

Analytical model for CO₂ injection into brine aquifers containing residual CH₄

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Seyyed A. Hosseini
Simon A. Mathias
Farzam Javadpour



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Abstract:

During CO₂ injection into brine aquifers-containing residual and/or dissolved CH₄, three distinct regions develop: (1) a single-phase, dry-out region around the well-bore filled with pure supercritical CO₂; (2) a two-phase, two-component system containing CO₂ and brine; and (3) a two-phase, two-component system containing CH₄, and brine. This article extends an existing analytical solution, for pressure buildup during CO₂ injection into brine aquifers, by incorporating dissolved and/or residual CH₄. In this way, the solution additionally accounts for partial miscibility of the CO₂-CH₄-brine system and the relative permeability hysteresis associated with historic imbibition of brine and current drainage due to CO₂ injection and CH₄ bank development. Comparison of the analytical solution results with commercial simulator, CMG-GEM, shows excellent agreement among a range of different scenarios. The presence of residual CH₄ in a brine aquifer summons two competing phenomena, (1) reduction in relative permeability (phase interference), which increases pressure buildup by reducing total mobility, and (2) increase in bulk compressibility which decreases pressure buildup of the system. If initial CH₄ is dissolved (no free CH₄), these effects are not as important as they are in the residual gas scenario. Relative permeability hysteresis increased the CH₄ bank length (compared to non-hysteretic relative permeability), which led to further reduction in pressure buildup. The nature of relative permeability functions controls whether residual CH₄ is beneficial or disadvantageous to CO₂ storage capacity and injectivity in a candid brine aquifer.

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