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Interfacial Impacts on Slickwater Imbibition and Gas Production in the Marcellus Shale

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Development in the dry unconventional gas-bearing Marcellus Shale in the Eastern United States has grown rapidly over the past decade. When a well is fractured in the Marcellus, only a small proportion of the slickwater fracturing fluid, typically <10%, is produced back following well completion. Most analyses also suggest that existing fracking and production practices only produce a fraction, typically <25%, of the Original Gas in Place (OGIP) over the life of the well. The connection between slickwater fate and gas production is poorly understood but it is generally assumed to involve trapping of imbibed water due to high capillary pressures, which impacts mobility of natural gas.

This work seeks to understand the connection between slickwater fluid properties, shale minerology and pore structure, and gas migration through fractured shales. Experiments were carried out to measure the fluid contact angles of Marcellus Shale mineral surfaces, representative fracturing fluids, and high pressure methane and the interfacial tension between fluids. These interfacial data were then integrated into a modeling framework developed using the EOS7C-ECBM equation of state modules within the TOUGH2 code, which includes the effect of non-Darcy flow regimes and sorption.

Our experimental results suggest that pre-wetted shale surfaces have a significantly lower static contact angle in the methane-water-shale system. Advancing contact angle on dry shale and drainage with receding angle on wet shale resulted in a difference of 70 degrees, illustrating the potential contribution of interfacial properties to relative permeability (Kr) and capillary pressure (Pc) hysteresis during imbibition and drainage in shale systems. These effects were correlated to specific Total Organic Carbon (TOC) content in the mineral. The experimental data were used to create synthetic inputs for using in the TOUGH2 code and the model was run to simulate flow behavior through the shale matrix, which was then used to represent different well configurations. Historical data of slickwater use and gas production from representative wells in the Marcellus region were used to benchmark the modeling output. The results suggest that there are key ways in which slickwater chemistry might be manipulated to increase the ultimate recovery of natural gas.

References

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