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Impacts of fractures on hydrodynamic trapping for CO2 storage in deep saline aquifers

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ABSTRACT

Natural or induced fractures are typically present in subsurface geological formations, which have received an increasing interest for geo-energy production and storage as well as for long-term carbon dioxide storage. Generally speaking, fracture networks have high-contrast properties compared to the neighbouring matrix. For instance, they may serve as highly conductive pathways which could potentially lead to the leakage of CO2. This undermines the storage capacity. On the other hand, they may act as flow barriers, causing significant pressure and stress gradients. Nevertheless, despite their high sensitivities, impacts of fractures on the full-cycle storage process have not been fully understood. In this study, a numerical model is used to examine the role of fractures on the flow and transport of CO2 plume in various conditions. A unified multiphysics framework is developed to model the hydrodynamic trapping mechanisms in a robust manner. In particular, the projection-based embedded discrete fracture model is incorporated into the compositional framework to describe fractures with varying conductivities. We first apply this numerical model to an illustrative domain with a single fracture of different configurations, and then simulate such process in a complex fracture network which is representative of a field-scale fractured system. Findings from the test cases for single fracture geometries are also observed in the larger-domain with complex geometries. Results indicate that the fracture exhibits differing effects regarding the dissolution/residual trapping, and therefore, accurate characterization of fracture geometry and its conductivity is essential for evaluation of CO2 storage in fractured formations.