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Flow Modeling for CO2 Sequestration: The Frio Brine Pilot

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Numerical modeling of the flow behavior of supercritical carbon dioxide (CO2) injected into a brine-bearing sandstone was an integral part of the Frio brine pilot for CO2 sequestration. Modeling was used to help design the pilot and to improve understanding of multi-phase and multi-component flow processes involved in geologic CO2 sequestration. During the design phase, modeling was used to determine which of several layers to inject into, how far apart injection and observation wells should be (in particular showing that existing wells were too far apart, necessitating the drilling of a new injection well), how much CO2 to inject, and at what rate. Modeling of pre-injection, site-characterization pump and tracer tests helped design these tests to optimize the information gained on formation flow properties, in situ phase conditions, and boundary conditions. As site-characterization proceeded, the model was modified to incorporate new information. CO2 injection was simulated prior to the actual pilot, to assess the model’s predictive ability. Further model improvements were added subsequently, based on detailed comparisons to the observed subsurface CO2 distribution.

Modeling illustrated the complex interplay between phase interference and buoyancy flow that occurs as CO2 is injected into a high-permeability, steeply dipping sand layer. By running simulations with a range of parameters and comparing model results to field data we improved our understanding of these flow processes. Generally good agreement between observed and modeled CO2 spatial distributions and travel times between injection and observation wells validated our ability to model CO2 injection, while discrepancies pointed out areas where future research is needed. The iterative sequence of model development, application, and refinement proved useful for getting early results in a timely manner as well as incorporating more complexities at later stages. This work has demonstrated that we have an effective modeling capability for representing the physical processes occurring during CO2 sequestration in brine-bearing sandstones, and moreover that the incorporation of modeling into geologic CO2 sequestration activities is beneficial from the earliest design stages through the final interpretation of field data.