Exploring the potential of carbon capture and storage-enhanced oil recovery as a mitigation strategy in the Colombian oil industry

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Abstract

Storage of large amounts of 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. This paper investigates CO_2 storage in deltaic saline aquifers through a combination of geological modeling and flow simulation.

The geological model in our study is developed based on a laboratory-scale 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 gravity- 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. In order 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 CO_2 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 CO_2 storage. The reservoir simulation model and phase behavior were validated against available field and lab 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 on the basis of invasion percolation (gravity 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 CO_2 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 CO_2 storage. The integrated conclusions will constrain predictions of actual subsurface flow performance and CO_2 storage capacity in deltaic systems, while identifying potential risks and primary stratigraphic migration pathways. This research gives insights on prediction of CO_2 storage performance and characterization of prospective saline aquifers.