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Pore-scale Modeling of Two-Phase Fluid Flow in the Fracturing-Shut In-Flowback Process of Tight Oil Reservoirs

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The storage space of tight formation after volumetric fracturing is complex, characterized by the coexistence of micro-nano pores and multi-scale fractures. This complexity hinders a clear understanding of pore-scale flow dynamics in the integrated fracturing-shut in-flowback process of tight oil reservoir. To tackle this issue, we introduced the micro-focus CT imaging and digital image processing technology to establish two digital rock geometry models retrieved from raw CT images. Subsequently, we proposed a pore-scale modeling workflow based on the pseudo- potential lattice Boltzmann model to explore the underlying mechanism of fluid exchange during the integrated development period. This workflow allowed us to investigate the oil-water exchange behaviors during the three stages of fracturing-driven, shut-in imbibition and flowback production. Ultimately, we conducted a systematic analysis of the influence of oil-water viscosity ratio, rock wetting angle and capillary number on the pore-scale oil-water exchange. Results show that during the fracturing-driven stage, fracturing fluid primarily migrates along the fractures, with only a small amount entering the pore space nearby the fractures. In the shut-in imbibition stage, the fracturing fluid preferentially flows into small pores, displacing the recovered oil droplets through the large pores. In the flowback production stage, oil droplets occupied in the fracture-matrix contact areas are preferentially stripped off, and there still exists a large amount of crude oil droplets that are difficult to be swept. A higher capillary number and a lower oil-water viscosity ratio will supply formation energy during hydraulic fracturing in tight oil reservoirs, activating the mobilization of crude oil droplet trapped in the stimulated reservoir volume region and improving imbibition recovery. The effect of wetting angle on energy supply during hydraulic fracturing in tight oil reservoirs is relatively little, while a higher water-wet degree will promote spontaneous imbibition, making it challenging for fracturing fluid to flowback.

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