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Pore-scale Simulation of Residual Trapping of Supercritical CO2 via Cyclic Injections

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A recent experimental study [Herring et al., 2016] shows the potential of enhancing residual trapping of supercritical CO2 (scCO2) via cyclic injections. Two competing mechanisms were identified that impact residual scCO2 trapping: (1) the wettability of solid surfaces is altered due to direct contact with scCO2; (2) different capillary pressure results in different initial states of scCO2 fluid connectivity and topology prior to imbibition. To trap more scCO2 after imbibition, the former mechanism requires higher extent of scCO2 drainage while the latter requires lower extent of scCO2 drainage. Due to experimental limitations, control of local alteration of wettability in real rock is not possible; extensive and strict parametric study of cyclic injections are very expensive and difficult to achieve. Direct numerical simulation can largely overcome the above issues and reveal the relative importance of the two mechanisms. In this work, we employ our in-house developed lattice Boltzmann code to perform pore-scale simulations on micro-CT scans of Bentheimer sandstone to study the scCO2 trapping mechanisms in cyclic injections. Following the experimental procedure, we apply different capillary pressure to achieve different scCO2 configurations after drainage. Wettability is altered in the simulations on solid surfaces that are directly exposed to scCO2. The computation cost of parametric study is very high due to the multiple cycle injections and different combinations of parameters, thus manycore supercomputers are employed to perform the simulations.

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References

Herring, A.L., L. Andersson, and D. Wildenschild, Enhancing residual trapping of supercritical CO2 via cyclic injections. Geophysical Research Letters, 2016. 43(18): p. 9677-9685.

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