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Characterization of wettability control on dynamics of two phase flow in natural porous media

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Leveraging high-fidelity lattice Boltzmann simulations (1,2) combined with analytical modeling, we investigate the interplay of surface wettability, small-scale heterogeneity of the pore geometry, and mobility conditions influencing the characteristics of immiscible two-phase fluid displacement in natural porous media (3). We present a detailed pore-scale analysis of flow regimes occurring during favorable ($M > 1$) and unfavorable ($M < 1$) displacement conditions in a rock sample of Tuscaloosa sandstone under a wide range of wettability ($25^\circ < \theta < 175^\circ$). As manifested by the saturation profile of invading fluid, we distinguished a transition of invasion morphology from fingering to compact (stable) displacement as the wetting condition varies from drainage to strong imbibition under both favorable and unfavorable mobility conditions. It becomes evident that the appearance of corner-flow plays a key role in the emergence of the transition zone in the displacement patterns. Furthermore, the corner-flow active zone is found to be mainly concentrated ahead of the primary invasion front and it is heterogeneously distributed in the pore space, preferentially hosted by small pores. It is found that the heterogeneous distribution of corner-flow events does not necessarily impose an adverse effect on the recovery of the defending fluid, as the maximum recovery efficiency is observed under the strong imbibition condition, where the corner flow is prevalent. In addition to numerical simulations, we derived an analytical model that can forecast the saturation profile of fluids as a function of wettability under different boundary conditions. The analytical model showed a reasonable agreement with the numerical results and can be a useful diagnostic tool for optimizing the displacement process in porous media (4).

Key words: Porous media, Heterogeneity, Two-phase flow, Wettability, Lattice Boltzmann modeling

References

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- [2] S. Bakhshian, S. A. Hosseini, N. Shokri, Pore-scale characteristics of multiphase flow in heterogeneous porous media using the lattice Boltzmann method, *Scientific Reports*, 9 2045–2322 (2019).
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- [4] S. Bakhshian, S. A. Hosseini, Pore-scale analysis of supercritical CO₂-brine immiscible displacement under fractional-wettability conditions, *Advances in Water Resources* 126 96–107 (2019).

Time Block Preference

Time Block C (18:00-21:00 CET)

References

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