Field Characterization of Reservoir Flow Paths Using Miscible and Immiscible Tracer Tests

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Injection of supercritical CO_2 into deep, brine-filled reservoirs may be used to slow the effect that greenhouse gas emissions have on global warming. During injection, the large contrast in fluid densities and viscosities causes immiscible displacement of the brine by CO_2, resulting in a two-phase system. We performed a series of tracer tests during the Frio CO_2 sequestration pilot program to study immiscible and miscible fluid displacement through the Frio sandstone, a deep saline reservoir located beneath the Gulf Coast Region of Texas. A two-well tracer test was initially performed to evaluate miscible fluid displacement in the single-phase, brine-filled reservoir. A dipole flow field was first established by pumping brine from a well penetrating the reservoir and then injecting it back into the same formation using a second well. A tracer, added to the injected water and monitored at the pumping well, allowed us to evaluate interwell travel times and tracer-breakthrough curves. These results are compared to CO_2 travel times and gas-tracer-breakthrough curves obtained from immiscible displacement of brine by CO_2, collected during a subsequent single-well CO_2 flood (radial divergence test). CO_2 breakthrough was faster than model predictions, and sweep efficiencies were relatively small, suggesting that gas movement occurred along preferential pathways. Estimates of formation dispersivity, porosity-thickness products and brine saturation provide further insight into the nature of these pathways.