Modeling Fingering at a Continuum Scale: A Stochastic Lagrangian Approach

K. S. Barnhart[1], D. W. Dean, and T. H. Illangasekare
Center for Experimental Study of Subsurface Environmental Processes (CESEP), Colorado School of Mines, Golden, Colorado

Abstract. A key factor in removing contaminants from hazardous waste sites is subsurface knowledge about the location of these hazardous materials. This is complicated because soil heterogeneities, even small ones, can cause irregular behavior of the contaminant plume due to capillary effects. One such phenomenon is the development of fingers -- an unpredictable propagation of the macroscopic interface between two fluids due to an instability at the interface. Although the instability can occur due to a number of factors, this work focuses on fingering that develops because of microscopic variations in the pore structure at the interface between sand layers. Prediction of such a process at the Darcian scale is difficult because estimating where the instabilities will occur requires detailed, unavailable information about the pore structure. This suggests a probabilistic approach. It is presupposed that there is a quantifiable relationship between the grain size distribution and pore size distribution in sands. By sampling from this distribution, an algorithm is presented which determines where fingering will occur. This stochastic element is added onto a continuum scale stochastic differential equation model[2] and describes how Lagrangian fluid particles are able to percolate in a manner similar to the fingering process. Numerical results are given as well as a discussion about difficulties concerned with modeling such phenomenon using typical numerical tactics.

[1] Colorado School of Mines
Division of Environmental Science and Engineering
1500 Illinois St
Golden, CO 80401
Tel: (303) 273-3483
Email: kbarnhar@mines.edu

[2] Dean, D. W. and T. F. Russell, *A Stochastic Differential Equation Approach To Multiphase Flow In Porous Media*, UCD/CCM Report No. 22X, June, 2005