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On the importance of aqueous diffusion and electrostatic interactions in advection-dominated transport in saturated porous media

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Diffusion and compound-specific mixing significantly affect conservative and reactive transport in groundwater. The variability of diffusion coefficients for different solutes has a relevant impact on their displacement at different scales, not only under diffusion-dominated regimes but also under advection-dominated flow through conditions. When the solutes are charged species, besides the magnitude of their aqueous diffusion coefficients also their electrostatic interactions play a significant role in the displacement of the different species. Under flow-through conditions this leads to multicomponent ionic dispersion: the dispersive fluxes of the different ions are cross-coupled due to the effects of Coulombic interactions. Such effects are illustrated in flow-through experiments in saturated porous media. Simple strong electrolytes were selected as tracers and their transport was studied under different advection-dominated conditions and in homogeneous and heterogeneous porous media. The interpretation of the experimental results requires a multicomponent modeling approach with an accurate description of local hydrodynamic dispersion and explicitly accounting for the cross-coupling of dispersive fluxes due to the Coulombic interactions between the charged species.