken from two selected key wells in order to provide direct information on thermal properties of the underlying strata. Thermal conductivity and rock matrix density were measured in the laboratory. These data were combined with a petrophysical log analysis (Gamma Ray, Sonic, Density and Resistivity), which resulted in continuous profiles of porosity, effective thermal conductivity and radiogenetic heat production. These profiles allowed to asses in detail the variability of the petrophysical properties with depth and to check for lateral changes between the wells.

All this data entered the numerical simulations which were performed by a 3-D coupled heat and flow forward computer code. The model was tested and calibrated against some available bottom hole temperature data. In spite of the few number of this data, several model runs yielded a good estimation for the basal heat flow of 63 ± 1 mW m^{-2}. Profiles and cross sections extracted from the calculated temperature field allow a detailed study of the temperature in the surrounding of the planned location. Test runs with different thermal conductivities for each layer showed the importance of a proper determination of this thermal parameter for a reliable temperature prediction.

In the second phase of the project, a detailed 3-D numerical reservoir model was set up. The temperature model from the first phase provided the boundary conditions for the reservoir model. Hydraulic parameters for the target horizons such as porosity and permeability were taken from data available from the nearby exploration wells. The aim is the prediction of the temperature evolution with, both at the producer and injector location. The main interest lies in the issue if production temperatures can be maintained throughout the years, and how far the cooling area around the injector extents.

Several runs were performed, varying the hydraulic properties in a reasonable range. The geometry was modified as well, according to different locations of the producer. The model was designed in order to ensure its long term usage in the project. To accomplish this, the model will be constructed to allow iterative updates, assimilating new information gained during the drilling, testing and production phase.