Investigations of Flow in Fractured Welded Tuffs

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RESEARCH OBJECTIVES

Preferential flow in fractured rock suggests channeling of flow through a subsection of the possible flow field. In recent years, investigations evaluating sites for geological disposal of high-level nuclear waste have been particularly focused on preferential flow, because of the potential for rapid movement of water to waste containers, and the subsequent migration of radionuclides that could escape from these containers.

The broad objective of this research effort was to study flow in fractured welded tuff. Specifically, the goal was to identify and characterize flow paths that developed as water was released under ponded conditions along a 12 m^2 infiltration plot. Of particular interest were features of flow paths such as flow velocities, size, spatial distribution, and temporal dynamics.

APPROACH

This experiment involved the release of ~22 m^3 of ponded water (at a pressure head of ~0.04 m) over a period of 7 months, directly onto a 12 m^2 infiltration plot located on a fractured welded tuff surface. As water was released, changes in moisture content were monitored along an array of horizontal boreholes located in the formation ~19–22 m below, with specially designed sensors to detect the arrival and persistence of flow through fractured rock.

ACCOMPLISHMENTS

This investigation has provided insights into specific features of flow zones that developed from the ponded release of water into fractured rock. To our knowledge, such specific flow zone features in unsaturated fractured rock have not been observed in previous studies at this spatial (i.e., >20 m vertical flow) and temporal scale (i.e., months).

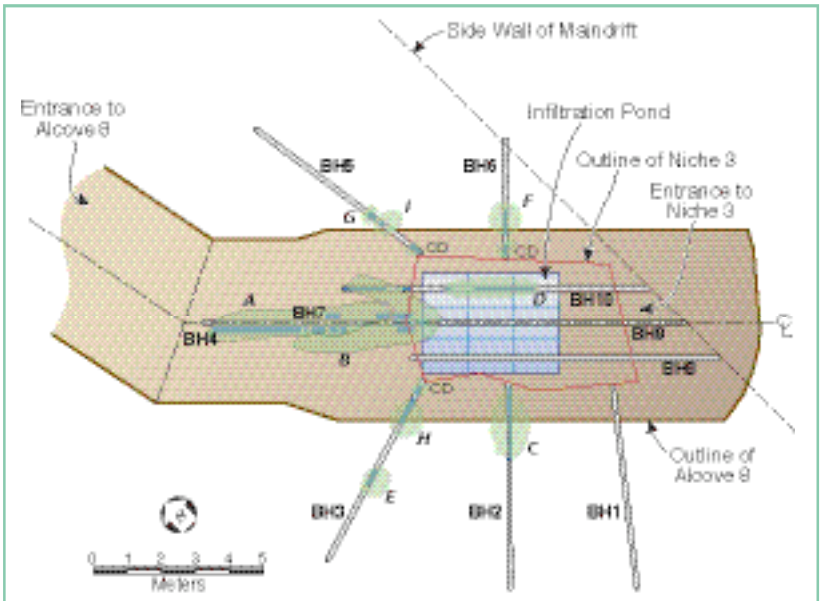

Figure 1. Plan view of the test bed showing the location of the infiltration plot (upper boundary) relative to monitoring boreholes surrounding Niche 3 (lower boundary). The letters A–H indicate the location of flow zones defined by wetting-front velocity and location.

SIGNIFICANCE OF FINDINGS

Observations from this investigation suggest that existing conceptual models could be improved in their representation of some fundamental aspects of water movement through unsaturated fractured rock. Specifically:

- Flow encompasses numerous fractures of various sizes to form flow conduits. Therefore, rather than individual fractures, the geometry of the fracture network forming these flow conduits is likely the dominant mechanism controlling flow through fractured tuffs.
- The inclusion of numerous fractures in individual flow conduits suggests that the area across which fracture-matrix interactions occur is significantly greater than would be expected from a model of focused flow along a fracture.
- Gravity-driven flow can have a significant lateral component likely dictated by the geometry of fracture networks.
- Flow conduits do not necessarily interact.
- Capillary barriers may increase the area through which flow seeps into an excavated cavity, by diverting water from the ceiling to sidewalls.
- The range in velocities for the leading edge of flow paths suggests a vertical spread, rather than a uniform edge, to the wetting front.

RELATED PUBLICATION

Salve, R., Observations of preferential flow during a liquid-release experiment in fractured welded tuffs. Water Resour. Res. (in press), 2005. Berkeley Lab Report LBNL-56265.

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