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X-ray microtomography imaging of two-phase fluid flow in water-wet and mixed-wet Bentheimer sandstone

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X-ray microtomography (micro-CT) provides a nondestructive way for estimating rock properties such as relative permeability. Relative permeability is computed on the fluid distributions generated on three dimensional images of the pore structure of a rock. However, it is difficult to numerically reproduce actual fluid distributions at the pore scale, particularly for a mixed-wet rock. Recent advances in imaging technologies have made it possible to directly resolve a large field of view for arbitrary wetting conditions.
Herein, the objective of this study is to evaluate relative permeability computations on imaged fluid distributions under water-wet and mixed-wet conditions. By simultaneously injecting oil and brine on a Bentheimer sandstone before and after wettability alteration, imaged fluid distributions are obtained under steady state conditions. Then we determine in situ phase saturations and capillary pressures from interfacial curvature measurements along an entire core, thus achieving the assessment of the capillary pressure gradient and its influence on multiphase flow. We demonstrate how the pore-scale capillary pressure gradient affects multiphase flow and, in turn, the core-scale relative permeability measurements. Analysis of imaged fluid distributions and connectivity demonstrates that under mixed-wet conditions , increased dynamic connectivity and ganglion dynamics result in non-equilibrium effects at the fluid-fluid interface. These effects result in more energy dissipation during fractional flow in mixed-wet systems and thus lower effective permeability than water-wet rock at the same saturation.

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