The Role of Fractures in the Flow and Transport Properties of Rock: A Basic Energy Sciences Project

Pore fluid flow within fractured rocks is a subject of primary importance to various fields of study including hazardous waste isolation and remediation, oil and gas production, geothermal energy extraction, and formation of vein fillings and ore deposits. For these reasons, considerable effort has been directed toward the characterization and modeling of flow in fractures and fracture systems. We are investigating the complex active chemical interaction between pore fluid and fractures that causes the fluid composition and fracture surface topography of these systems to change over time.

Our experimental model consists of gypsum samples pressed with a constant force against an inert textured fracture surface. Pore fluids ranging from unsaturated to supersaturated, which are at a variety of flow rates, are introduced to one end of the sample in order to actively alter the topography of the gypsum surface. Using a laser profiler, we are able to quantitatively monitor the changing surface topography over time as it relates to the measured sample permeability and calcium saturation of the pore fluid. These methods allow us to create and analyze many features seen in natural fractures, including high-flow dissolution channels, plateaus, and caverns formed in the precipitate. In addition, the laser profile of the sample surface can be used to produce a map of aperture across the sample. Using this information, we have applied numerical modeling via finite difference and lattice Boltzmann (LB) methods to calculate pore fluid flow direction and magnitude over the entire sample surface.

We find that when experimental parameters (e.g. initial surface topography, flow rate history, and total experimental time) are duplicated, the topography developed on the plaster sample is reproducible. The flow channel networks, as observed visually and through numerical simulations, evolves from a homogeneous system to one more (self) organized and complex. The permeability initially drops as the experiment begins and the surfaces settle into

  contact: *sbrown@ner.com*

place, then gradually rises with several further smaller decreases as some supporting asperities are destroyed. LB methods predict the formation of major dissolution features, such as long “stringers” in the lee of obstacles.

LB predicts that dendrites may grow along fracture surfaces under saturated conditions. This form of growth can be the major cause of decreasing permeability, even when the added solid fraction is small. LB predicts dendrites will grow toward time-varying regions of fast flow, a prediction borne out by previously published experiments.