

Gas-water-rock interactions in Frio Format on following CO₂ injection: implications for the storage of greenhouse gases in sedimentary basins

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Abstract:

To investigate the potential for the geologic storage of CO₂ in saline sedimentary aquifers, 1600 t of CO₂ were injected at 1500 m depth into a 24-m-thick sandstone section of the Frio Formation, a regional brine and oil reservoir in the U.S. Gulf Coast. Fluid samples obtained from the injection and observation wells before CO₂ injection showed a Na-Ca-Cl-type brine with 93,000 mg/L total dissolved solids (TDS) at near saturation with CH₄ at reservoir conditions. Following CO₂ breakthrough, samples showed sharp drops in pH (6.5–5.7), pronounced increases in alkalinity (100–3000 mg/L as HCO₃) and Fe (30–1100 mg/L), and significant shifts in the isotopic compositions of H₂O, dissolved inorganic carbon (DIC), and CH₄. Geochemical modeling indicates that brine pH would have dropped lower but for the buffering by dissolution of carbonate and iron oxyhydroxides. This rapid dissolution of carbonate and other minerals could ultimately create pathways in the rock seals or well cements for CO₂ and brine leakage. Dissolution of minerals, especially iron oxyhydroxides, could mobilize toxic trace metals and, where residual oil or suitable organics are present, the injected CO₂ could also mobilize toxic organic compounds. Environmental impacts could be major if large brine volumes with mobilized toxic metals and organics migrated into potable groundwater. The $\delta^{18}\text{O}$ values for brine and CO₂ samples indicate that supercritical CO₂ comprises ~50% of pore-fluid volume ~6 mo after the end of injection. Postinjection sampling, coupled with geochemical modeling, indicates that the brine gradually will return to its preinjection composition.

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