Strange travels: Unusual journey of transport phenomena in fractured materials

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Transport phenomena in highly heterogeneous media can be dramatically different from those in homogeneous media and therefore are of great fundamental and practical interest. Anomalous transport occurs in semiconductor physics, plasma physics, astrophysics, biology, and other areas. It plays an especially important role in hydrogeology because it may govern the rate of migration and degree of dispersion of groundwater contaminants from hazardous waste sites.

A series of four articles in Special Section: Nonclassical Transport of the November 2008 issue of *Vadose Zone Journal* is devoted to transport phenomena in heterogeneous media in the context of geologic disposal of radioactive waste. Guest Editors Leonid Bolshov and Peter Kondratenko (Nuclear Safety Institute, Russian Academy of Sciences) and Karsten Pruess (Lawrence Berkeley National Lab.) assembled the articles, which are the results of joint investigations performed at the Nuclear Safety Institute of the Russian Academy of Sciences and Lawrence Berkeley National Laboratory in California. The work was supported by the USDOE.

The problems addressed in this research involve a broad range of space and time scales and were approached using modern methods of theoretical and computational physics, such as scaling analysis and diagrammatic techniques used before in critical phenomena theory. Special attention is paid to concentration tails. This issue is exceptionally important for the reliability assessments of radioactive waste disposal because, depending on the structure of the tails, concentrations at large

distances from the source can differ by many orders of magnitude.

The first paper of this special section presents an overview of field and laboratory observations that demonstrate nonclassical flow and transport behavior in geologic media, with an emphasis on the fractal geometry of natural fracture networks and the presence of contaminant traps. The second paper is devoted to the analysis of diffusion in heterogeneous media with sharply contrasting properties; the authors show that as time progresses, three different transport regimes can be realized. In the third paper, it is shown that the solute transport regime is determined by a competition of two mechanisms: random advection through a fracture network and trapping caused by sharply contrasting properties of the medium. In the fourth paper, the authors develop a model of anomalous diffusion to simulate solute transport in highly heterogeneous media, and the new model is shown to result in reasonable agreement with experimental data on solute transport in highly heterogeneous media.

The full article is available for no charge for 30 days following the date of this summary. View the abstract at vzj.scijournals.org/cgi/content/full/7/4/1133 .

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