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Pore-Scale Exploration of Wettability Impact on Fluid Flow: Micro-CT Imaging and Relative Permeability Analysis in a Sandstone Core

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In recent years, advancements in micro-computed tomography (micro-CT) imaging technology and image processing have significantly enhanced our understanding of the internal structure of rock cores and the distribution of fluids during multiphase flow. Herein, we utilize micro-CT to explore the impact of wettability on fluid flow in a sandstone rock at the pore-scale in combination with relative permeability measurements by history matching steady state flow experiments. Steady state experiments were conducted by the co-injection of decane and water into a sandstone core under different fractional flows (Fw=0, 0.25, 0.5, 0.75, and 1) and wetting conditions. At each stabilized fractional flow, the system was imaged with micro-CT at a resolution of 6.7μm under dynamic flow conditions. The sandstone core as initially tested in a clean state, i.e., water-wet condition, followed by aging in crude oil for two weeks at 90oC to create an aged state core, i.e., oil-wet/mixed-wet condition. For the aged-state core, it was observed that the oil-water interface was dynamically changing under so-called steady state conditions while the clean state core provided static connected pathways for flow. Consequently, the aged-state core was also imaged under static conditions to capture fluid/fluid interfaces and common lines. Based on the scanned images, parameters such as contact angle, curvature, pore occupancy, and Euler number were calculated, comparing differences between the clean state and aged-state conditions. Furthermore, history matching of relative permeability was performed to analyse the flow characteristics at the continuum scale, providing a comprehensive understanding of pore-scale mechanisms linked to relative permeability behaviour.

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