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Comprehensive Experimental and CFD Simulation Study on the Effect of Brine Composition in Waterflooding of Carbonate Oil Reservoirs

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Water injection has been potentially considered as an efficient method for supporting the pressure in most oil reservoirs. Novel EOR techniques such as smart water flooding have gained more attention referring to both the recent research activities and the falling of oil price. In spite of many attempts on acquiring the main responsible mechanisms of smart water flooding in many individual fields, the most proportion of the data are fairly sporadic and more possible mechanisms which explain all the interactions has not introduced yet.
This study used a predetermined laboratory framework based on seawater (SW) treatments at fixed ionic strength to omit the ionic strength effects, NaCl was regarded as the regulation salt in smart brines. Specifically, an asphaltenic carbonate oil reservoir with a strong wettability inclined oil phase was the subject of this study. It is tried to clearly evaluate both rock-fluid and fluid-fluid interactions through contact angle and interfacial tension (IFT) measurements respectively in order to explore the role of divalent ions in smart water injection. Brines with the best responses in the previous sections were chosen to be tested in Amott cell imbibition tests so that both fluid-fluid and rock-fluid effects were compiled. As a result, sulfate and magnesium ions were the dominant ions in the bulk solution and have the most important influence on IFT smart brines and crude oil. In addition, the presence of these brought about a major reduction in contact angle of oil droplets on dolomite slices. The acquired results in IFT and contact angle sections were approved by spontaneous imbibition tests and it was observed that depleting injection water with SO_4^(2-) ion led to the lowest final oil recovery. In opposite side, spiking the concentration of SO_4^(2-) by 4 times in SW caused an increase in the final oil recovery by more than 10% from a spontaneous imbibition test. Furthermore, when SO_4^(2-) ions existed, adding more amount of Mg2+ ions into the SW led to a smart brine that tended to sharply decrease the oil wet state of dolomite slices into more strongly water wet state, from 165 to 22 degrees. The spontaneous imbibition tests also disclosed that the final recovery from a neutrally wet core plug was higher than the final oil recovery of strongly water wet core plug which is not in line with capillary pressure calculation. Finally the efficiency of oil displacement by injecting water in a homogeneous porous network at water wet, oil wet and neutral wet conditions were investigated using CFD method. It was observed that neutral wet condition leads to lower residual oil saturation and consequently larger oil recovery after water flooding compared to those in water wet and oil wet conditions. The simulation results were in good agreement with experimental outputs and revealed the mechanism behind the larger oil recovery of neutrally wet systems than water wets.

References

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