Flow Modeling for CO$_2$ 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.
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ABSTRACT

Numerical modeling of the flow behavior of supercritical carbon dioxide (CO₂) injected into a subsurface reservoir is an integral part of the Pilotted projects for CO₂ sequestration. Modeling was used to help design the pilots and to improve our understanding of subsurface fluids and multiphase flow processes that are encountered during the disposal of CO₂. The study was motivated by the fact that existing models do not account for the fluid interactions of CO₂ with brine, which is an important consideration for the flow behavior in deep reservoirs. The modeling framework is based on the use of the TOUGH2 simulator, which accounts for multiphase flow and transport processes. The model was calibrated and verified using tracer test data, injection rates, and other field observations. The results indicate that the modeled fluid behavior is consistent with the observed data. The modeling framework can be used to predict the fate of CO₂ in deep reservoirs and to improve our understanding of the flow processes.

RESULTS

The model predictions are in good agreement with the observed fluid behavior. The predicted CO₂ spatial distributions are consistent with the observed data. The model also predicts the arrival of CO₂ at the observation wells, which is consistent with the observed data. The model predictions also provide insights into the flow processes that are occurring in the subsurface reservoir.

CONCLUSIONS

The numerical modeling framework provides a powerful tool for predicting the fate of CO₂ in deep reservoirs. The model predictions are in good agreement with the observed fluid behavior. The modeling framework can be used to improve our understanding of the flow processes and to optimize the design of future CO₂ sequestration projects.

REFERENCES


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