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Pore-scale imaging and analysis of surfactant flooding

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Carbonate reservoirs account for most of the global daily oil production and hold more than half of the world's total proven conventional oil reserves. Surfactant flooding is one promising improved oil recovery technique to maintain production from mature carbonate reservoirs.

We apply three-dimensional pore-scale imaging and analysis at representative reservoir conditions to observe and interpret the mechanisms of improved recovery during surfactant flooding. The work can be used to improve the assessment and design of improved oil recovery in carbonate formations. We focus on low-concentration surfactant injection where the likely mechanism for improved recovery is a wettability transition towards more water-wet conditions. We study recovery using cationic surfactants. They have positive charges on their heads and are considered the best candidate for carbonate rock wettability alteration.

We investigate fluid displacement, oil recovery, and quantify in situ changes in wettability when a cationic surfactant, DTAB, is injected into a cm-scale carbonate rock sample. X-ray microtomography along with sophisticated image processing software is used to acquire, process, and analyse the images. The interfacial tension between brine and oil, and between the surfactant-laden aqueous phase and oil is measured to determine the impact of interfacial tension on wettability alteration and recovery. The phase behaviour and nature of any emulsion formed is also quantified.

The rock sample is a Estaillades limestone core which undergoes crude oil injection for three weeks at a high temperature to reach a representative reservoir wettability state. Then, the brine is injected to represent secondary waterflooding. Finally, the surfactant is injected as a tertiary recovery method. High-resolution images were used to quantify the fluid configuration in the pore space. Wettability is quantified and characterized by measurements of in situ contact angles and curvatures.

The outcome of this work is to establish a methodology in which high-resolution 3D imaging using X ray micro tomography can be combined with surfactant flooding in secondary or tertiary mode to quantify in situ changes in wettability and to elucidate micro-scale fluid displacement processes. This work furthers our understanding of oil recovery mechanisms when a cationic surfactant is used as a secondary or tertiary enhanced oil recovery process.

Participation

In-Person

References

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