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An Integrated Modeling Approach for Characterizing Multiphase Flow, Chemical Transport, and Heat Transfer in Fractured Reservoirs

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Abstract

Even with the significant progress made in modeling flow and transport in fractured rock in the last few decades, characterizing fractured reservoirs remains a great challenge. This is because of the inherent complexity within actual fractured reservoirs, from multiphase flow and transport to the spatial variability of the fracture network. To investigate coupled processes of fluid and heat flow and chemical isotopic transport in the highly heterogeneous, unsaturated fractured tuff of Yucca Mountain (a proposed underground repository site for storing high-level radioactive waste of the U.S.), we present an integrated modeling methodology. The proposed modeling approach integrates a wide variety of moisture, pneumatic, thermal, and geochemical isotopic field data into a comprehensive three-dimensional numerical model for modeling analyses. The model is then used for the evaluation of unsaturated percolation fluxes and flow patterns, which is the most important goal of the site characterization. In particular, the results of this evaluation indicate that moisture data, such as water potential and liquid saturation in the rock matrix, are not sufficient to determine *in situ* percolation flux, whereas temperature and geochemical isotopic data provide better constraints to net infiltration rates and flow patterns. In addition, pneumatic data are found to be extremely valuable in estimating large-scale fracture permeability. The integration of hydrologic, pneumatic, temperature, and geochemical data into modeling analyses is thereby demonstrated to provide a practical modeling approach for characterizing flow and transport processes in complex fractured reservoirs.