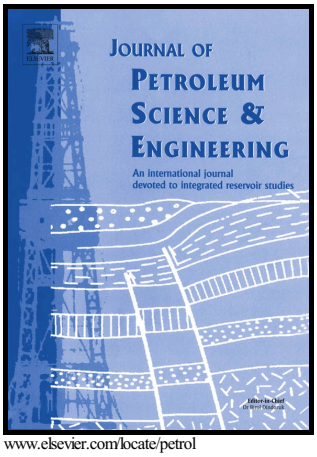

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Experimental Investigation of the Coupling Impacts of New Gaseous Phase Formation and Wettability Alteration on Improved Oil Recovery by CWI

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1. Abstract

It has been shown that carbonated (CO_2-enriched) water injection (CWI) has the potential to improve oil recovery in oil reservoirs. Introduced oil recovery mechanisms were oil swelling and oil viscosity reduction. However, most early studies have neglected to consider two important factors: (i) using ‘’live’’ reservoir oil (oil with dissolved gases) rather than refined oil or dead oil, (ii) establishing the native wettability state of the oil reservoirs which is generally mixed-wet to oil-wet. Previously, we reported the fluid-fluid and rock-fluid interactions that took place during CWI under realistic reservoir conditions using ‘’live’’ oil and aged rock. The results indicated CO_2 partitioning at the interface of carbonated water (CW) and live oil leads to nucleation of a new gaseous phase inside the oil that boosts the performance of CWI significantly which represents being a game-changer for this EOR technique. Furthermore, based on our reported wettability studies, low pH of CW can change the wettability state of the brine-oil-rock system and thereby improve the oil recovery. In this study, through a series of carefully designed coreflood and micromodel experiments, the aim has been to comprehensively investigate (i) the complex fluid-fluid interactions which happen at pore scale during CWI in both ‘’live’’ and dead oil systems and (ii) the effects of formation of the new phase and wettability alteration on oil recovery by CWI at core scale. For the coreflood experiments two systems were considered, a mixed-wet system and a water-wet system, and for each system a secondary waterflood and a secondary CWI were conducted at pressure and temperature of 2500 psia and 100 °F. Synthetic live reservoir crude oil was used.

The results of pore scale observations revealed the rapid formation and growth of the new phase as CW comes in contact with ‘’live’’ oil. However, this phenomenon was not observed for the dead oil system. Furthermore, the results of coreflood tests for both water-wet and mixed-wet systems revealed the good potential of CWI compared to waterflood. However, secondary CWI in the mixed-wet system resulted in higher and earlier additional oil recovery than shown in the water-wet system. For the water-wet system, secondary CWI led to 6.2% ultimate additional oil recovery. This incremental oil recovery took place after the