Insights on solute transport in drying porous media gained from discrete and continuum model simulations

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Abstract

Drying of capillary porous media initially saturated with saline water is central to many engineering and environmental applications. In order to predict the evolution of solute concentration in a porous medium, the macroscopic continuum models (CMs) are commonly employed. However, the predictive aptitudes of the CMs is still questionable at this stage. In this work, we solve the classical advection-diffusion equation for solute transport in an isothermally drying capillary porous medium for the limiting condition of capillary-dominated regime. The solution of the continuum model is compared with pore network simulations. The results of both models are analyzed in terms of instantaneous and time-averaged local solute concentration profiles. On this basis, the ability of the continuum model to predict the time for the onset of precipitation (i.e. the time that is required for local solute concentration to reach saturation concentration) is assessed. An example is shown in Figure 1, where instantaneous solute concentration profile obtained from classical continuum model solution is compared with that obtained from pore network simulations at network saturation of 0.7. Apart from this, we characterize the degree of heterogeneity in the liquid phase structure (i.e. splitting the bulk liquid into the main cluster, the isolated clusters and the isolated single menisci) by performing pore network Monte-Carlo simulations. Based on the statistical analysis of Monte-Carlo simulations, we compute the probability of first crystals to appear in the respective liquid phase elements.

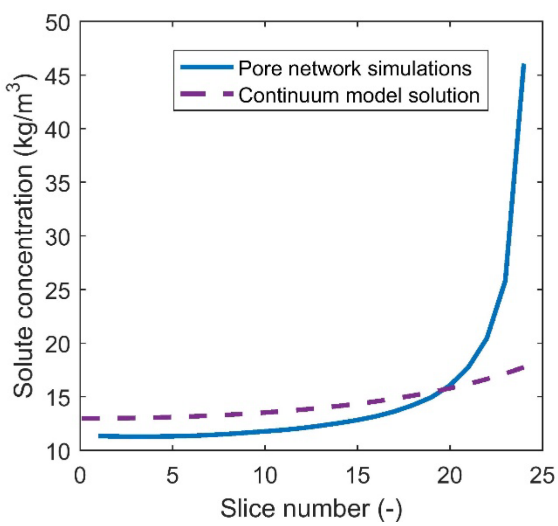

Figure 1: A comparison between instantaneous solute concentration profile obtained from pore network simulations with the corresponding solution of classical continuum model for solute transport.