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Anomalous transport dependence on Peclet number, porous medium heterogeneity and a temporally-varying velocity field

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We investigate the effects of the Peclet number (Pe) on transport of an inert chemical tracer in heterogeneous porous media. We simulate fluid flow and transport through two-dimensional pore-scale matrices with varying structural complexity. With increasing Pe, the anomalous nature of the transport becomes enhanced as the host domain becomes more heterogeneous, due to the increasingly dominant effects of the complex velocity field. The sensitivity of (anomalous) transport to Pe is shown to be controlled by the medium structure. We quantify the effects of Pe by interpreting the numerical simulations within the continuous time random walk method (CTRW) framework. We evaluate the CTRW tracer transition functions from the numerical simulations, through a division of the fluid velocity distribution into different classes, and incorporate Pe within the underlying temporal transition distribution. We find that Pe has a nonlinear effect on the CTRW temporal tracer transition function. We then investigate transport behavior subjected to temporal variation in the velocity field magnitude, accounting for tracer propagation controlled by Pe. Because of the nonlinear influence of Pe on the transport behavior, we show that temporal variations in the velocity field can lead to an increase in the anomalous nature of the transport.