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Quantitative analysis on areal displacement efficiency in a $scCO_2$-water-quartz sands system

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Geological CO_2 sequestration is one of the most important technologies to mitigate greenhouse gas emission into the atmosphere by isolating great volumes of CO_2 in deep geological formations. This novel storage option for CO_2 involves injecting supercritical CO_2 into porous formations saturated with pore fluid such as brine and initiate CO_2 flooding with immiscible displacement. Despite of significant effects on macroscopic migration and distribution of injected CO_2, however, only a limited information is available on wettability in microscopic $scCO_2$-brine-mineral systems.

In this study, a micromodel had been developed to improve our understanding of how CO_2 flooding and residual characteristics of pore water are affected by the wettability in $scCO_2$-water-quartz sands systems. The micromodel (a transparent pore structure made of quartz sands between two glass plates) in a pressurized chamber provided the opportunity to visualize spread of supercritical CO_2 and displacement of pore water in high pressure and high temperature conditions. CO_2 flooding followed by fingering migration and dewatering followed by formation of residual water were observed through an imaging system with a microscope. Measurement of areal displacement of porewater by $scCO_2$ in a micromodel under various conditions such as pressure, temperature, salinity, flow rate, etc. were conducted to estimate displacement sweep efficiency in a $scCO_2$-water-quartz sands system. The measurement revealed that the porewater (deionized water or NaCl solutions) is a wetting fluid and the surface of quartz sand is water-wet. It is also found that the areal displacement efficiency at equilibrium decreases as the salinity increases, whereas it increases as the pressure and temperature increases. The experimental observation results could provide important fundamental information on capillary characteristics of reservoirs and improve our understanding of CO_2 sequestration process.