Coupled processes in rock fractures from micro to macro

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Keywords: Fracture closure; Fracture sealing; Phase-field model; Computed tomography; Contact mechanics

ABSTRACT

Fractures are an important feature in numerous reservoirs acting as flow paths or barriers and significantly determine reservoir productivity or safety performance of potential host rocks of nuclear waste disposals. Reservoir models are often based on discrete fracture network (DFN) models, whose performance rely on true input parameters representing actual fracture properties. Our study summarizes three advanced methods that are able to reproduce mechanical and chemical fracture closure geometries providing representative fracture apertures and permeabilities. A novel contact mechanical approach is shown and validated for a granodiorite fracture in order to simulate normal fracture closure and local apertures [1]. Furthermore, medical X-ray computed tomography (CT) scans and a calibration approach based on the missing attenuation (MA) method are used to simulate stress-dependent permeability changes in a fracture [2]. Lastly, a phase-field model (PFM) for hydrothermally induced quartz growth is introduced to simulate the sealing of fractures [3]. We found out that the proposed methods are able to estimate hydraulic properties of rock fractures under mechanical and chemically alternating conditions. The results of the contact model using the elastic-plastic module is able to reproduce experimentally derived normal closure and local apertures providing a comprehensive basis for subsequent fluid flow simulations. Flow simulations based on CT-scans showed that the calibration approach is able visualize stress-dependent flow phenomena and to approximate actual experimental fluid flow data. The PFM-based models demonstrated that hydraulic properties in sealing fractures significantly depend on the evolving crystal shapes. Consequently, a new equation to estimate hydraulic apertures is introduced, which uses a geometry factor α for different crystal geometries (α = 2.5 for needle quartz and α = 1.0 for compact quartz). All three proposed methods are significantly contribute to a better understanding of coupled processes in fractures and are therefore able to improve future DFN-based reservoir simulations.

REFERENCES

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