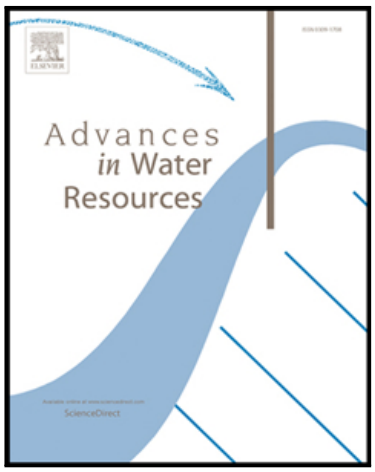

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Anomalous Behaviors During Infiltration Into Heterogeneous Porous Media

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Abstract

Flow and transport in heterogeneous porous media often exhibit anomalous behavior. A physical analog example is the uni-directional infiltration of a viscous liquid into a horizontal oriented Hele-Shaw cell containing through thickness flow obstacles; a system designed to mimic a gravel/sand medium with impervious inclusions. When there are no obstacles present or the obstacles form a multi-repeating pattern, the change of the length of infiltration F with time t tends to follow a Fickian like scaling, $F \sim t^{\frac{1}{2}}$. In the presence of obstacle fields laid out as Sierpinski carpet fractals, infiltration is anomalous, i.e., $F \sim t^n$, $n \neq 1/2$. Here, we study infiltration into such Hele-Shaw cells. First we investigate infiltration into a square cell containing one fractal carpet and make the observation that it is possible to generate both sub ($n < 1/2$) and super ($n > 1/2$) diffusive behaviors within identical heterogeneity configurations. We show that this can be explained in terms of a scaling analysis developed from results of random-walk simulations in fractal obstacles; a result indicating that the nature of the domain boundary controls the exponent n of the resulting anomalous transport. Further, we investigate infiltration into a rectangular cell containing several repeats of a given Sierpinski carpet. At very early times,

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