Modeling of Wettability Alteration During Spontaneous Imbibition of Mutually Soluble Solvents in Mixed Wet Fractured Reservoirs

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Abstract

Mutually-soluble solvents can enhance oil recovery both in completely and partially water wet fractured reservoirs. When a strongly or partially water-wet matrix is surrounded by an immiscible wetting phase in the fracture, spontaneous imbibition is the most important production mechanism. Initially, the solvent moves with the imbibing brine into the core. However, upon contact with oil, as the chemical potential of the mutual solvent is different in both phases, diffusion occurs and the solvent is transported in the oleic phase. Through the migration of the mutually soluble component from the aqueous phase into the oleic phase, oil properties and/or rock-fluid interactions are modified. The hypothesis in this work is that a mutually-soluble solvent improves the ultimate recovery and the imbibition rate in partially and completely water-wet cores. The main recovery mechanisms are the wettability change of the partially water-wet cores, oil swelling and oil viscosity reduction in both partially and completely water-wet cores.

This paper considers the numerical modelling of experiments that use an Amott imbibition cells to study solvent enhanced spontaneous imbibition in completely water-wet and partially water-wet cores. In the first stage of the experiment, the completely water-wet core was exposed to brine without solvent. In a second stage, the core was put in a new Amott cell that was filled with a solvent/ brine mixture. The extra recovery by a solvent/brine mixture strongly depends on the residual oil saturation after brine imbibition and it is relatively insensitive to the permeability of the core or the oil viscosity. We implemented the swelling mechanism, the oil viscosity reduction mechanism, and the IFT reduction mechanism in the numerical model. Our studies show that the most important production mechanism in the completely water wet system is the oil swelling and the second most important mechanism is the oil viscosity reduction. The effect of the IFT reduction in the oil production is not significant. The numerical results show an improvement of 10%.

For the partially water-wet samples, we also started with exposing the core to pure brine without solvent. Contrary to the completely water-wet samples, the numerical results show a significant increase in recovery rate when the sample is transferred to another Amott cell where it is exposed to a mixture of solvent and brine. The main modification in simulating the recovery process is that now a wettability change mechanism is taken into account. Our numerical studies show that the contribution of the wettability change is the main contributor to the oil recovery,

which is enhanced by 35 %.

Reference

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Figures used in the abstract

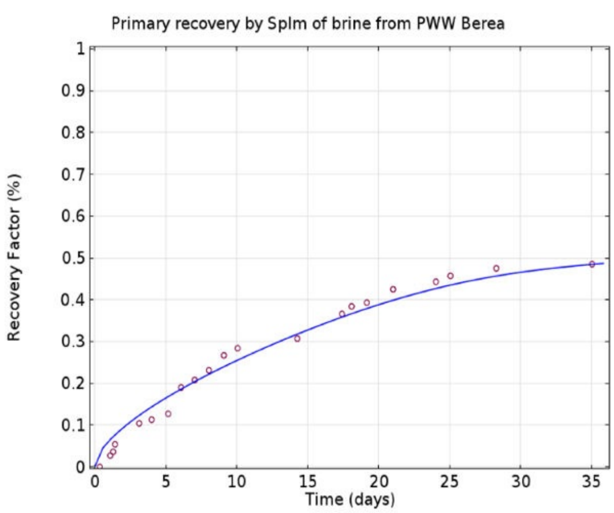

Figure 1: Oil Recovery by Brine imbibition in Mixed-wet core1

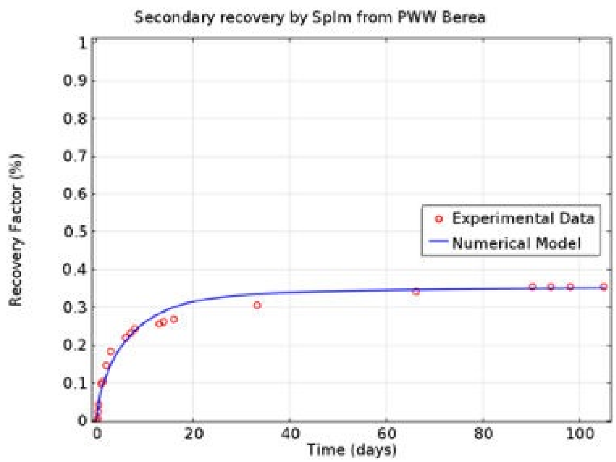

Figure 2: Oil Recovery by solvent imbibition in Mixed-wet core1

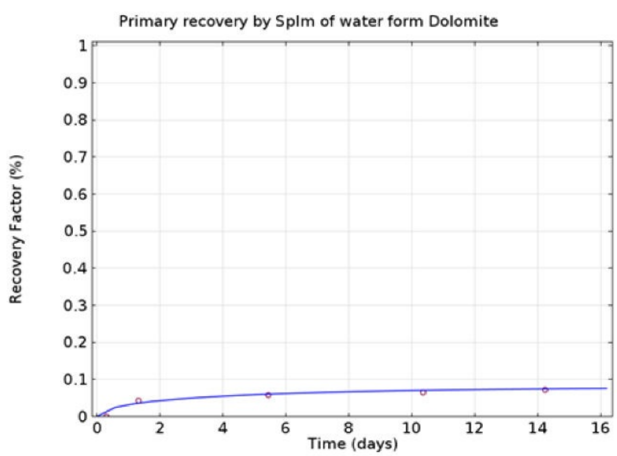

Figure 3: Oil Recovery by Brine imbibition in Mixed-wet core2

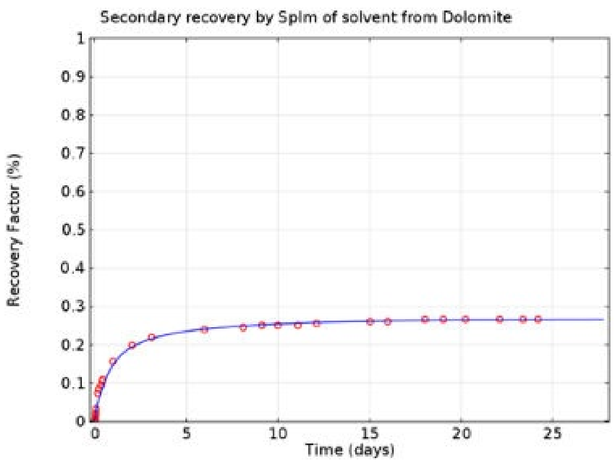

Figure 4: Oil Recovery by solvent imbibition in Mixed-wet core2