Carbon Dioxide Storage in Deltaic Saline Aquifers: Invasion Percolation and Compositional Simulation

GCCC Publication Series #2021-9

Tavassoli, S. Krishnamurthy P. Beckham, E. Meckel, T.A. Sepehrnoori, K.

Keywords: (none found)

Cited as:
Tavassoli, S., Krishnamurthy, P., Beckham, E., Meckel, T., and Sepehrnoori, K., 2021, Carbon dioxide storage in deltaic saline aquifers: invasion percolation and compositional simulation: Society of Petroleum Engineers Reservoir Evaluation & Engineering, v. 24, no. 3, article no. SPE-196723-PA, 13 p., http://doi.org/10.2118/196723-PA

Abstract:

Storage of large amounts of carbon dioxide (CO_2) within deep underground aquifers has great potential for long-term mitigation of climate change. The U.S. Gulf Coast is an attractive target for CO_2 storage because of the favorable formation properties for injection and containment of CO_2. Deltaic formations are one of the primary targeted depositional environments in the Gulf Coast. In this paper, we investigate CO_2 storage in deltaic saline aquifers through a combination of geological modeling and flow simulation. The approach presented in this paper based on a combination of invasion percolation and compositional reservoir simulation focuses on buoyancy-dominant flow of CO_2 in the long term and its pressure-driven flow in the short term. The results provide insights into how to screen and identify prospective locations for CO_2 storage and determine the underlying geological features controlling CO_2 migration for a basin-scale study.

The geological model in our study is developed based on a laboratory-scale three-dimensional (3D) flume experiment replicating the formation of a delta structure and populated with geologic properties according to Miocene Gulf of Mexico natural analogues. We used invasion percolation simulations to understand the buoyancy-driven flow and the relationship between architecture, stratigraphy, and fluid migration pathways. The results were used to develop an upscaled model for compositional simulation with the key features of the original geological model and to determine injection schemes that maximize the injection capacity and minimize the amount of mobile CO_2 in the formation. To achieve this, we used compositional reservoir simulations to study the pressure-driven flow and phase behavior.

The results of invasion percolation simulations were used to identify the key stratigraphic units affecting CO2 migration. The realistic geometries and high resolution of the model facilitate the transfer of results from synthetic to subsurface data. The results allow for the analysis of deltaic depositional environments, important stratigraphic surfaces, and their impact on CO2 storage. The reservoir simulation model and phase behavior were validated against available field and laboratory data. The results of reservoir simulations were used to investigate the effects of main mechanisms, such as gas trapping and solubilization, on storage capacity. We compared our simulation results based on invasion percolation (buoyancy driven) and reservoir simulation (pressure driven). The comparison is helpful to understand the strengths and weaknesses of each approach and determine best practices to evaluate CO2 migration within similar formations.

The unique and extremely well-characterized deltaic model allows for unprecedented representation of the depositional aquifer architecture. This research combines geologic modeling, flow simulation, and application for CO2 storage. The integrated conclusions will constrain predictions of actual subsurface flow performance and CO2 storage capacity in deltaic systems while identifying potential risks and primary stratigraphic migration pathways. This research provides insights on prediction of CO2 storage performance and characterization of prospective saline aquifers.