Contribution ID: **362** Type: **Poster (+) Presentation**

Pore-Scale Imaging of Tertiary Controlled-Salinity Waterflooding in a Heterogeneous Carbonate Rock at Reservoir Conditions

Wednesday, 2 June 2021 09:00 (1 hour)

Over the last decade multiple studies have shown the significance of controlled salinity water-flooding (CSW) as an efficient technique to improve recovery from oil fields. Most of the published experimental work in the literature was performed at the core scale and mainly focused on comparing the incremental oil recovery from low salinity (LS) and high salinity (HS) brine injection in secondary or tertiary modes. Wettability alteration towards a more water-wet state is believed to be the prominent effect of LS on reservoir rocks. However, the underlying pore-scale mechanisms responsible for the CSW effects are not fully understood especially in heterogeneous carbonate reservoirs.

In this work, we investigated pore-scale oil displacement and rock wettability in tertiary LS waterflooding (LSW), i.e. injecting LS brine at HS waterflooding (HSW) residual oil saturation. X-ray micro-computed tomography (micro-CT), combined with a high-pressure high-temperature flow apparatus, was used to image in situ CSW on an Estaillades limestone core sample (6 mm in diameter and 12 mm in length). To establish the wettability conditions found in oil reservoirs, the sample was aged for three weeks at 11 MPa and 80℃. The moderately oil-wet sample was then injected with HS brine at a range of increasing flow rates, namely at 1, 2, 4, 11, 22 and 42 µL/min with 10 pore volumes injected at each rate. Subsequently, LS brine was injected following the same procedure. A total of 8 micro-CT images, with a resolution of 2.3 µm/voxel, were acquired throughout LS and HS waterflooding. These images were utilised to characterize fluid configurations in the pore space and obtain saturations and occupancy maps. Pore space was quantified by micro-CT resolved porosity of 12.5% and sub-resolution micro-porosity of 17.0%. Wettability was characterised by measurements of in-situ contact angle and curvature.

The results showed that LSW has yielded an incremental oil recovery of 9% of OIIP, based on fluid saturations values measured on resolved macro-pores. The mean contact angle and curvature values showed insignificant changes with HSW; the measured mean curvature and the associated capillary pressure values remained negative. However, with LSW the capillary pressure increased towards a positive value, as the wettability progressed towards a mixed-wet state. The pore and throat occupancy analysis revealed a salinity-induced change in fluid distribution in the pore space. HS brine invaded mainly the larger pores and throats, but as LS brine was injected the fraction of medium- and small-size pores and throats occupied by oil decreased.

Overall, our analysis showed that a shift from a weakly oil-wet towards a mixed-wet state was observed mainly after low salinity brine was injected into the sample, hence the increase in oil recovery. This approach helped further investigate pore-scale wettability alteration in carbonates and enhanced the understanding of LSW as enhanced oil recovery method for potential field-scale applications.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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