Contribution ID: **64** Type: **Oral 20 Minutes**

Modeling CO2 Storage in Fractured Reservoirs: Fracture-Matrix Interactions of Supercritical and Dissolved CO2

Monday, 14 May 2018 09:45 (15 minutes)

The injection and storage of supercritical CO2 (scCO2) have been conducted in fractured sandstone reservoirs at In Salah, Algeria and Snøhvit, Norway, and planned in fractured sandstone, carbonate, and dolomite reservoirs at Longyearbyen, Norway, Hontomin, Spain, and Kevin Dome, USA, respectively, with matrix permeability varying from 0.01 to 60 md. For densely fractured reservoirs with low matrix permeability (e.g., at Longyearbyen, Norway), injected scCO2 can dissolve into the resident brine at fracture-matrix interfaces and the dissolved CO2 (dsCO2) can diffuse into the rock matrix making solubility trapping the dominant trapping mechanism. For fractured reservoirs with intermediate matrix permeability (e.g., at In Salah, Algeria), the storage of scCO2 in the rock matrix dominates with strong fracture-matrix interactions observed through field monitoring at In Salah. We developed a comprehensive conceptual model for enhanced CO2 storage to account for global migration of scCO2 in the fracture continuum, local storage of scCO2 and dsCO2 in the matrix continuum, driving forces for scCO2 invasion and dsCO2 diffusion from fractures, and brine outflow through connected matrix blocks.

For the dominant matrix scCO2 storage, we developed high-resolution fracture-matrix models for individual matrix blocks, homogeneous columns of fractures and matrix blocks, and heterogeneous REVs consisting of multiple columns of matrix blocks with varying flow properties and sizes. The multiscale modeling results show that the equilibrium efficiency of local scCO2 storage strongly depends on matrix entry capillary pressure, matrix-matrix connectivity, and reservoir thickness, while dynamic efficiency and transfer function are also sensitive to fracture spacing and matrix flow properties. The transfer functions calculated for various REVs were used along with reservoir-scale dynamics of scCO2 plume flow in fractures, showing that the preferential migration of scCO2 through fractures is coupled with bulk dsCO2 storage in the rock matrix that in turn retards the scCO2 fracture plume. The bulk matrix storage is mainly driven by buoyancy between fracture scCO2 and matrix brine and facilitated by matrix-matrix connectivity that allows displaced brine to outflow, enabling the rock matrix to act like an open system. Conventional dual-continuum models cannot capture these processes because they model isolated matrix blocks with no capillary continuity, thereby underestimating storage efficiency.

For the dominant matrix dsCO2 storage, we developed the unified-form equations of diffusive flux of dsCO2 into brine-bearing matrix blocks of varying shapes (i.e., spheres, cylinders, slabs, squares, cubes, rectangles, and rectangular parallelepipeds) and sizes (Zhou et al., 2017a, b). We then applied the flux equations to a fractured reservoir with various scenarios of matrix blocks by assuming 1-D and 2-D radial scCO2 flow in fractures and by using diffusion of dsCO2 from fracture-matrix interfaces into matrix blocks as the sink for scCO2 in fractures. For each scenario, the dynamic dsCO2 plume with different mass fraction was produced analytically, showing that solubility trapping is significant in fractured reservoirs with low matrix permeability and small fracture spacing.

References

Zhou, Q., C.M. Oldenburg, J. Rutqvist, J.T. Birkholzer, 2017. Revisiting the fundamental analytical solutions of heat and mass transfer: The kernel of multirate and multidimensional diffusion, Water Resources Research doi: 10.1002/2017WR021040.

Zhou, Q., C.M. Oldenburg, L.H. Spangler, and J.T. Birkholzer, 2017. Approximate solutions for diffusive fracture-matrix transfer: Application to storage of dissolved CO2 in fractured rocks, Water Resources Research, 53(2), 1746–1762, doi:10.1002/2016WR019868.

Acceptance of Terms and Conditions

Click here to agree

Primary authors: ZHOU, Quanlin (Lawrence Berkeley National Laboratory); Dr OLDENBURG, Curtis M. (Lawrence Berkeley National Laboratory); Dr BIRKHOLZER, Jens T. (Lawrence Berkeley National Laboratory)

Presenter: ZHOU, Quanlin (Lawrence Berkeley National Laboratory)

Session Classification: Parallel 1-A

Track Classification: MS 3.11: fundamental aspects of geological storage of CO2