



Estimation of DNAPL dissolution stage from aqueous phase concentrations in rough-walled fractures

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Contamination of dense non-aqueous phase liquids (DNAPLs) poses a serious environmental problem. Because of higher density of DNAPLs than water, they migrate downward through water table, finally entering the fractures where they tend to be trapped as residual phases by capillary resistance of smaller apertures. It has been reported that many industrial complexes in Korea, placed on the fractured bedrock, have been contaminated by DNAPLs. Due to the way DNAPLs are discontinuously in small quantity at unfixed spots even within the site in Korea, DNAPL sources tend to exist scattered in the subsurface environment and are almost impossible to locate, especially in fractured bedrocks. Furthermore, DNAPL contamination is often found after a long period of time has passed since the contamination started. These characteristics of DNAPL contamination make it very difficult to infer DNAPL source configuration, which consequently leads to considerable uncertainties about the effective management and remediation of DNAPL contaminated site. This study aims to figure out DNAPL source zone configuration in rough-walled fractures, in particular dissolution stage of DNAPL, from downgradient aqueous phase concentrations. Interpretation and estimation of the dissolution stage are very important for the design and required time of site remediation. Numerical works have been systematically conducted with a single rough-walled fracture to investigate the interrelationship between DNAPL architecture and downgradient aqueous-phase contaminant concentrations. The finite element code was programmed for fluid flow and solute transport through a rough-walled fracture, which was incorporated with the dissolution kinetics. DNAPL is emplaced as residual phase in a rough-walled fracture with variable apertures measured from a real rock fracture, and the mass transfer is allowed to take place at the interface between DNAPL and flowing groundwater. The aqueous phase contaminant transports with groundwater through a rough-walled fracture, the concentrations of which are monitored at the downgradient. The breakthrough curve from aqueous-phase contaminant concentrations varies depending on DNAPL architecture such as residual saturation and blob size, groundwater velocity, and sampling point, each of which will be evaluated on its influence on the breakthrough curve. Then, the derivative analysis for the breakthrough curve will be conducted for producing the type curve with which the dissolution stage can be estimated.