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The Effect of Porous Medium Wettability on the Relationship Between Capillary Pressure, Saturation, and Interfacial Area for Three-Phase Flow

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It has become increasingly common to examine multi-phase flow systems in the context of thermodynamics, with the aim of expanding the traditional capillary pressure-saturation (Pc-Sw) relationship to remove its dependence on the history of the system. A commonly used multiphase flow theory based on rational thermodynamics introduces specific interfacial area of fluid-fluid interfaces, anw (interfacial area per unit volume of the porous medium), as a separate thermodynamic entity to extend the Pc-Sw relationship and better describe the the system, including hysteresis. Past pore-network models and 3D imaging experiments have verified that the Pc(Sw, anw) relationship can uniquely describe two-phase flow under quasi-equilibrium conditions, but very limited work has considered three-phase-flow systems, and in particular the issue of interfacial area formation under three-phase-flow conditions for systems of varying wettability.

In this study, we examine the impact of porous medium wettability on three-phase-flow systems. High resolution three-dimensional images, allowing us to measure and analyze capillary pressure, saturation, and interfacial area throughout water and gas invasion (imbibition and drainage scenarios), were generated using x-ray microtomography. The experimental data allows us to evaluate the contact angle behavior for the various fluid pairs under both water-wet and oil-wet conditions, and demonstrated a significant difference in the three-dimensional capillary pressure-saturation-interfacial area relationship as wettability was altered from water-wet to a fractionally-wet.

Participation

In-Person

References

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