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Microscopic transport and phase behaviors of CO2 injection in heterogeneous formations using microfluidics

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CO2 injection into the geological formations is a promising option to enhance oil recovery while simultaneously contributing to carbon storage. Conventional core tests provide critical insights but still leave ambiguous transport mechanisms due to the limitation of real-time visualization. This study aims to directly observe the multiphase flow behaviors and phase change in CO2 injection at pore-scale using microfluidics. Our all-in-one chip design provides a universal platform to reproduce various CO2 injection strategies in the formation with permeability contrast, including flooding and huff-n-puff processes, and integrated a rapid measurement of minimum miscibility pressure (MMP). Miscible injection eliminates the capillary force in immiscible scenario, and promotes stable film-wise displacement with a higher recovery rate and an attenuated heterogeneity impact. We find that effective huff-n-puff operations require a sufficient gas concentration to generate bubbles and an adequate pressure gradient to push the dissolved gas displacement, which supports the importance of high depressurization rate from both physical phenomenon and inherent mechanism. Huff-n-puff re-energizes the reservoir after immiscible flooding through deep gas-oil interactions and induces a considerable growth in cumulative recovery. These micromodel results can significantly improve our fundamental understanding on detailed multiphase transport phenomena in CO2 injection and help to optimize implementation schemes.

Participation

In-Person

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