Systematic Hydrological Characterization of the Topopah Spring Lower Lithophysal Unit

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RESEARCH OBJECTIVES

Over 80% of the proposed repository for the permanent disposal of high-level radioactive nuclear waste will be situated in the lower lithophysal unit of the Topopah Spring welded tuff, Yucca Mountain, Nevada. Within the Exploratory Studies Facility at Yucca Mountain, a 5 m diameter drift (tunnel), called the East-West Cross Drift, traverses this lower lithophysal unit. The welded tuff is intersected by many submeter fractures and interspersed with lithophysal cavities ranging from 15 to 100 cm in diameter. The size and spacing of both these features (fractures and cavities) varies appreciably. This indicates that hydrological characteristics at one particular location may not be representative of the entire lower lithophysal unit. Therefore, systematic testing at regular intervals, unbiased by the knowledge of specific features, is in progress, with the objective of gaining a greater understanding of the hydrological characteristics and associated heterogeneity of this potential repository unit.

APPROACH

Liquid-release (seepage) tests determine the ability of the open drift to act as a capillary barrier that diverts water around itself. Seepage into drifts increases the potential for corrosion of waste canisters and subsequent release of radionuclides. Seepage tests through this highly heterogeneous rock are being performed every 30 m along an 800 m stretch of the 5 m diameter drift. Water is released steadily into a series of 20 m boreholes drilled upward at a 15° angle along the drift crown. Water that then seeps through the rock is measured by a drip capture system, and evaporation area is estimated using time-lapse photography. Seepage and evaporation are subtracted from the water released to determine how much water has been diverted.

Figure 1 shows a series of time-lapse photos taken of the drift crown as water from a test seeps through. These photos were taken about 6 days apart and show a gradual decrease in the rate of wetting. The photos show the evaporation pan with its white umbrella, which prevents seepage from accidentally filling the pan. The wire mesh (also shown) has a 7.5 cm spacing, which is used to estimate the size of the wet patch. Multiplying this size by the flux from the pan yields the amount of evaporation from the crown. The photos also help determine when the first seep occurs after initiation of water release and how the flow first intersects the drift, whether it be by fractures, through cavities, or in the matrix itself. In addition, these photos help pinpoint whether a threshold water-release-rate value exists, below which no water enters the drift.

ACCOMPLISHMENTS AND SIGNIFICANCE OF FINDINGS

Testing has progressed through the fifth of the series of boreholes along the drift. As the systematic hydrological testing progresses, a catalogue of flow characteristics for the drift is being developed. Not only can the various flow characteristics themselves be logged, but the distances for which they persist along the drift can now also be measured. Length scales from 1 to 23 m, with flow characteristics up to 100% impermeability and 100% diversion, have now become apparent, because of the expansive coverage of drift that can be tested with the systematic approach.

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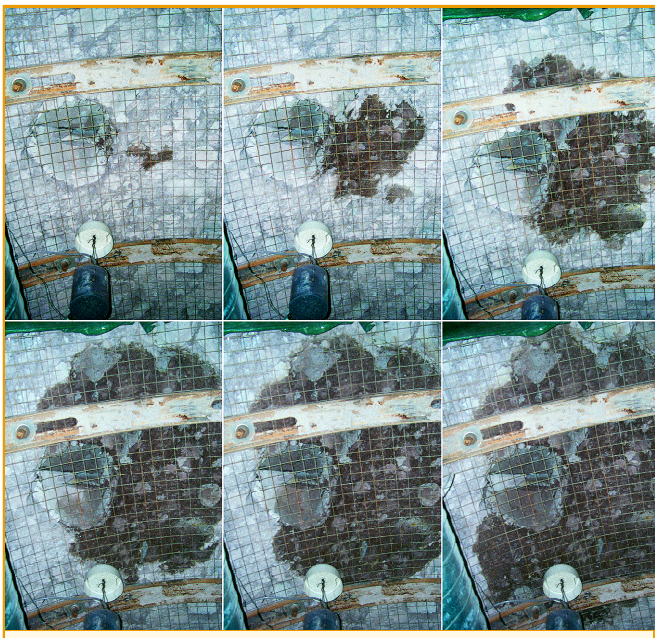

Figure 1. Time-lapse photos of the drift crown under a section of borehole being tested