Computational Modeling of CO2 Migration and Trapping in Geologic Formations for Risk Assessment of Carbon Sequestration Impacting Carbon Footprint

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Over the last 150 years, the average global temperature on Earth has rapidly increased. This detrimental impact has created–among others–widespread famine, the melting of ice caps, larger, more frequent storms, drought, and poverty. Geologic carbon sequestration (GCS) involves the process of artificially injecting CO2 into underground geologic formations such as saline aquifers, enabling us to continue using fossil fuels as a source of energy while mitigating their environmental impacts, as it is unlikely that we will be able to transition to renewable energy sources overnight. This experiment leveraged computational fluid dynamics and high-performance computing to explore the mechanics of CO2 transport and trapping in rough-walled fractures focusing on the effect of fracture geometric factors such as aperture, roughness, and wettability–aimed towards GCS leakage risk assessment to mitigate potential leakage into urban infrastructure for large-scale implementation. When the fracture aperture was tight, CO2 bypassed the water in the high capillary pressure zone. While for a wide water-wet fracture, CO2 tends to centrally migrate to the fracture opening and thin film of residually trapped water occurs on the surface of the fracture. Less water-wet conditions led to a larger degree of CO2 capillary trapping on the surface of the fracture. An unstable and fingering type of CO2 displacement by increasing the injection rate in a rough fracture indicates that the fracture roughness is a key factor in controlling the CO2 displacement regime in potentially fractured reservoirs. The results of this study provide novel insight of CO2 behavior in rough-walled fractures.

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