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Pore-scale investigation of the effect of lithology on residual oil displacement in chemical flooding using nuclear magnetic resonance experiments

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Chemical flooding is one of the most promising EOR technique in both laboratory research and field trials. It has been applied in conglomerate reservoir as well as sandstone reservoir. To full understand the displacement mechanisms of chemical flooding in reservoirs with different lithology, it is essential to recognize the residual oil displacement in pore scale.

We selected three cores with similar permeability, including outcrop sandstone, sandy conglomerate and inequigranular conglomerate to perform unclear magnetic resonance experiments. Deuteroxide was used to replace water as aqueous to distinguish signals of water phase and oil phase. The threshold values of different pore sizes were established from the relationship between mercury injection curves and NMR T2 spectrums. The distribution and migration of residual oil in different flooding processes was evaluated by quantitatively analyzing the change of the relaxation time. The oil displaced from pores of different sizes after the water flood, polymer flood, and the surfactant/polymer (SP) flood was calculated, respectively.

Compared with sandstone, the diagenesis of conglomerates normally takes place in a shallower depth and then possesses more tortuous pore structures. The sequence of ultimate oil recovery of chemical flooding from high to low is outcrop sandstone, sandy conglomerate and inequigranular conglomerate. On contrary to sandstone rocks, more residue oil is observed after water flood in conglomerated rocks, especially in pores which size is less than 5um. Although both polymer and SP flood can mobilize residual oil in which pore size is larger than 1μm, SP flood has much higher oil recovery than polymer flood, especially for the conglomerate core. The residual oil in medium pores (5μm to 15μm) contributed the most to the incremental oil recovery for the SP flood. It was nearly no trapped oil in large pores which sized larger than 15μm after SP flood. Therefore, the residual oil in small and medium pores were the main target for EOR after the SP flood in both sandstone and conglomerate reservoir.

Since there are many different lithology in conglomerate reservoir, it is necessary to investigate the effect of lithology on residual oil displacement. Our studies elucidated the pore-scale oil recovery mechanisms of different lithology during three flood processes. This research result can help ensuring the distribution of residue oil based on well log result and offer a good guidance to field production.

References

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