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Characterizing CO2 Residual Trapping through Experiments

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CO2 storage in deep geologic formations is a necessary method to address the climate change problem. To ensure long-term security of the injected CO2, a better understanding of the post-injection CO2 residual trapping phenomena is needed. Using multiphase coreflooding experimental methods, we seek to characterize and predict the amount of CO2 residual trapping after injection.

Spatial heterogeneity is ubiquitous and exists from the pore scale to field scale. While large-scale heterogeneities have been much studied, small-scale heterogeneities received much less attention. However, it has recently been shown that millimeter-scale or small-scale heterogeneities have significant effects on large-scale CO2 injection (drainage) processes [1]. While some previous research has explored how small-scale heterogeneities affect the CO2 post-injection (imbibition) and trapping processes [2], [3], many uncertainties still remain about residual trapping. Historically, the dominant mechanism for residual trapping has been identified as snap-off trapping at the pore scale. However, recent studies have shown that capillary heterogeneity trapping at the millimeter scale can also be significant [4]. The relative importance of these two residual trapping mechanisms has not yet been established.

By conducting coreflooding experiments on sandstone samples with different degrees and nature of heterogeneity, we can investigate voxel-level trapping relationships, and gain insights into how small-scale heterogeneities affect CO2 residual trapping after capillary-dominated imbibition. The following conclusions can be drawn from the experimental results. Small-scale heterogeneities have less significant effects on imbibition than on drainage, as the CO2 saturation field is more uniform after imbibition. Although the effect of small-scale heterogeneities on imbibition may be less than for drainage, it is still significant. Within a core, voxel-level residual trapping correlates well with permeability and not porosity, demonstrating the influence of small-scale permeability change on the capillary-dominated imbibition process. Across different cores, core-averaged CO2 residual trapping efficiency is well correlated positively with the core-averaged degree of small-scale heterogeneity. By extrapolating that relationship, we can then quantify the contribution to residual trapping from the snap-off and the capillary heterogeneity trapping mechanism separately.

References

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