

INJECTION OF CO₂ WITH H₂S AND SO₂ AND SUBSEQUENT MINERAL TRAPPING IN A SANDSTONE-SHALE FORMATION

Tianfu Xu, John A. Apps, and Karsten Pruess

Contact: Tianfu Xu, 510/486-7057, Tianfu_Xu@lbl.gov

RESEARCH OBJECTIVES

Carbon dioxide (CO₂) injection into deep geologic formations can potentially reduce atmospheric emissions of greenhouse gases. Sequestering less-pure CO₂ waste streams (containing H₂S and/or SO₂) would require less energy than separating CO₂ from flue gas. The long-term interaction of these injected acid gases with shale-confining layers of a sandstone injection zone has not been well investigated. We therefore have developed a conceptual model of CO₂ injection with H₂S and/or SO₂ into a sandstone-shale sequence, using hydrogeologic properties and mineral compositions commonly encountered in Gulf Coast sediments of the United States.

APPROACH

We have performed numerical simulations of a 1-D radial well region considering sandstone alone, and a 2-D model using a sandstone-shale sequence under acid-gas injection conditions. The reactive fluid flow and geochemical transport simulator TOUGHREACT was used for these simulations. We considered the presence of organic matter, the kinetics of chemical interactions between the host rock minerals and the aqueous phase, and CO₂ solubility dependence on pressure, temperature, and salinity of the system.

ACCOMPLISHMENTS

The co-injection of H₂S, compared to injection CO₂ alone, does not significantly affect pH distribution and the mineral alteration pattern. The co-injection of SO₂ results in a different pH distribution and mineral alteration pattern. A zonal distribution of mineral alteration and formation of CO₂ and sulfur-bearing minerals has been observed in the simulations, which reflects the pH distribution. Co-injection of SO₂ results in a larger and stronger acidified zone (as low as a pH of 0.6). Corrosion and well abandonment problems will be a very significant issue for SO₂ injection. Most CO₂ is trapped by precipitation of ankerite and

dawsonite, with some in siderite. Using conditions and parameters presented in Xu et al. (2005), a CO₂ mineral trapping capability after 10,000 years can reach about 80 kg per cubic meter of medium. The CO₂ trapping capability depends on the primary mineral composition. For example, precipitation of siderite and ankerite requires Fe²⁺ supplied by the dissolution of primary iron-bearing minerals. Most of the sulfur is trapped by alunite precipitation, some by anhydrite, and some still smaller amount by pyrite. Precipitation of these sulfur-bearing minerals occurs primarily during the injection operation period, because the SO₂

inventory is very small (1 wt.% of CO₂ injected in the simulations). Adding acid gases leads to increases in porosity close to the well, caused by mineral dissolution, and decreases at distances, resulting from CO₂ trapping. The simulated mineral alteration pattern is generally consistent with available field observations of natural CO₂ reservoirs.

SIGNIFICANCE OF FINDINGS

The effects of co-injection of H₂S and SO₂ on CO₂ geological sequestration is evaluated, and CO₂ mineral trapping capability is estimated. The "numerical experiments" give a detailed understanding of the acid gas injection system.

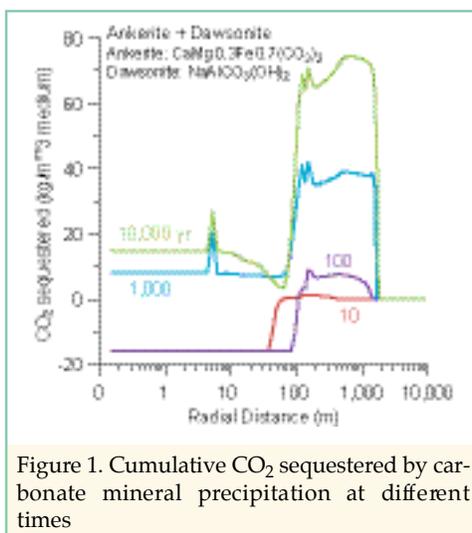


Figure 1. Cumulative CO₂ sequestered by carbonate mineral precipitation at different times

RELATED PUBLICATION

Xu, T, J. A. Apps, K. Pruess, and H. Yamamoto, Injection of CO₂ with H₂S and SO₂ and subsequent mineral trapping in sandstone-shale formation. Berkeley Lab Report LBNL-57426, 2005.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy, under Contract No. DE-AC03-76SF00098 with Lawrence Berkeley National Laboratory.

