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Physically based model for extracting dual permeability parameters using non-Newtonian fluids

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The complexity of pore structure in soils, fractured rocks, or porous media in general poses a major challenge to classic flow and transport methods. Dual permeability models evolved as effective tools capable of accounting for macro and micro structures. For that, different methods were developed to describe hydraulic characteristics of soils with two dominant structures. However, those models require additional parameters that should ideally be determined through affordable, simple, and non-destructive procedures. We utilize water and a non-Newtonian fluid in saturated flow experiments to develop a dual-permeability model that physically predicts the micro and macro structures of porous dual-structured soils. The objective of the study is to test the ability of these two fluids to accurately derive two physically-based average radii representing the bimodal pore size distributions in dual-domain soils. We developed two sub-models to determine the effective pore sizes of macropores and micropores. We assumed that macropores have either cylindrical (e.g., biological pores) or planar (e.g., shrinkage cracks and fissures) pore geometries, with the micropores assumed to be represented by a single effective radius. Furthermore, the model determines the percent contribution (wi) of the representative macro and micro pores to water flow. A user-friendly solver was developed to numerically and analytically solve the system of equations using appropriate non-Newtonian viscosity models. The proposed dual-permeability model is capable of measuring dual hydraulic conductivities, and therefore may be useful in improving predictions of non-equilibrium preferential flow and transport in structured soils.