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Investigating the influence of aperture variability on fracture surface area in enhanced geothermal reservoirs

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To estimate the performance and sustainability of enhanced geothermal systems (EGS), an accurate characterization of the fractures created by hydraulic stimulation is crucial. It is common practice to perform tracer tests to obtain relevant reservoir parameters such as reservoir impedance, potential production flow rate as well as fracture surface area [Shook, 2017]. The fracture surface area is one of the most relevant parameters for heat transfer between the rock and the working fluid. However, it is also one of the most uncertain parameters in the characterization of fractured reservoirs.
Generally, fractures of all scales are characterized by two opposite rock surfaces with variable surface roughness. Consequences of varying surface roughness are a heterogeneous local aperture distribution and the formation of channels and barriers within the fracture planes. This significantly affects flow and transport and the resulting fracture surface area. In summary a heterogeneous local aperture distribution is highly relevant for heat extraction.
In a typical rock fracture, the local aperture is statistically represented by a spatially autocorrelated random field, which is characterized by the variogram model and a correlation length [Tsang, 1989].

In this study, we investigate the influence of correlation length with respect to aperture distribution on fracture surface area and its implication for the results of tracer tests. To this end, numerical simulations of a single circular fracture embedded in a low permeability host rock are performed. Various heterogeneous aperture fields with different correlation lengths are considered. Using a mixed-dimensional discretization to represent the fracture numerically allows us to model heterogeneous fractures by applying the corresponding material parameters. In the fracture plane, flow and tracer transport occurs between an injection and a production well.
The numerically calculated fracture surface area is compared to the results of analytical methods where the fracture surface area is calculated based on the injected and produced tracer rates [Shook, 2017]. Furthermore, our simulations enable the investigation of the influence of different correlation lengths on the results of tracer tests. We show how the aperture variability impacts the results of tracer tests and the fractured surface area. Our results contribute to improvement of reservoir characterization and performance assessment of EGS.

References

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