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Remobilization mechanism of microscopic residual oil in heterogeneous sandstones during water flooding process

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The displacement of residual oil by water flooding in porous media is important in many sandstone reservoirs. Our fundamental understanding of the influence of complex pore geometries of natural sandstones on fluid distribution is still incomplete. To study the formation mechanism and mobilization potential of microscopic discontinuous residual oil, this paper constructs a two-phase flow simulation model in heterogeneous sandstone pores based on the N-S equation and fluid volume method (VOF). The pore structure characteristics are accurately described using the watershed method, and the relationship between residual oil distribution and pore structure parameters was quantitatively characterized. Our findings suggest that pore-scale displacement and snap-off processes have a strong dependence with the coordination number, pore radius and aspect ratio. Moreover, the micro remobilization mechanism of different types of residual oil is analyzed from a hydrodynamics perspective. The results show that the residual oil of network form is the main type during the high-water period influenced by the low coordination number of heterogeneous pore space. Mechanical analysis shows that the mobilization of residual oil is the result of the combination of capillary force and driving force during low-capillary number water flooding process. Pores with good connectivity are the potential breakthrough positions for oil phase. The increasement of driving force would further push the two phase interface to move and form a combined force with the capillary force, and effectively remobilizing oil clusters. The statistical analysis revealed that the development of sub-pathways and the suppression of snap-off are responsible for the decrease of remaining oil saturation under higher capillary number water injections. This study reveals the formation and remobilization mechanism of microscopic residual oil in the high-water cut stages, providing a theoretical basis for fine tapping of the highly disconnected remaining oil in sandstone reservoir.

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