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Improving CO2 Sweep Efficiency in Carbonate Rock by Injecting Water-Saturated CO2

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We present a comparison between water-saturated CO2 injection and CO2 injection into an Indiana limestone core. Micro computed tomography (micro-CT) imaging (Figure 1) and mercury intrusion capillary pressure (MICP) measurement (Figure 2) technologies were used to determine the pore size distribution. Results suggest that Indiana limestone consists of three pore sizes: large pores > 200 μm, medium pores in range 3-200 μm, and small pores < 3 μm. Pure CO2 or wsCO2 are injected into the core having crude oil and irreducible water at 70 ℃ and 12 MPa, representing near-miscible conditions.
wsCO2 injection yields 4.9% - 13.6% additional oil recovery (Figure 3d), and 19-36 times greater pressure difference across the core (Figure 3b). Our observations during wsCO2 injection suggest that water might be condensed into oil phase creating an emulsion (Figure 4). Emulsification leads to greater flow resistance therefore, the pressure difference increased. Results also suggest that pure CO2 could only displace crude oil from pores greater than 21 μm, while wsCO2 could entry into an order of magnitude smaller pores due to the 19-36 times higher ultimate pressure difference (Figure 5). The pore space vacated by additional oil recovery is occupied by CO2 yielding a 3% - 9% PV additional CO2 stored compared to pure CO2 injection (Figure 3f).
Keywords: CO2 injection; Water-saturated CO2 injection; Carbonate rock; CO2 storage.

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