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The influence of Capillary Trapping on Dynamic CO2 Storage Capacity and Long Term Storage Integrity

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Containment of injected CO_2 is of prime importance for long term integrity of CO_2 geological storage projects. Structural/stratigraphic, dissolution, residual, capillary and mineral trapping mechanisms play significant roles on different time scales to keep the injected CO_2 within the storage zone boundaries. In heterogeneous media the impact of capillary trapping mechanism becomes significant. Overlooking the capillary trapping contribution may result in underestimating the dynamic storage capacity, and overestimating the leakage risk. In this study the significance of capillary trapping mechanism for a heterogeneous storage zone is highlighted. Publically available well log and petrophysical data is used to construct a representative model of a 1,000 ft thick storage zone in Louisiana, USA. This zone has significant locally interbedded sand and shale intervals that are not continuous over the entire areal extent of the zone. Reservoir simulation is used to model different injection scenarios and resultant movement of CO_2 plume. The CO_2 is injected for a period of 50 years and then monitored for additional 50 years for its plume movement. In order to capture the contribution of capillary trapping, the capillary pressure for each grid block is scaled by its porosity and permeability values. Therefore each grid block have its own capillary pressure curve, in comparison to a case in which a single capillary pressure curve is used for the entire storage zone. Sensitivity analysis shows that the upward movement of buoyant CO_2 plume is substantially impeded by the capillary forces when separate capillary pressure curve is used for each grid block that honors the permeability and porosity of respective block. This results in significant local capillary trapping. This phenomenon has significant implications for dynamic storage capacity and long term stability of CO_2 plume. For the studied case, it is observed that capillary trapping mechanism results in enhancing the dynamic storage capacity by a factor of nearly 1.5. It is also observed that the capillary trapping also effects the lateral movement of CO_2 plume and CO_2 is contained in the storage zone more effectively. The results strongly suggests that for heterogeneous storage zones, ignoring the capillary trapping mechanism can result in significant errors in determining dynamic storage capacity and long term storage integrity.

References

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