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Sensitivity Analysis of Impacts of Natural Internal Fault Zones and Well Design on Fluid Flow and Heat Transfer in a Deep Geothermal Reservoir

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In order to show the impacts of natural internal fault zones and well design on geothermal energy production, two main deep geothermal reservoir sites in Germany, Groß Schönebeck (GrSk) and Berlin Tempelhof which are part of the North German Basin (NGB) are investigated. Groß Schönebeck is located at about 40km away from the Berlin centre whereas Berlin Tempelhof is situated in the south-central Berlin.

Hydrothermal power plant shows complex coupling between four major components, the deep geothermal reservoir, the boreholes, the heat exchangers of the primary thermal water cycle and the power plant unit. In order to study the lifetime behavior of the overall Enhanced Geothermal System (EGS), it is mandatory to develop a combined transient model representing all relevant components as whole and their inter-relations. In this regards, the framework of Groß Schönebeck (GrSk) project is posed as the first scenario. The hydrothermal power plant is subdivided logically into components modeled separately and subsequently a standalone 3D transient hydro-thermal FEM (finite element method) reservoir model which consists of reservoir, fractures, wells and fault zones is weighted in the first place and its hydro-thermal processes are simulated for a period of 35 years.

Using COMSOL Multiphysics, two significant objectives are achieved. Deviated geometries such as the production well and dipping geometries such as natural internal fault zones are successfully implemented into the 3D transient reservoir model which is constructed with the integration of hydraulically induced fractures and reservoir rock layers which are conducive to geothermal power production. Using OpenGeoSys (OGS), sensitivity analysis of varied conductivity of natural internal fault zones due to different permeability and apertures, on current fluid flow and heat transfer pattern is carried out. Study shows that natural internal fault zones play a significant role in the generation of production temperature. Production temperature is increased with the increment in both permeability and aperture of internal fault zones. In other words, highly permeable faults increase production temperature. Wide opening of faults are as well conducive to increase production temperature, particularly with reference to a non-faulted system.

The framework of Energy Atlas project in Berlin Tempelhof is posed as the second scenario at which a structurally simpler 3D transient hydro-thermal FEM reservoir model is developed. Preliminary sensitivity analysis is carried out in order to estimate the productivity and thermal power through a virtual well doublet, which allows thermal supply scenarios at city scale. The 3D reservoir model is subsequently linked via an interface to a subsurface and surface heat exchanger model thus advancing simultaneous cross-scale modeling of deep geothermal reservoir and power plant unit.