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Assessment of Capillary Entrapment and Geological Leakage in CO_2-Aquifer Storages

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The success of underground CO_2 sequestration projects relies on the ability of keeping CO_2 immobilized. The risk of CO_2 leakage into the atmosphere through faults, cap rock formations or wellbore must be evaluated for the long term safety of storage. In case of CO_2 sequestration in a saline aquifer capillary trapping of CO_2 is one of the essential mechanisms controlling the upward and lateral migration of CO_2 plumes after the injection phase. Therefore, assessment of CO_2 immobilization requires accurate modelling of multi phase flow performance.

A generic reservoir model was created to examine the impact of the relative permeabilities and capillary forces on capillary trapping. This study reveals how the mechanism of capillary trapping is affected by varying the CO_2 injection rate, hysteresis between drainage and imbibition processes and residual phase saturations. To identify the effects of certain geological features, shale layers in the target formation, sand channels in the cap rock and a fault were considered. The presence of shales has a significant effect on decreasing the CO_2 leakage risk. It is because CO_2 tends to migrate laterally and become trapped under the shale layers. The impact of the transmissibility and the location of the fault on pressure profile within the aquifer and the migration path of gas were examined. The distribution of CO_2 is strongly affected by the location of the well with respect to the fault.

The leakage risk of injected CO_2 in vertical and horizontal wells was also compared to identify the effective injection geometry. Vertical injection across entire target formation interval leads to extensive contact with cap rock and leakage through it. Horizontal wells located in the lower part of the formation both increase the aquifer utilization and eliminate contact with cap rock. Thus horizontal wells can be an alternative to

inject more CO_2 and minimize leakage.