Reactive Transport Models with Geomechanics to Mitigate Risks of CO_2 Utilization and Storage

Award Number: DE-FE0009773

Prime Performer:
University of Utah

Key Performers:
Idaho National Laboratory

Principal Investigator:
Milind Deo

Project Duration:
10/1/2012 – 12/31/2015

Performer Location:
Salt Lake City, Utah

Program:
Carbon Transport & Storage

Project Summary:

The overall goal of the project was to develop a validated carbon dioxide (CO_2) subsurface model that combines the CO_2 reactive transport and reservoir mechanics with the intention of performing more physics-based simulations and predictions of coupled thermal-hydro-mechanical-reaction behaviors due to CO_2 injection. The project aimed to add the phenomena of petrophysical changes due to dissolution or precipitation of materials to the models while coupling the Idaho National Laboratory's discrete element method-based models with the University of Utah's flow models to add the capability of geomechanics to CO_2-based reactive transport. Iterative coupling and implicit (simultaneous) coupling were utilized. In addition, high-temperature, high-pressure core floods on three different rock types were performed and changes in porosities and permeabilities were visualized using micro-computed tomography (CT) visualization to compare model results with experiments.

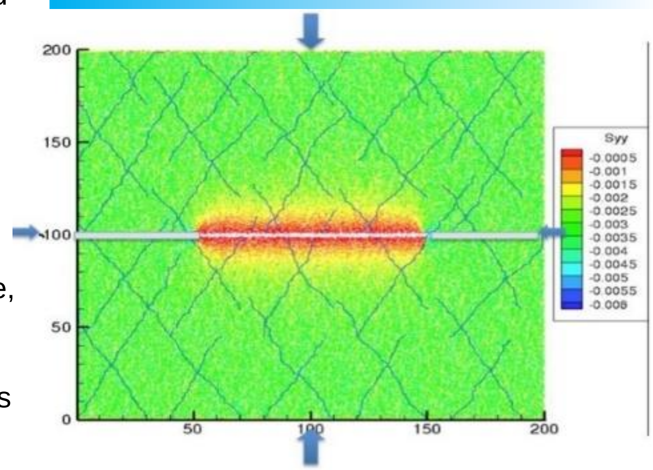

Figure 1: Synthetic fractured reservoir with a horizontal injection well. The color scales with the vertical stress. Fractures are colored by their initial permeability.

Project Outcomes:

This project examined if the reactions between CO_2, brine, and rocks affect the nature of the porous medium and properties including petrophysical properties by carrying out experiments at sequestration conditions (2000 pounds per square inch [psi] for coreflood tests and 2400 psi for batch experiments, at 600°C) with sandstone, limestone, and dolomite. Experiments were performed in batch mode and core floods were conducted over a two-week period. Batch experiments were performed with samples of differing surface area to understand the impact of surface area on overall reaction rates. Toughreact, a reactive transport model, was used to interpret and understand the experimental results. The role of iron in dissolution and precipitation reactions was observed to be significant, as siderite and ankerite, iron containing minerals, dissolution resulted in changes in porosity and permeability. The results indicated that during injection operations mineralogical changes may lead to injectivity enhancements near the wellbore and petrophysical changes elsewhere in the system. Limestone and dolomite cores showed consistent dissolution at the entrance of the core, indicating that near wellbore dissolution in these rock-types may lead to rock failure. Micro-CT images of the cores before and after the experiments revealed that an initial high-permeability pathway facilitated the formation of wormholes. A field-scale model of reactive transport and geomechanics that considers complex chemistry, interactions of natural fractures and faults, and poroelastic geomechanical factors was developed at Idaho National Laboratory.

Presentations, Papers, and Publications

Final Report: Reactive Transport Models with Geomechanics to Mitigate Risks of CO_2 Utilization and Storage (March 2016) Milind Deo, Hai Huang, Hyukmin Kweon, and Luanjing Guo.