Model Complexity and Choice of Model Approaches for Practical Simulations of CO_2 Injection, Migration, Leakage, and Long-term Fate

Award Number: DE-FE0009563

Project Summary:

The main goal of this project was to assemble a set of modeling approaches relevant to geologic carbon storage (GCS) across the spectrum of model complexity, and to determine the applicability of these modeling approaches to different conditions and questions relevant to GCS. In addition, two new modeling approaches were developed during this project to fill in gaps in the model complexity spectrum. The following five existing modeling approaches were also considered in this project: (1) fully coupled models, (2) simplified 3D, (3) vertically integrated vertical equilibrium models, (4) single-phase models, and (5) macroscopic invasion percolation models. This exercise demonstrated the degree to which models of different complexity can be used to address design and optimization issues associated with placement and scheduling of injection, extraction, and observation wells. This project focused on developing and assessing the applicability of reservoir process models having different degrees of complexity.

Prime Performer:
Princeton University

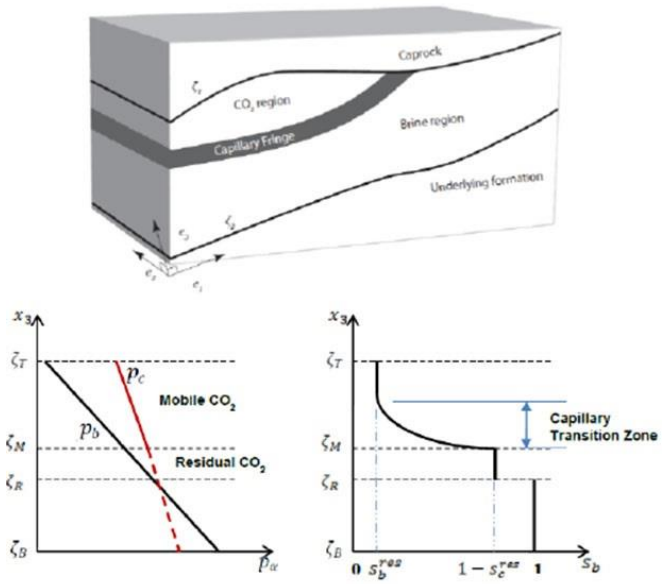
Principal Investigator:
Michael Celia

Project Duration:
10/01/2012 – 9/30/2016

Performer Location:
Princeton, New Jersey

Program:
Carbon Transport & Storage

Figure 1: Schematic of typical injection formation (top), pressure distribution under vertical equilibrium (bottom left), and associated saturation profile (bottom right).



Project Outcomes:

The applicability of the modeling approaches mentioned above to GCS modeling was investigated based on five example sites (Sleipner, In Salah, Basal Cambrian Aquifer, Ketzin, and Kimberlina). A set of modeling approach guidelines was formulated based on this project. Two new modeling approaches were investigated to fill gaps in the model complexity spectrum: vertical dynamic reconstruction and macroscopic invasion percolation with viscous effects. This research resulted in the following conclusions: (1) single-phase models are the appropriate choice for basin-wide pressure response modeling, (2) vertical equilibrium models should be used when multi-phase flow effects cannot be neglected and vertical permeability is higher than 100 millidarcy (mD), and (3) the new vertical dynamic reconstruction approach is appropriate when vertical segregation dynamics need to be included and vertical flow due to heterogeneity in formation parameters is low. It was also observed that simplified 3D models are best used with complex 3D flow dynamics, and the fully coupled 3D models should only be used if there is significant two-way coupling between flow and geochemistry or geomechanics. This research found that macroscopic invasion percolation models are not appropriate for GCS modeling except under specialized

Presentations, Papers, and Publications

Final Report: Model complexity and choice of model approaches for practical simulations of CO_2 injection, migration, leakage and long-term fate. (December 2016) Michael A. Celia