Effect of Fracture Aperture Variations on the Dispersion of Contaminants

Arturo A. Keller[1], Paul V. Roberts[2], Martin J. Blunt[3]

[1]Bren School of Environmental Science and Management
University of California, Santa Barbara
Santa Barbara, CA 93106

[2]Civil and Environmental Engineering Dept.
Stanford University
Stanford , CA 94305

[3]Petroleum Engineering Dept.
Stanford University
Stanford , CA 94305-2220

Abstract

Dispersion of dissolved contaminants in fractured rocks is strongly dependant on the variability of fracture aperture. Large fracture aperture regions result in significant channeling of the fluid flow, accelerating the movement of solutes in a particular direction, which may differ locally with respect to the main flow direction from high to low hydraulic potential. This may result in very early breakthrough of the contaminants, significantly earlier than in the conventional "parallel plate" simplification of fluid flow in fractured systems. In addition, flow and transport in the low aperture regions can be orders of magnitude smaller, which has major implications for remediating contaminated fractured media. In this study, we observed the transport of a non-sorbing solute in a naturally fractured rock which was characterized at very high resolution using Computed Tomography (CT) scanning to determine the fracture aperture distribution. We compared the observed breakthrough curve of the solute at various flowrates with the predicted breakthrough curve using the fracture's geostatistics and small perturbation analysis, as well as direct numerical simulation of flow through the fracture using the measured fracture aperture distribution. The experimentally determined fracture transmissivity and dispersivity are within a factor of two from those predicted using either the small perturbation approach (using the fracture geostatistics) or explicit numerical modeling of breakthrough, which differ by around 20%, indicating that the geostatistics of the fracture aperture can be used to predict the approximate shape of the breakthrough curve for a fracture.