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Numerical analysis of the Coupling effect between dissolution at the interface and fingering evolution.

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The injected super-critical CO2 (scCO2) has a lower density and viscosity than the reservoir fluid. When the scCO2 is in contact with the formation fluid, dissolution will occur at the interface between the two phases, which will have a fingered structure due to viscosity contrasts, thus resulting in a relatively large interface area between the two phases, see [1]. For a given deviation from Henry's law equilibrium between the phases, the transfer velocity of the dissolved CO2 into the brine liquid is determined by the rate of exchange of the gas across the interface.
On the other hand, the evolution of the fingering patterns is defined by the interface kinematic and dynamic matching conditions, which describe mass and momentum conservation cross the interface. The transfer velocity of the dissolved gas reduces the interface displacement velocity described by the kinematic matching condition, in this way delaying the evolution of the fingering. On the other hand, the momentum flux across the interface, due to the dissolution, modifies the dynamic matching condition at the interface, changing the fingering patterns, for more details about general interface matching conditions see [2]. This coupling effect of enhancing dissolution by the resulting large surface area of the fingering interface and the changes in fingering dynamics and pattern formation due to the effect of the dissolution transfer velocity across the interface has not been previously considered in the literature. In this work, present a numerical study of this type of coupling effect between dissolution at the interface and fingering evolution.
Most of the numerical simulations of geological CO2 sequestration are based on index of saturation between the phases (Multiphase models). This type of approach considers that one of the phases is continuous, with the other existing as a suspended component. The concept of saturation implies mixture, which is not a physical process occurring at the interface between the immiscible fluids. In this type of formulation, robust implementation of interface processes is not possible, and some form of semi-empirical approach must instead be adopted, for more details see [3].
To have a clear understanding of the effect of the dissolution on the fingering evolution of the injected scCO2, we study the CO2 plume evolution in terms of sharp interface formulation. This type of approach can directly take into the interface dynamic and processes, as is the case of the corresponding CO2 dissolution across the interface.

References

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