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In Situ Measurement of Nonwelded Tuff Permeability where Heterogeneities are Induced by Fault Zone Deformation, Bishop Tuff, Bishop, California

Fluid Flow and Transport through Faulted Ignimbrites and other Porous Media:
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Outcrop analyses and hydrologic tests by *Fedors, et al.* [2001] suggest that the Bishop Tuff is a suitable analog for the Paintbrush Tuff: a unit overlying the proposed high-level radioactive waste repository at Yucca Mountain, Nevada. The nonwelded Bishop Tuff includes matrix-supported massive ignimbrites and clast-supported bedded deposits. Fluid flow through such nonwelded tuff is likely to be influenced by a combination of host rock properties and the presence of deformation features, such as open fractures, mineralized fractures, and fault zones that exhibit comminuted fault rocks and clays. Lithologic contacts between fine- and coarse-grained subunits of nonwelded tuff may induce formation of capillary and/or permeability barriers within the unsaturated zone, potentially leading to down-dip lateral diversion of otherwise vertically flowing fluid. However, secondary discontinuities (e.g. faults and fractures) may lead to preferential sub-vertical fast flow paths in the event of episodic elevated infiltration rates, thus disrupting the potential for large-scale capillary and/or permeability barriers to form as well as the redirection of water flow over horizontal distances of great length.

This study focuses on an innovative technique for measuring changes in matrix permeability near faults *in situ*—changes that may lead to the enhancement of vertical fluid flow and the disruption of lateral fluid flow. The influence of primary lithology, texture, and faults on fluid flow through the nonwelded Bishop Tuff are interpreted using data obtained from a small-drillhole gas minipermeameter probe. Advantages of the new technique include (1) *in situ* measurement, eliminating the need for extraction of fragile samples (*Molz, et al.*, 2002) and (2) a field-proven sealing mechanism surrounding the gas injection zone (*Dinwiddie*, 2001).

To evaluate the effect of faults and fault zone deformation on nonwelded tuff matrix permeability, and to address the potential for disruption of lithologic barrier-induced lateral diversion of flow, data were collected from two fault systems and from unfaulted host rock. Two hundred sixty-seven permeability measurements were made at 89 locations during June 2002 (i.e., triplicate measurements at each location using three different flow rates). Four hundred forty-nine permeability measurements were made at 90 locations during September 2002 (i.e., data were collected at each location using five different flow rates, on the average).

At the Chalk Cove Fault, permeability data were collected perpendicularly away from it within the hanging wall to a distance of 5.8 m along one transect; a second transect lies perpendicular to the fault, and traverses from the footwall to the hanging wall for a distance of 5.5 m. Fifteen water-permeameter tests were also conducted to augment this gas permeability data, and to provide additional confidence in the gas minipermeametry technique.

The second fault system, Crucifix/Crossing Faults, is exposed by a roadcut. Here, gas permeability data were collected within two different beds along a 10.5 m horizontal transect that traverses from the main fault into the footwall and that crosses several secondary faults. Gas permeability data were also collected within the fault gouge of the main fault along a short vertical profile, and were found to vary therein by one order of magnitude.

Overall results indicate that the undeformed nonwelded basal Bishop Tuff host rock is very homogeneous, and that permeability within the damage zone associated with a fault may increase by one to two orders of magnitude above that of the host rock.

This Bishop Tuff study supports the U.S. Nuclear Regulatory Commission (NRC) review of hydrologic property studies at Yucca Mountain, Nevada, which are conducted by the U.S. Department of Energy. This paper is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the NRC.

References:

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Unit Conversions:

1 m = 3.28 ft