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Microscopic visualization experimental study of salt precipitation during supercritical CO2 injection into saline aquifers

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Abstract: CO2 storage in deep saline aquifers is considered an effective means of mitigating climate change induced by increased CO2 levels in the atmosphere. Additionally, CO2 has a significant impact on enhancing gas recovery (CO2-EGR). Therefore, injecting CO2 into water-bearing gas reservoirs is a win-win way for both CO2 storage and utilization. However, CO2 injection into saline aquifers leads to salt precipitation, resulting in decreased permeability. Hence, under conditions of 20MPa and 80℃, this study conducted laboratory-scale microscopic visualization experiments to investigate the growth, distribution， and migration patterns of salt precipitation, and its impact on permeability at the pore scale.
The experimental results indicate: (1) During CO2 injection, salt precipitation grows faster within the mainstream channels while exhibiting slower growth on the sides, primarily distributing along the CO2 mainstream paths. (2) As CO2 is injected, pressure differentials rise at the inlet and outlet, and decrease after CO2 breakthrough. Pressure differentials increase after salt crystallization. Finally, and increases by a factor of 12.6 due to salt precipitation, leading to a reduction in permeability. (3) Salt precipitation in the mainstream area increases the CO2 sweep area and reduces gas channeling. Salt precipitation at the boundary between swept and unswept areas limits the growth of the CO2 sweep area. (4) Salt precipitation mainly occurs in narrow pore throats and at crossed channels. Salt precipitation at narrow throats is formed, due to the limited liquid by capillary pressure is evaporated. At a crossed channel, salt precipitation primarily is formed by the evaporation of liquid film attached to the grain and aggregation of salt particles during movement. (5) Salt precipitation at narrow pore throats occurs mainly on the sides of channels with higher CO2 velocity, while at a crossed channel, it predominantly grows facing the direction of the CO2 flow, being ‘cone-shaped’ and growing. (6) In enclosed brine, a little salt precipitation is formed as CO2 is injected. Through these experiments, the mechanisms of salt precipitation during CO2 injection are elucidated, and providing a reliable basis for enhancing water-bearing gas recovery and storage.

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