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The impact of small-scale heterogeneities on residual trapping: case study from the Otway CO2 storage site

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The injection of CO_2 into subsurface reservoirs provides a long-term solution for anthropogenic emissions. However, rapid plume migration, not predicted in typical reservoir simulations have been observed at CO_2 storage projects such as the Sleipner project. Recent work has shown that small-scale heterogeneities, not currently included in reservoir models, can manifest as rapid field-scale plume migration [1]. These small-scale heterogeneities will also influence trapping, so it is important to understand their impact on CO_2 storage projects.

In this work, we explore the impact of small-scale heterogeneities on the distribution and trapping of CO_2 in core-scale samples (5cm diameter) from the Otway storage site in Australia. We perform steady-state CO_2 injection into samples from the site, and image the CO_2 distribution using a medical CT scanner. We measure the relative permeability and trapping efficiency for the samples.

A wide range of heterogeneities were observed, shown in Figure 1. We observed fine layers (Figure 1a), thicker layers (Figure 1b) and more complex patterns of heterogeneity (Figure 1c) over a narrow interval of 5m. As can be observed in Figure 1, these different heterogeneities lead to a wide range of CO_2 distributions, as well as the subsequent trapping. The scale over which these heterogeneities impact the flow and trapping of CO_2 is much smaller than the grid sizes than in typical reservoir models. We explore how the small-scale heterogeneities control the flow of CO2 in the subsurface, and how they cannot be ignored at the field scale. These results form the Special Core Analysis (SCAL), whose inputs are being used to model the injection of 10,000 tons of CO_2 in the Otway basin.

[1] Jackson, S.J. and Krevor, S., 2020. Small-scale capillary heterogeneity linked to rapid plume migration during CO2 storage. Geophysical Research Letters, 47(18), p.e2020GL088616.

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References

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