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Cold reinjection in the Soultz-sous-Forêts reservoir during geothermal exploitation based on 3D hydrothermal modelling

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As a part of the European project called MEET, the geothermal powerplant of Soultz-sous-Forêts (Bas-Rhin, France) is investigating the possibility of producing more energy with the same infrastructure. This research project aims to study the potential increase of electricity production by reinjecting the geothermal fluid at lower temperature. Indeed, during the operation of the powerplant, the geothermal fluid is currently reinjected at 70°C, and the MEET project aims to test its reinjection at 40°C. This temperature drop could generate several impacts on the reservoir such as induced seismicity, scaling, and cooling. Thus, a 3D hydrothermal study was achieved in order to evaluate the spreading of the thermal front during colder reinjection and its impact on production temperature.

In a first step, to achieve this goal, a 3D structural model of the Soultz geology was created in software PETREL integrating different geometric models that have been done in previous studies from 2D vintage seismic profiles and calibrated with well data. Our project contains 5 major lithostratigraphic horizons from tops of Jurassic to Paleozoic granite layers. In parallel, fractures and faults datasets were compiled by Sausse et al. (2010). They have been collected thanks to geological studies, well logs, vertical seismic profiles and induced micro-seismicity clouds and gathered into a 3D model. About 50 fractures in the granite have been considered during this structural compilation.

In a second step, this first geometrical model was simplified in order to be able to run hydrothermal simulation. Previous studies demonstrated that the convection within the fracture system seems to affect the Paleozoic granite but also the Triassic sediments. Due to well completion, only Buntsandstein and granite tops were considered for circulation simulation. Each of 50 faults initially present in the model were assessed in term of permeability from various indicator such as: flow anomalies, temperature anomalies, mud losses and tracer tests results. The fracture extension was also considered as an input parameter according to the degree of hydrothermal alteration around the fracture network in the well or to the VSP and micro-seismicity data. Finally, the most elaborated 3D hydrothermal model contains five main fractures which were subject to thermal cooling.

In a third step, once the structural model is defined, the hydrothermal tests can be performed with the software FEFLOW: a finite-element simulation software able to model groundwater flow, mass and heat transfer in porous and fracture media, in 2D, tabular or fully unstructured 3D mesh. A3D hydrothermal model has been built based on the structural model. It has been calibrated with power plant operation data and interpretations of hydraulic tests, tracer tests, logging and core sample measurement. This model allowed estimating the impact over time of power plant operation with a colder reinjection in the fractured reservoir of Soultz-sous-Forêts. A sensibility study on main reservoir hydraulic and temperature parameters have been realized to better understand their influence.

Finally, the 3D model will be presented as well as the preliminary results of the hydrothermal simulation related to a colder reinjection in the deep fractured granite reservoir.

Reference:

Sausse J., Dezayes C., Dorbath L., Genter A., Place J., 2010. 3D model of fracture zones at Soultz-sous-Forêts based on geological data, image logs, induced microseismicity and vertical seismic profiles. C. R. Geoscience 342, 531-545, https://doi.org/10.1016/j.crte.2010.01.011.

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