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Microfluidic experimental study of CO2-water-oil three-phase flow in porous media

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Understanding the mechanisms of CO2-water-oil three-phase low is crucial for enhancing oil recovery and improving CO2 storage efficiency. In the present study, with the help of high pressure high temperature microfluid experimental system, the pore-scale CO2-water-oil three-phase flow is directly visualized and the underlying mechanisms of triple-phase flow are revealed.
During the experiments, the contact angle of the microfluidic porous chip is altered to study the triple phase flow with different wettability In water-wet systems, water tends to occupy the small pores, oil exists in the intermediate pores, while CO2 enters the large pores. Gas ganglia disconnected with continuous gas injection do not reconnect and CO2 is displaced in the form of disconnected ganglia by a double/multiple displacement process. In contrast in the oil-wet system, , a three-phase Haynes jump occurs in the pore space during oil replacement by gas.
Under supercritical conditions, it can be observed that the oil droplets are extracted during gas displacement. The CO2 displacement in oil-water filled porous chip which has been already displaced by water can further reduce the oil saturation. The residual oil presents in the form of columns, membranes and corners. In addition, as the gas injection rate is increased from 0.005ml/min to 0.01ml/min, the residual oil content is reduced from 42.11% to 18.35%, indicating greatly enhanced oil recovery. When the gas injection rate is further increased to 0.02ml/min, the increase of the oil recovery is negligible, due to the occurrence of gas channeling.

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