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ORIGINAL ARTICLE

Site characterization for CO_2 geologic storage and vice versa: the Frio brine pilot, Texas, USA as a case study

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Abstract Careful site characterization is critical for successful geologic storage of carbon dioxide (CO_2) because of the many physical and chemical processes impacting CO_2 movement and containment under field conditions. Traditional site characterization techniques such as geological mapping, geophysical imaging, well logging, core analyses, and hydraulic well testing provide the basis for judging whether or not a site is suitable for CO_2 storage. However, only through the injection and monitoring of CO_2 itself can the coupling between buoyancy flow, geologic heterogeneity, and history-dependent multi-phase flow effects be observed and quantified. CO_2 injection and monitoring can therefore provide a valuable addition to the site-characterization process. Additionally, careful monitoring and verification of CO_2 plume development during the early stages of commercial operation should be performed to assess storage potential and demonstrate permanence. The Frio brine pilot, a research project located in Dayton, Texas (USA) is used as a case study to illustrate the concept of an iterative sequence in which traditional site characterization is used to prepare for CO_2 injection and then CO_2 injection itself is used to further site-characterization efforts, constrain geologic storage potential, and validate understanding of geochemical and hydrological processes. At the Frio brine pilot, in addition to traditional site-characterization techniques, CO_2 movement in the subsurface is monitored by sampling fluid at an observation well, running CO_2-saturation-sensitive well logs periodically in both injection and observation wells, imaging with crosswell seismic in the plane between the injection and observation wells, and obtaining vertical seismic profiles to monitor the CO_2 plume as it migrates beyond the immediate vicinity of the wells. Numerical modeling plays a central role in integrating geological, geophysical, and hydrological field observations.

Keywords Geologic carbon dioxide storage · Site characterization · Multi-phase flow · Numerical modeling · Frio Formation

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Introduction

Successful geologic storage of CO_2 requires thorough site characterization, especially for storage in saline formations that have not previously been considered an economic resource. It is important to understand the processes and mechanisms by which CO_2 is transported, in light of its low density and viscosity compared to brine, and the diverse geochemical processes that can occur. Traditional site characterization techniques, such as geological mapping, geophysical imaging, well logging, core analyses, and hydraulic well testing form the foundation for assessing site suitability. However, the injection and monitoring of CO_2 itself provides a wealth of additional information, illustrating the coupling between buoyancy flow, geologic heterogeneity, and history-dependent multi-phase flow effects, factors which may ultimately determine the viability of a potential storage site.

We therefore recommend that after traditional site characterization activities (e.g., geologic, geophysical, and hydraulic testing) have been used to assess site suitability for subsurface storage of CO_2, reservoir models be reassessed