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Modeling the evolution of fractured media using a multiscale approach

Friday, 4 June 2021 15:15 (15 minutes)

Understanding the evolution of fractured media is essential in many subsurface energy applications, including subsurface storage, shale gas production, fracking, CO2 sequestration, nuclear waste storage, and geothermal energy extraction. This evolution is the result of coupled flow, transport, reaction and geomechanical processes and is affected by both the physical and mineralogical heterogeneity of fractured media.

Here we focus on the geochemically driven evolution of fractured media and the role of transport processes. In the fracture opening, the transport of solutes is determined by the dynamics of flow in the complex geometry of the fracture. In the matrix bordering the fracture, reactions with the solid phase and solute transport through the porous medium are affected by the heterogeneity in the mineralogical composition of the matrix and in the porous medium properties. The evolution brought on by the dissolution-precipitation reactions may result in further enhancement of this heterogeneity. This includes the development of an altered layer in the matrix bordering the fracture, with heterogeneous porosity, tortuosity and permeability, and widening/narrowing of the fracture opening.

In this work, we develop a model of fracture evolution that conceptualizes the fractured medium as a multiscale medium composed of a fracture (or fractures) and a porous matrix. Fracture processes are described with a pore-scale model, while matrix processes are described with a porous medium model. The model is implemented in the Chombo-Crunch reactive transport code (Molins et al. 2012; Trebotich et al. 2014; Molins et al. 2014, 2017, 2019, 2020). We use this model to simulate CO2 attack on fractured cementitious media. The geochemical problem follows from experimental and modeling work by (Li, Steefel, and Jun 2017). Flow of a CO2-rich solution in the fracture is followed by the alteration of the cementitious matrix as the invading solution diffuses into the matrix. Both precipitation and dissolution reactions take place resulting in increases and decreases in porosity locally. In contrast to previous work, consideration of flow and transport processes in the fracture (both over its width and along its length) makes it possible to capture the heterogeneous evolution of the matrix not only in the direction perpendicular to the fracture but also parallel to the fracture.

Time Block Preference

Time Block C (18:00-21:00 CET)

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Primary authors: MOLINS, Sergi (Lawrence Berkeley National Laboratory); TREBOTICH, David (Lawrence Berkeley National Laboratory); STEEFEL, Carl (Lawrence Berkeley National Laboratory)

Presenter: MOLINS, Sergi (Lawrence Berkeley National Laboratory)

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