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Micro-scale characterzaition of wettability in tight rocks

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Summary

A Low-permeability (unconventional) hydrocarbon reservoirs exhibit a complex nanopore structure and micro (µm)-scale variability in composition which control fluid distribution, displacement and transport processes. Conventional methods for characterizing fluid-rock interaction are, however, typically performed at a macro (mm)-scale on rock sample surfaces. This talk will describe innovative methods for the quantification of micro-scale variations in wettability and fluid distribution in low-permeability oil reservoirs (Bakken and Montney) using an environmental scanning electron microscope (E-SEM). Imaging of controlled water condensation and evaporation experiments allowed micro-droplet contact angles to be evaluated, while imaging combined with x-ray mapping of cryogenically frozen samples facilitated the evaluation of oil and water micro-droplet contact angles after successive fluid injection. Live imaging of fluids injected through a micro-injection system has enabled quantification of sessile and dynamic micro-droplet contact angles, and spontaneous imbibition rates.

Contact angle measurements made at the micro-scale are compared with a conventional macro-scale approach (sessile drop) for low-permeability samples obtained from the Montney Formation in Western Canada. Two micro-wettability evaluation procedures are applied to these samples to evaluate water micro-contact angles: 1) imaging of condensation/evaporation experiments; and 2) imaging of injected fluids using a micro-injection system. Micro contact angles are estimated by extracting sessile droplet profiles (with user-guided software) and then fitting a parameterized Young-Laplace equation to the droplet profile. Results of this study suggest that laboratory-derived macro-droplet contact angles cannot be confidently and consistently applied at the micro-scale for use in digital rock physics (DRP) models for tight heterogeneous formations such as the Montney. Errors in simulating fluid displacement processes, fluid saturation distributions, capillary pressure and relative permeability curves using DRP methods may result if micro-scale variations in wettability are not considered.