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Discussion

Reply to "Commentary: Assessment of past infiltration fluxes through Yucca Mountain on the basis of the secondary mineral record—is it a viable methodology?", by Y.V. Dublyansky and S.Z. Smirnov

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Abstract

Xu et al. (2003) [Xu, T., Sonnenthal, E., Bodvarsson, G., 2003. A reaction-transport model for calcite precipitation and evaluation of infiltration–percolation fluxes in unsaturated fractured rock. J. Contam. Hydrol., 64, 113–127.] presented results of a reaction-transport model for calcite deposition in the unsaturated zone at Yucca Mountain, and compared the model results to measured abundances in core from a surface-based borehole. Marshall et al. (2003) [Marshall, B.D., Neymark, L.A., Peterman, Z.E., 2003. Estimation of past seepage volumes from calcite distribution in the Topopah Spring Tuff, Yucca Mountain, Nevada. J. Contam. Hydrol., 62–63, 237–247.] used the calcite distribution in the Topopah Spring Tuff to estimate past seepage into lithophysal cavities as an analog for seepage into the potential repository waste emplacement drifts at Yucca Mountain in southern Nevada (USA). Dublyansky and Smirnov (2005) [Dublyansky, Y.V., Smirnov, S.Z., 2005. Commentary: assessment of past infiltration fluxes through Yucca mountain on the basis of the secondary mineral record—is it a viable methodology? J. Contam. Hydrol. (this issue).] wrote a commentary paper to Marshall et al. (2003) [Marshall, B.D., Neymark, L.A., Peterman, Z.E., 2003. Estimation of past seepage volumes from calcite distribution in the Topopah Spring Tuff, Yucca Mountain, Nevada. J. Contam. Hydrol., 62–63, 237–247.] and Xu et al. (2003) [Xu, T., Sonnenthal, E., Bodvarsson, G., 2003. A reaction-transport model for calcite precipitation and evaluation of

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infiltration–percolation fluxes in unsaturated fractured rock. J. Contam. Hydrol., 64, 113–127.], containing two points: (1) questionable phenomenological model for the secondary mineral deposits and (2) inappropriate thermal boundary conditions. In this reply we address primarily the modeling approach by showing results of a sensitivity simulation regarding the effect of an elevated temperature history that approximates the temperature history inferred from fluid inclusions by Wilson et al. (2003) [Wilson, N.S.F., Cline, J.S., Amelin, Y.V., 2003. Origin, timing, and temperature of secondary calcite–silica mineral formation at Yucca Mountain, Nevada. Geochimica et Cosmochimica Acta, 67 (6), 1145–1184.]. Modeled calcite abundances using the time-varying temperature history are similar to the results for the steady-state ambient temperature profile (Xu, T., Sonnenthal, E., Bodvarsson, G., 2003. A reaction-transport model for calcite precipitation and evaluation of infiltration–percolation fluxes in unsaturated fractured rock. J. Contam. Hydrol., 64, 113–127), and are still consistent with the measured abundances at the proposed repository horizon.

Keywords: Yucca mountain; Calcite precipitation; Thermal boundary conditions; Infiltration rate; Reactive transport modeling

1. Introduction

Dublyansky and Smirnov's (2005) comments on Marshall et al. (2003) and Xu et al. (2003) contain two major points: (1) a questionable origin of the secondary calcite and opal deposits found within cavities and on fracture surfaces at Yucca Mountain and (2) inappropriate thermal boundary conditions for simulations used by Xu et al. (2003). In Marshall et al. (2003) the calcite distribution in the Topopah Spring Tuff was used to estimate past seepage into cavities as an analog for seepage into the potential repository waste emplacement drifts. The latter paper estimated the water flux required to form calcite and opal using a batch geochemical model calculation that assumed equilibrium of percolating water with calcite and silica gel. Xu et al. (2003) presented results of a dual-continuum (fracture-matrix) reaction-transport model for calcite precipitation in the unsaturated zone at Yucca Mountain, and compared the results to measured abundances from cores taken from a deep surface-based borehole (WT-24). This model considered local equilibrium between calcite, water, and CO_2 in the gas phase.

2. Discussion

The origin of calcite and silica deposits in open fractures and lithophysal cavities at Yucca Mountain (from meteoric water descending along fractures or from upwelling hydrothermal fluids) has been discussed in numerous earlier papers, including Whelan et al. (2002, 2004). Whelan et al. (2004) reaffirmed that secondary minerals in open fractures and lithophysal cavities at Yucca Mountain formed primarily by infiltrating meteoric water. This point has also been discussed briefly in the reply of Marshall et al. (2005).

Here, we address primarily the issue of inappropriate thermal boundary conditions as pertains to the Xu et al. (2003) paper. The reactive transport model presented in Xu et al. (2003) considered several important factors controlling calcite precipitation: (1) infiltration