VERTICAL DISTRIBUTION OF CALCITE AT YUCCA MOUNTAIN, NEVADA, AS
AN INDICATOR OF FLOW THROUGH A THICK UNSATURATED ZONE

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Meteoric water percolating through 500 to 700 m of hydrologically unsaturated felsic
tuffs provides a mechanism for release and transport of radionuclides from a potential
high-level radioactive waste repository at Yucca Mountain, Nevada. Modern flow
through the unsaturated zone (UZ) is low (probably <20 mm/year) and has not been
observed directly. However, calcite formed from water percolating through fracture and
lithophysal cavities over the last 12.8 million years provides, in part, a time-integrated
record of UZ flow. Calcite concentration profiles were determined in dry-drilled
boreholes USW WT-24 and USW SD-6 by acidifying samples of powdered rock cuttings
collected over 5-foot intervals and measuring the evolved CO₂ using gas
chromatography. Resulting CO₂-derived calcite concentrations ranged from 30,800 to
less than 20 ppm. Aliquots of the same powders also were analyzed for Ca, Ti, and Zr by
energy-dispersive X-ray fluorescence. Concentrations of Ti and Zr in the crystal-poor,
high-silica rhyolite parts of the Topopah Spring Tuff are uniform (standard deviations of
3 to 4%); however, Ca scatters widely (standard deviations of 21 and 32%).
Concentrations of Ca are positively correlated to CO₂-derived calcite concentrations and
regressions for samples of the two major rhyolitic tuffs yielded r^2 values >0.9, CO₂-
intercept Ca concentrations in the range of values determined on fresh rock samples, and
slopes equivalent to addition of stoichiometric calcite. Therefore, combined CO₂ and Ca

data provide a means of determining the amount of secondary calcite added to the rock mass from percolating water.

The vertical distribution of calcite is related to lithostratigraphy with the largest concentrations in the welded hydrogeologic unit of the Tiva Canyon Tuff near the land surface and progressively smaller values with depth into the underlying nonwelded units. Large values also may be present in the upper parts of the underlying welded hydrogeologic unit of the Topopah Spring Tuff, but generally decrease in the deeper parts of the unit. The spatial distribution of calcite is complex and likely is related, in part, to spatial variations in the amount of water and vapor transported through the thick UZ.

KEYWORDS: Calcite concentration, Yucca Mountain, Unsaturated zone, water flow

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