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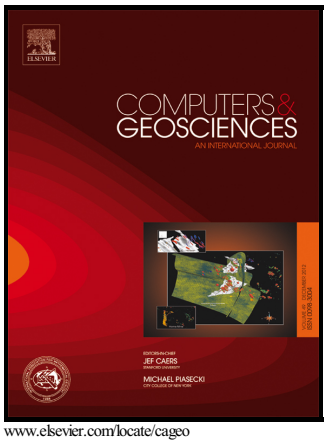

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Fracture-based modeling of complex flow and CO_2 migration in three-dimensional fractured rocks

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ABSTRACT

The fractures and pores in rock formations are the fundamental units for flow and contaminant-transport simulations. Modeling and meshing a fractured rock system are challenging tasks because mesh generations of fractured networks typically involve complex procedures in conducting topological transformations, and the modeling of such a complex mesh system is computationally expensive. The objective of this study was to develop a three-dimensional (3D) discrete fracture network (DFN) model and an associated unstructured mesh generation (UMG) model to simulate flow and transport for fractured rock systems. This study employed coupled multicomponent, multiphase fluids in a 3D porous and fractured media simulator (the TOUGH2/ECO2N model) to analyze flow and CO_2 migration in fracture formations. The developed DFN and UMG models were first tested using a single and horizontal fracture plate to evaluate the results based on various mesh types. The models were then implemented in multiple DFN realizations to assess the behavior of equivalent permeability of a rock block influenced by various fracture intensities. By exploiting the well-developed TOUGH2/ECO2N model, the developed DFN and UMG models were applied to problems of flow and CO_2 migration in fracture formations. The simulation results showed that the developed models can capture behaviors of the flow and transport in fractured formations. Different types of mesh led to slight variations in pressure distribution near injection wells. However, such pressure variations can be reduced with refined mesh around the injection wells. The results based on 52 DFN realizations indicated that the value of equivalent permeability for the simulated rock block shows three to four orders of magnitudes lower than the value of the specified fracture permeability. The injection of supercritical CO_2 exhibited a rapid migration of gaseous and aqueous phase CO_2 along connected fractures.

Keywords: fractured rock, discrete fracture network, unstructured mesh generation, fracture intensity, CO_2 injection

1. Introduction

Flow and transport simulations in fractured formations play a crucial role in assessing water resources, high-level nuclear waste storage, oil and gas enhanced production, nonconventional