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Brine-Oil Interfacial Rheological Response to Adjusted Water Chemistry in Berea Sandstone at High Temperature

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The effect of sulfate concentration and salinity on wettability alteration and crude oil-brine viscoelastic interfacial properties at elevated temperature was investigated in this work. Evidence exists that oil recovery can be improved through management of rock-fluid and fluid-fluid interactions. The multicomponent interfacial dynamic response is complex function of brine composition and temperature. Wettability alteration at high temperature was examined in Berea sandstone. Contact angle measurements on a high pressure/high temperature pendant drop system and spontaneous imbibition experiments were conducted on aged (oil-wet) cores at high temperature. Interfacial viscoelastic characteristics of the crude oil-brine interface are concurrently investigated applying a newly developed spinning drop technique. Droplet-size distribution of water-in-oil emulsions were tracked over time through low-field NMR measurements. Four brines were selected to assess the effects of both salinity and sulfate ion, and all measurements were conducted at high temperature to compare with previously collected data at low temperature. Our results provide insights into crude oil-brine and rock-fluid interactions at near reservoir conditions. Carefully designed spontaneous imbibition experiments show that in strongly water-wet media, recovery responses are consistent with changes in the interfacial rheology. Stable oil ganglia maintain connectivity of the oil phase encouraging a low residual oil saturation. While in strongly oil-wet media, wettability alteration could dominate fluid-fluid interactions. Subsequently, the higher crude oil-brine viscoelasticity allows the small detached oil droplets to more frequently coalesce forming oil banks, and therefore, contributing to improved oil recovery. Spinning drop results at high temperature show that low-salinity brines produce a more elastic interface than brines with increased sulfate concentrations. Data suggests that excessive sulfate concentrations may resemble properties characteristic of high salinity brines. Droplet-size distribution analysis supports these observations, showing a change from low temperature behavior that correlates with the interfacial viscoelasticity response. Wettability alteration is shown to exist within the experimental system studied in this work, but fails to address the big picture; an underlying coexistent mechanism must be investigated. Fluid-fluid interactions are poorly represented in the literature and as such, the conditions under which each interaction dominates are unclear. The work presented herein provides an initial framework to identify the situationally dominant mechanism.

References

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