

The Den Haag Geothermal District Heating Project – 3-D Models for Temperature Prediction.

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In the frame 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“, an upper Jurassic sandstone layer, which has been extensively explored for oil- and gas reservoirs in the last century. In the target area, this layer is found at a depth of about 2200 m with an average thickness of about 50 m. Information on temperature and production rates is crucial for planning a deep geothermal installation. In the first planning stage temperature predictions were made by extrapolating temperature data from the neighbouring oil and gas exploration wells. A critical point of this method is, that the existing wells are only located at NNW-SSE striking anticline structures, while the doublet is planned to be drilled into a syncline in order to achieve higher production temperatures at greater depth.

Since no direct information on temperature is available, a 3-D underground model was constructed. 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 data. To achieve this target, a larger area had to be investigated, which resulted in model dimensions of about 22.5 x 24.3 km size and a depth of 5 km.

The most critical feature in numerical models is to provide representative model input parameters. Therefore, all available information were collected: 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 assess in detail the variability of the petrophysical properties with depth and to check for lateral changes between the wells. Using these profiles, statistical values were calculated for the stratigraphic layers and were incorporated as input parameter in the 3-D model.

The model is based on finite differences. The numerical grid consists of 2,430,000 nodes, horizontally equally spaced by 150 m and vertically by 50 m. Simulations were performed in the forward mode under steady state heat transport conditions. This was carried out by a 3-D coupled heat and flow forward computer code using the numerical simulation tool SHEMAT (Clauser 2003). The model was tested and calibrated against some available bottom hole temperature data. In

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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. Adding or subtracting the standard deviation from the mean measured values result in temperature differences up to 10 K at reservoir depth. Thus, the large number of laboratory measurements along with log and seismic data is a requirement for a reliable temperature prediction.

Literature

CLAUSER, C., ED. (2003), "Numerical Simulations of Reactive Flow in Hot Aquifers: SHEMAT and Processing SHEMAT", Springer, Berlin-Heidelberg.