Modeling Study of the Temporal Damping Effect in Unsaturated Fractured Rock of Yucca Mountain.

Keni Zhang, Yu-Shu Wu, and Lehua Pan
Earth Sciences Division, Lawrence Berkeley National Laboratory

Performance assessment of the Yucca Mountain unsaturated zone as an underground repository of radioactive waste is based on a crucial assumption that physical processes in the unsaturated zone can be approximated as a steady-state condition. Justification of such an assumption relies on temporal damping effects of certain geological units within the unsaturated formation. In particular, the nonwelded tuff of the Painbrush Group (PTn unit) at Yucca Mountain, due to its highly porous physical properties, has been conceptualized to have significant capacity for temporally damping transient percolation fluxes (Wu et al., 2000). Spatially and temporally variable infiltration pulses can rapidly flow through the top layers of highly fractured tuffs (Tiva Canyon welded, TCw unit). At the TCw–PTn interface, welded tuffs grade sharply into nonwelded tuffs. The PTn unit attenuates the episodic infiltration flux significantly, such that the net episodic surface infiltration, once crossing the PTn, can be approximated as steady state. In this study, we use a three-dimensional mountain-scale model (with over a million grid-blocks) to examine the changes of percolation flux in space and time. The damping effect of the PTn unit is investigated through model simulation, and the hydrogeological conditions required to achieve the effective damping are analyzed.

The 3-D model incorporates a wide variety of field data for the highly heterogeneous formation at Yucca Mountain. Fracture and matrix flow is treated using a dual-permeability modeling approach. The model is first run to steady state and calibrated using field-measured data. Then, pulse infiltrations are applied to the top boundary. Infiltration pulses are assumed to be present-day mean infiltration, with a one-week infiltration cycle for every 50 years, i.e., the model’s top boundary is subject to nonzero infiltration (with a pulse of 2609 times of present-day mean infiltration) for only one week every 50 years. Additionally, the model with non-infiltration boundary conditions is also run for 2000 years to examine the percolation flux attenuation with time at the PTn bottom.