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Experimental and numerical study of colloid transport in a fractured rock sample

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In fractured rocks with low matrix permeability, fluid flow and transport are dominated by flow paths that occupy discrete fracture networks. In these systems fractures act as the main channels for the distribution of fluids and for the migration of pollutants, solid particles (colloids), and microorganisms. An accurate understanding of how fluid flows through fractures is fundamental to protecting groundwater against contamination, assessing the safety of long-term hazardous waste sites, and determining remediation strategies for contaminated sites. In this paper we explore the influence of the geometry and distribution of surface roughness on the directional anisotropy of fluid flow and transport properties of natural fractures. For this study, a Phoenix v|tome|x s 240 micro X-ray Computed Tomography (CT) system is used to obtain high-resolution 3D geometry of a fractured sample. The geometry of the fractures and their aperture spatial distribution was input into directly coupled numerical model of fluid flow and transport. We simulated the transport of particles through the fracture and, as suggested data collected during laboratory flow tests, found significant sensitivity of the particle breakthrough to flow direction of the fracture. Particles were observed to be trapped in low velocity and recirculation zones (named as trapping areas) on the lee side of fracture walls. These observations have significant implications for quantifying the transport of dissolved and solid phase materials through fractured rock. The results also show a promising venue for the use of micro-CT technique for obtaining the real geometry of fractured samples and the use of these data as input for numerical modeling. Moreover, micro-CT data allow to map the real micro-structure of the fracture surface, allowing for more in depth study on the effect of mineral composition on the growth of biofilm colonies.

Keywords: lattice Boltzman, micro CT, colloid transport, roughness, fracture