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On the use of effective parameters to describe transport phenomena in geomaterials

Brian Berkowitz

Weizmann Institute of Science, Environmental Sciences and Energy Research, Rehovot, Israel (brian.berkowitz@weizmann.ac.il, 972 8 9344124)

The effort to define "effective" quantities that describe hydraulic, flow, transport and geochemical reaction parameters at the macroscopic scale is ubiquitous. However, this approach must be questioned: local behaviors cannot always be averaged to yield "upscaled" behaviors, and serious errors can arise when employing "effective" parameters in equations of flow, transport and reaction. For example, small-scale heterogeneities often do not simply average out and become insignificant at large field scales, chemical transport does not necessarily homogenize on the same temporal and spatial scales as fluid flow, and numerical analyses based on single realization studies maybe fundamentally different from ensemble realization studies. We illustrate these features through several examples, including: (i) flow in fracture networks and porous media, accounting for channelling and percolation properties; (ii) dispersion of conservative tracers in porous media; and (iii) transport and reaction of chemical species in porous media.