Impact of Microstructure on the Containment and Migration of CO_2 in Fractured Basalts

Award Number: DE-FE0023382

Project Summary:

The objective of this project was to advance the scientific and technical understanding of fracture microstructure on the flow and mineralization of carbon dioxide (CO_2) injected into fractured basalt. The project combined bench-scale CO_2-water-rock testing, geochemical characterization of rock cores, and advanced characterization of the evolution of fracture structure and carbon trapping mechanisms. This project contributed to the Carbon Storage Program goals of improving reservoir storage efficiency while ensuring containment effectiveness and predicting CO_2 storage capacity in geologic formations to within ±30%.

Prime Performer:
Washington University

Principal Investigator:
Daniel Giammar

Project Duration:
10/1/2014 – 3/31/2018

Performer Location:
St. Louis, Missouri

Program:
Carbon Transport & Storage

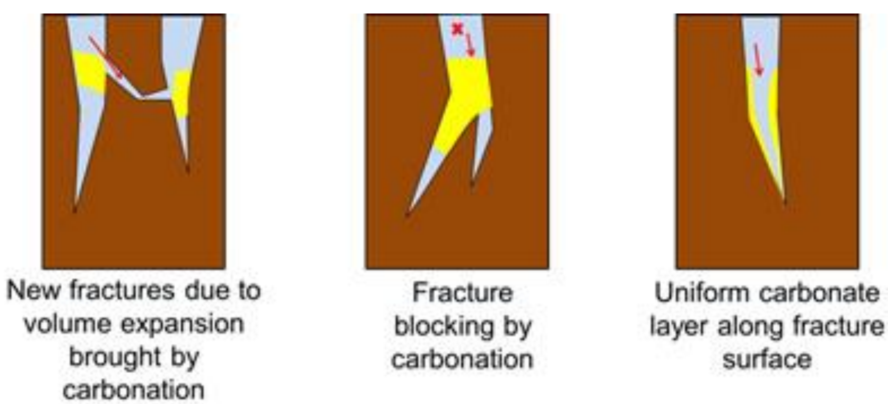

Figure 1: Three different possible carbonation scenarios within fractures in basalts. The carbonation is the result of chemical precipitation from interactions between the minerals in the basalt and injected CO_2. Each scenario will affect the carbonation by either impeding or accelerating storage

Project Outcomes:

The project demonstrated the value in combining X-ray computed tomography imaging, electron microscopy, and Raman spectroscopy to determine the locations, morphology, and identity of carbonate minerals that form in laboratory samples. A novel nuclear magnetic resonance probe was developed that can provide real-time information on carbon speciation in minerals in contact with CO_2-rich solutions while those reactions are progressing at elevated pressure and temperature. Reactive transport modeling was performed, and it was determined that the formation of carbonate minerals in basalts subjected to injection of CO_2-rich aqueous solutions can be rapid and extensive. Results also indicated that pyroxene should be considered as the target mineral for carbon storage in basalts with larger modal volumes of pyroxene. Researchers concluded that it is unlikely that significant mineralization will occur near wellbores or along interconnected fracture pathways due to strong advective flow of CO_2-acidified solutions. Rather, CO_2 mineral carbonation is most likely to occur in dead-end fractures, at distances further away from the wellbore where advective forces may be less dominant, or long after injection has ceased.

Presentations, Papers, and Publications

Final Report: **Impact of Microstructure on the Containment and Migration of CO_2 in Fractured Basalts** (July 2018) Daniel Giammar, Brian Ellis, Sophia Hayes, Phillip Skemer, Anne Menefee, Erika Sesti, Rachel Wells, Wei Xiong