Multiscale Modeling of Carbon Dioxide Migration and Trapping in Fractured Reservoirs with Validation by Model Comparison and Real-Site Applications

Award Number: DE-FE0023323

Project Summary:

The project sought to develop new modeling approaches to improve the accuracy of modeling carbon dioxide (CO_2) and brine migration and CO_2 storage in fractured reservoirs by including interactions of flow in fractures and in the rock matrix. The primary objectives of the project were to develop new mass transfer functions for CO_2 and brine and a new vertically integrated modeling approach for fractured reservoirs, and use these to investigate CO_2 storage capacity and trapping efficiency in site-scale fractured reservoirs with various sensitivity analyses, predict CO_2 migration and trapping at the In Salah storage site, and conduct sensitivity analysis of fracture matrix interactions.

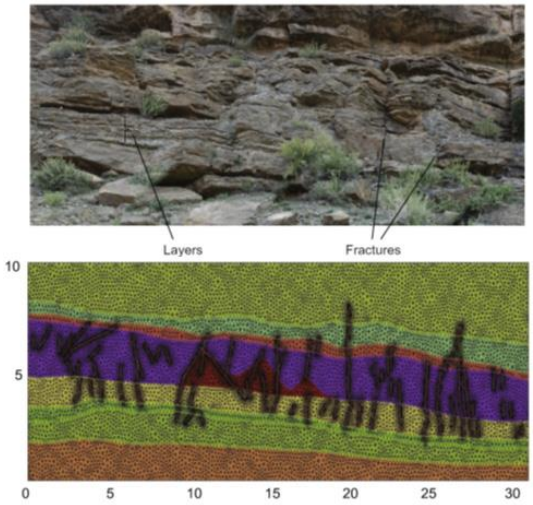

Figure 1: Image of an outcrop (top) with layering and fractures identified. Understanding the fracture network is an important function in developing the discrete fracture model (bottom) that is the initial step in the development of the project's multiscale model.

Prime Performer:
Princeton University

Principal Investigator:
Michael Celia

Project Duration:
10/1/2014 – 9/30/2018

Performer Location:
Princeton, New Jersey

Field Sites:
In Salah Field Site, Algeria

Program:
Carbon Storage

Project Outcomes:

In this project new mass transfer functions were developed for both free-phase and dissolved CO_2, which may be an important storage mechanism in fractured reservoirs with low permeability or high capillary entry pressure of the rock matrix, to enable dual-continuum approaches to be applied to CO_2-brine systems. A new vertically-integrated dual-continuum modeling approach was also developed which takes advantage of the large density difference between CO_2 and brine (~500 kg/m^3) and the expected high permeability of the fractures. Newly developed and existing models were used to conduct several sensitivity analyses to better understand geologic carbon storage in fractured reservoirs and to investigate conditions favorable for CO_2 storage in fractured reservoirs. The newly developed modeling capabilities were demonstrated by simulating CO_2 migration at the In Salah site, where CO_2 was injected into a fractured reservoir for six years. Overall, the results of this project show that dual-continuum modeling approaches are well suited for modeling of geologic carbon storage in naturally fractured reservoirs.

Presentations, Papers, and Publications

Final Report: Multiscale Modeling of CO_2 Migration and Trapping in Fractured Reservoirs with Validation by Model Comparison and Real-Site Application (January 2019) Karl Bandilla, Michael Celia, Florian Doster, Quanlin Zhou