Impact of effective normal stress on two-phase ow through a single fracture with rough surfaces

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ABSTRACT

Supercritical CO_2 has been proposed to serve instead of water as the underground heat transmission fluid for Enhanced Geothermal Systems (EGS) projects, due to its superior thermophysical properties. The economical feasibility of fractured deep geothermal reservoirs, which are highly abundant, is tightly coupled to factors that determine the reservoir productivity and injectivity, such as the rock transmissivity and flow rates in fractures. Even though fracture apertures and corresponding transport properties are associated to the effective normal stress acting on the fracture, techniques under zero-stress conditions, such as laser scanning or photogrammetry, are commonly used to determine fracture aperture fields. In this study, fracture geometries of naturally-fractured granite cores from the Grimsel Test Site (GTS) in Switzerland are used to numerically model CO_2 injection into these fractures under different effective normal stress conditions. Photogrammetric scanning is used to map the fracture surfaces of 2.5 × 3.0 cm, which are later matched to obtain the fracture aperture fields at the zero stress condition. The aperture distributions under different effective normal stresses (0.25 to 10 MPa) are then obtained by means of a Fast Fourier Transform (FFT)-based convolution numerical method. Finally, we perform two-phase flow simulations of brine displacement with CO2 injection within the aforementioned aperture fields, using an in-house application based on the MOOSE framework. Analyses on the resulting CO_2 saturation patterns enable investigation of the relationships coupling effective normal stress, multiphase flow channeling and fracture transmissivity. The obtained results will assist the evaluation of applications such as enhanced geothermal systems using CO_2 and geological CO_2 sequestration in fractured reservoirs.

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