Research on characteristic of CO₂/brine two-phase flow in a homogenous micromodel

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Abstract

As a prospective method to alleviate CO₂ emission into the atmosphere, carbon dioxide capture and storage (CCS) is considered as one of the most efficient ways to sequester a large amount of CO₂ into unminable coal seams, deep saline aquifers, depleted oil or gas reservoirs and deep ocean sediments. Among these potential sites, deep saline aquifers are especially popular due to their large capacity for CO₂ storage, small cost and influence on the environment. Thus, several studies have focused on injection of CO₂ into brine-saturated porous media, which investigated the processes associated with migration and trapping of CO₂ in the porous structure. However, there is few fundamental understanding about the flow mechanisms and characteristics in porous media. State-of-the-art visualization techniques for investigating two-phase flow in porous media at the pore scale are extremely valuable and have provided great advances in understanding these mechanisms and characteristics. So in this study we used an etched homogenous glass micromodel to investigate pore-scale displacement process in brine-saturated reservoirs with the injection rates of CO₂ from 0.005 ml · min⁻¹ to 0.05 ml · min⁻¹ at ambient temperature and pressure conditions. Four different types of brine: 1 mol/kg, 2 mol/kg, 3 mol/kg, 4 mol/kg, were seeded with fluorescent particles and the dynamic displacements were recorded in real time by a fluorescence inversion microscope and a digital single lens reflex camera. Combined with the technology of micro-PIV, the phase distribution and velocity field have been attained. Based on the experimental results, a detailed discussion about the instability of CO₂ front and CO₂ saturation variation was made. At the same time, the effect of CO₂ injection rate and brine salinity on drainage process was also analysed specifically. Through the velocity field of brine, it was found that the values of velocity magnitude were consistent with the continuity principle by which flow accelerated through the pore throats and decelerated in the pore spaces. During the experiments, Haines jumps has been observed where the velocity changed abruptly. It was found that the displacement became more and more unstable with an advancing CO₂ front. Furthermore, CO₂ bypassing caused by channelling and viscous instabilities was found with developing displacement.