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Viscous Fingering in Miscible Displacements in Porous Media with Dead-End Pores

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The finger-like instabilities, referred to viscous fingering (VF), are commonly observed when a less viscous fluid displaces a more viscous fluid in a Hele-Shaw cell (two parallel plates with a small gap) and porous media. It is well recognized that the VF can reduce the sweep efficiency of displacement processes. But in the SWEPT area by injected fluids, the existing numerical modeling shows that nearly no displaced fluid is left. This is valid for the fluid flow displacements in porous media with all well-connected pores. However, real porous media, such as subsurface rocks, especially the carbonate rocks, have non-negligible proportion of dead-end pores, the stagnant volume in which fluid is nearly immobile and cannot be directly displaced. The only mechanism for mass transfer from dead-end pores to well-connected pores is diffusion or dissolution. The consequence is that such trapped fluids cannot be cleaned up by injected fluids. Accordingly, the swept area behind the VF still has a certain amount of displaced fluids, depending on the mass transfer rate and proportion of dead-end pores.

To investigate the VF dynamics in porous media with dead-end pores, we assume the miscible displacements take place in a two-dimensional horizontal porous medium with a uniform distribution of dead-end pores. We conducted numerical simulations to model the displacement processes. We found that the VF dynamics is strongly affected by the dead-end pores. Specifically, the proportion of dead-end pores and dissolution rate from fluids from dead-end pores to well-connected pores play an important role. The larger proportion of dead-end pores leads to earlier breakthrough of the injected fluids but more residual displaced fluids. However, the influences of dissolution rate on VF are non-monotonic. There is a range of dissolution rate that lead to the least unstable VF in miscible displacements. The dissolution fingering in the dead-end pore network is reported for the first time.

This research has wide applications in a series of displacement process involving porous media such as soil and water contaminate remediation, CO2 sequestration, enhanced oil recovery, geothermal recovery, drug delivery, and chromatographic separation.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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