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Supercritical CO_2/brine transport in a fractured rock under geologic sequestration conditions

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Carbon capture and storage (CCS) is a promising technology for mitigating CO_2 emissions into the atmosphere. In general, densely fractured natural reservoirs are rarely considered as suitable candidates due to issues related to safe and secure long-term storage. Nevertheless, assessment of CO_2 storage processes in a storage medium with fractures is critical, as fractures occur in nearly all geological settings and play a major role in hydrocarbon migration as well as entrapment. We evaluated the impact of fractures on CO_2/brine transport under geologic sequestration conditions by conducting both experimental and numerical studies. Laboratory experimental results showed a piston-like brine displacement with gravity over-run effects in the homogeneous core regardless of CO_2 injection rates. In the fractured core, however, two distinctive types of brine displacements were observed; one showing brine displacement only in the fracture whereas the other shows brine displacement both in the fracture and matrix with different rates, depending on the magnitude of the pressure build-up in the matrix. In the experiments, the injectivity in the fractured core was twice greater than that in the homogeneous core at our experimental condition, while the estimated storage capacity was greater in the homogeneous core than in the fractured core by over 1.5 times. Capillary pressure curves were illustrated for both cores including entry pressures and irreducible brine saturation. The free-phase CO_2 transfer in a fracture-matrix system was addressed by numerical simulation, and provided transient flux exchange processes during the brine displacement by CO_2. The pressure gradient between the fracture and matrix induced CO_2 transfer from fracture into matrix at the front of CO_2 plume in fracture. In contrast, at the rear zone of CO_2 plume, the reversal of pressure gradient resulted in a reverse CO_2 flux. Additionally, the influence of fracture aperture on CO_2 transfer between fracture and matrix was assessed with numerical simulation. The pressure built-up behind the small aperture enhanced the CO_2 transfer from the fracture into matrix. The combined results of experimental and numerical study provided insights on the transient multi-phase flow behavior in fracture-matrix system.