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Microfluidic experiments on constrained oil remobilization induced by water transport in the oil phase

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Given the complex physical and chemical processes, several controlling mechanisms have been proposed to explain the oil remobilization due to low-salinity effects. Osmosis and water-in-oil emulsification are among these mechanisms. However, our knowledge of these processes is limited and their associated time scales are not well understood. To verify their roles, we conducted a series of microfluidic experiments by sequentially injecting high-salinity water, pure or surfactant-added synthetic oil, low-salinity water into the hydrophobized glass-based microchips. Several selected specific areas were continuously observed over at least 30 hours, with sandwiched systems of trapped high-salinity water along the solid grains, low-salinity water in bulk, and oil. The systems mimicked the contact status of these three fluids in the natural reservoir. In the experiments using pure oil, we found that the expending high-salinity water gradually squeezed the sandwiched oil phases out of the pores. The area of high-salinity water increased by 41.21% with an average rate of 141.88 μm2/hr after 70 hours of monitoring. In the experiments with adding surfactant (SPAN 80) in oil, we observed that the expansion rate of high-salinity water was 1.85 times higher than it without adding a surfactant, meaning that the emulsification contributed to accelerating water transport in the oil phase. Therefore, we proposed a hypothesis of emulsification and water diffusion in the oil phase. On the other hand, visualizations of water-in-oil emulsions were investigated from nano-scale to pore-scale. A corresponding series of experiments were carried out using Zetasizer to capture the size trend in water-in-oil emulsion around the oil/salinity-water interface under different salinity conditions. In the case of 2,000 ppm salinity, we found that the water-SPAN80-dodecane emulsions kept a primary size of around 50 nm for the first 4 hours, then generated a second primary size of 2 nm during 4-20 hrs. Finally, the small emulsions progressively dominated the size distribution around the interface, and relative big emulsions, e.g., 4,800 nm, occurred with the coalescence until the emulsification process reached equilibrium. This tendency matched well with the observation on the emulsion transformation in the microfluidic experiments and helped explain the process of high-salinity water expansion.

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References

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Unsure

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