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Characteristics of fluid-fluid displacement in model mixed-wet porous media

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Fluid-fluid displacement in porous media occurs in many natural and engineering processes such as geological CO2 storage and enhanced oil recovery. It has been recognized that wettability plays an important role in the displacement process. Thanks to decades of research, we now have a good understanding of fluid-fluid displacement in porous media with uniform wettability. In contrast, our knowledge of fluid-fluid displacement in porous media with heterogeneous wettability (i.e., mixed-wet) is much less complete, even though mixed-wet conditions are common in many subsurface processes.

Here, we study fluid-fluid displacement in simple mixed-wet micromodels. The micromodels are made of an oil-wet polymer whose wettability can be locally tuned to become water-wet via deep UV exposure. Our experiments show the mixed-wet pores exert fundamental control over the macroscopic displacement pattern and that the incorporation of the capillary entry pressures at mixed-wet pores into a dynamic pore-network model reproduces the experiments. Using the pore-network model, we systematically vary the fraction of water-wet to oil-wet regions and obtain a variety of displacement patterns over a wide range of Ca. We find that the impact of mixed-wettability is most prominent at low Ca, and it depends on the complex interplay between wettability fraction and the intrinsic contact angle of the water-wet regions. Mixed-wettability is also manifested in the injection pressure signature, which exhibits fluctuations at low wettability fractions. Finally, we demonstrate that scaling analyses based on a weighted average description of the overall wetting state of the mixed-wet system can effectively capture the variations in observed displacement pattern morphology.

Participation

In-Person

References

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