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A coupled geochemical model to predict oil recovery during low salinity waterflooding

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1. Introduction

The wettability alteration is the most prominent mechanism for a favorable effect of low salinity waterflooding (LSWF) in enhanced oil recovery (EOR). Numerous thermodynamic and numerical models have been developed to capture the wettability alteration mechanism in the prediction of oil recovery [1]. The characteristics of crude oil/brine and rock/brine interfaces significantly influence the interaction of the crude oil with rock surface and thus wettability alteration. In this study, the interface characteristics were coupled with a solute transport model to simulate low salinity water flooding in carbonate and sandstone reservoirs. The wettability alteration was determined based on the adsorption of crude oil sites on rock surface. And the relative permeability was modified by implementing the wettability alteration for the prediction of oil recovery.

2. Modelling approach

The ionic transport and two-phase flow of oil and water equations were solved in MATLAB® and coupled with IPhreeqc for geochemical calculations. A triple-layer surface complexation model was employed in IPhreeqc to predict electrokinetic properties of crude oil/brine and rock/brine, and the wettability alteration was calculated from the zeta potential and surface species concentration. The positive surface of calcite can attract the deprotonated -COOH in crude oil whereas the negative surface of kaolinite can adsorb calcium/magnesium adsorbed -COOH. At each time step, the wettability was calculated as the ratio of adsorbed crude oil on calcite or kaolinite surface to the initial value. In addition, the coupled model considers the dissolution and precipitation of minerals thorough thermodynamic phase-equilibrium module in IPhreeqc.

3. Results and Discussion

The coupled model allows to predict spatiotemporal variation of ionic profiles, surface and zeta potentials, minerals changes, and total disjoining pressure in addition to oil recovery in carbonate and sandstone reservoirs. The chemistry of injecting solution significantly influences the dissolution of minerals and the surface chemistry of the interfaces and thus affecting oil recovery. The coupled model was validated and verified with the published experimental data for two-phase flow experiments. An example of verification for a tertiary core flooding in sandstone is shown in **Figures 1** and **2**. The sandstone core was injected by a high salinity water to produce reservoir condition before evaluating the effect of low sanity water [2]. The predicted effluent ion concentration reproduces well the experimental data (**Figure 1**). **Figure 2** compares the predicted oil recovery with experimental data. The findings of this study show the importance of interface characteristics on the adsorption of crude oil on rock surface and thus wettability alteration. The coupled model can be used to optimize the brine composition for oil recovery in sandstone and carbonate reservoirs.

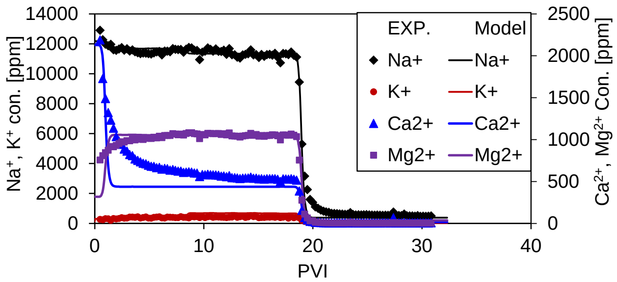

Figure 1. Comparison of simulated and measured [2] effluent concentration during core flooding in sandstone.

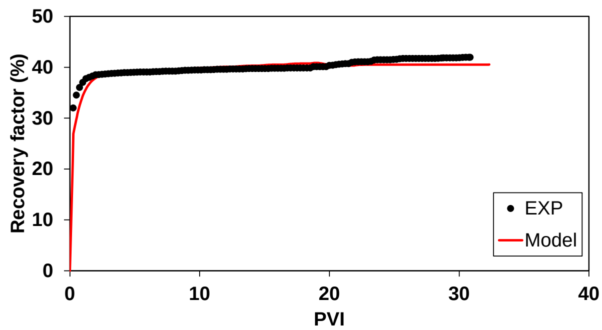

Figure 2. Comparison of simulated and measured [2] oil recovery in sandstone.

1) H. Sharma and K. Mohanty, Journal of Petroleum Science and Engineering 165 (2018) 1021–1039
2) R. Morishita et al., Energy Fuels 34 (2020) 5258−5266

