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Preferential Flow in Welded and Non-Welded Tuffs: Observations from field experiments

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The development of a potential permanent storage facility for the geological disposal of high-level nuclear waste at Yucca Mountain, Nevada, is contingent on a clear understanding of flow and transport in the unsaturated fractured rock environment. Over the past few decades, several conceptual models have been developed to describe flow through the unsaturated zone at Yucca Mountain. However, because of the paucity of experimental data, conceptualization of these models has often required many assumptions, which may oversimplify the role of fractures, faults, and the matrix.

When water flows in unsaturated fractured rock, preferential flow is inevitable given the contrast in hydraulic conductivities of the fractures and porous matrix. Not surprisingly, in various field and laboratory studies conducted in unsaturated rocks, preferential flow, identified as either fracture, funneled or unstable/finger flow, has emerged as a dominant process.

We have carried out a series of *in situ* liquid-release experiments to examine liquid flow along potential fast flow paths in welded and non-welded tuffs. For these experiments, in which vertical flow paths ranged between ~ 1 m and ~20 m, the objective was to evaluate the relative dominance of near-vertical faults and fractures, over the

surrounding matrix, in transmitting water. Specifically, the goal was to characterize wetting-front movement, flow-field evolution, and drainage as water was released along a fault or fracture. The experiments included releases of water along isolated sections of tuffs that included a fault or fracture, during and after which, changes in moisture content in the formation below were monitored and continuously recorded by an automated data acquisition system. The lower boundary of each test bed was defined by a cavity excavated to permit visual inspection for seepage.

Our experiments show that when water was introduced along a fault or fracture located in *welded tuff*, the feature served as the primary vertical flow path. However, while seepage was observed at discrete points along an extended section of fault/fracture, the limited area occupied by each seepage point suggests that these flow paths are small relative to the surface area of the fault/fracture. In the adjacent fractured matrix water moved laterally and vertically. When water was introduced along a fault located in *non-welded tuff*, much of the water was initially imbibed by the surrounding matrix. Although the fault began to dry immediately after an infiltration event, the matrix remained wet for long periods of time (extending to months). While episodic infiltration events were dampened by an initially dry matrix, the fault (embedded in non-welded tuff) conveyed a pulse of water over larger distances after the matrix was wetted. However, this effect may be have been offset as suggested by the observation that over a longer period (days to weeks) of wetting, the fault permeability appeared to decrease relative to the initially dry fault.

Note the extended abstract will be submitted if this abstract accepted for symposium.

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