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Hydraulic modeling and the evaluation of the representative elementary volume (REV) of a fractured geothermal vulcanite reservoir in the Northern German Basin

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In times of climate change and a fast-growing world population, there is an increasing interest in the use of regenerative energy sources, like deep geothermal energy in potential hot dry rock formations. One of the main difficulties in the use of geothermal energy is the unpredictable hydraulic conductivity in the geothermal reservoir. Due to their tectonic history, fracture systems often show a significant permeability anisotropy controlled by the geometry of the discrete fracture network.

The objective of this study is the evaluation of the 2D permeability tensor and the representative elementary volume (REV) of a fractured geothermal vulcanite reservoir in the Northern German Basin using the discrete fracture network (DFN) model approach. The estimation of flow behavior in the geothermal reservoir and the definition of a REV can be used for the hydraulic modeling of large-scaled fracture systems.
To model these systems, in-situ analyses from a deep geothermal reservoir (drilling cores) and field measurements of outcrop reservoir analogues were conducted to reproduce a representative fracture network.
The first two discrete fracture networks were generated using statistically-derived fracture input data from in-situ analyses and field measurements, in order to estimate the permeability of the fracture systems. The flow in the discrete fracture networks, described by the cubic law, is simulated using the software Frac2D.
Both data sets show a preferred flow in the direction of the major joint set (NW-SE). The discrete fracture network of the drilling core data reveals a higher joint density, thus an increased flow rate can be estimated. However, both discrete fracture networks are characterized by a well hydraulic connection.
The base for large-scaled hydraulic modeling is described by a representative elementary volume with a size of 10 m x 10 m. This was determined for both discrete fracture networks showing different fracture densities. This forms the basis for large-scaled hydraulic modeling.

The next step is to model the reactivation of fractures within the discrete fracture networks under conditions of the regional in-situ stress field. Reactivation will be simulated by injecting a fluid of a certain density and with a defined pressure. This allows the estimate of reactivation on the mechanical behavior of the fracture, hence the hydraulic parameters.