Evaporation from Near-Drift Fractured Rock Surfaces

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The amount of water entering emplacement drifts from a fractured unsaturated rock is an important variable for performance evaluation of a potential high-level radioactive waste repository at Yucca Mountain, Nevada. Water entering the drifts as liquid or gas may enhance waste package corrosion rates and transport released radionuclides. Liquid water in form of droplets may emerge from fractures, or flow along the drift wall and potentially evaporate and condense at other locations. Driven by pressure and temperature gradients, vapor may be transported along fractures, or liquid water may evaporate directly from the matrix. Within the drift, heat-driven convection may redistribute the moisture leading to condensation at other locations. The geometry of the evaporation front around the drift is not fully understood and this, in turn, influences processes related to reflux, rewetting as the thermal pulse dissipates.

Existing models focus on processes in the porous media (e.g., two-phase dual-permeability models for matrix and fractures), or on processes in the drift (e.g., gas-phase computational fluid dynamics models). This study focuses on the boundary between these two domains, and the corresponding models, where evaporation at the solid rock/drift air interface appears to play an important role. Studies have shown that evaporation from porous media is a complex process sensitive to factors such as (i) hydrological properties of the porous media, (ii) pressure gradients in the porous media, (iii) texture of the interface or boundary, (iv) local vapor and temperature gradients, and (v) convective flow rate and boundary layer transfer. Experimental observations based on passive monitoring at Yucca Mountain have shown that the formation surrounding the drift is able to provide and transport large amounts of water vapor over a relatively short period. This study will examine the basic processes that govern evaporation in the unsaturated rock surrounding drifts for ambient and thermally-perturbed conditions, and illustrate the effect of the contrasting hydrologic properties of the matrix and fracture continua. Simple analyses to establish bounds on vapor flux into the drift are proposed. A more prominent role for gravity to evaluate potential seepage is proposed. Available models will be evaluated for their applicability for in situ conditions at Yucca Mountain.

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