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Treatment of the FEP "Hydrothermal Activity" in the performance assessment of the proposed Yucca Mountain high-level nuclear waste disposal site

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The U.S. Code of Federal Regulations, 10 CFR Part 63, provides that expected performance of the geological high-level nuclear waste repository must be demonstrated through a total system performance assessment (TSPA). The TSPA represents an analysis which: (1) identifies the features, events, processes (FEPs) that might affect the disposal system and their probabilities of occurring during the regulatory compliance period; (2) examines the effects of those FEPs upon the performance of the disposal system; and (3) estimates the dose incurred by the reasonably and maximally exposed individual as a result of releases caused by all significant FEPs weighted by their probability of occurrence. Regulations require that the TSPA must be based on a thorough understanding of all relevant processes that may affect repository performance. We determined, however, that at least one potentially important, if not critical, FEP, Hydrothermal Activity, was treated arbitrarily in the course of the U.S. Department of Energy (DOE) selection process and was unjustifiably excluded from the TSPA.

Secondary minerals (calcite, quartz, fluorite) from the thick (400-900 m) vadose zone of Yucca Mountain were deposited from waters with temperatures of up to 70-90^{o}C [1, 2]. U-Pb dating of opals from this assemblage constrained the ages of elevated temperatures to the period of 10 to 5-6 million years ago [3]. The data strongly suggest relatively youthful circulation of thermal waters through the vadose zone. Such circulation is an imposing safety concern for the proposed Yucca Mountain repository.

The exclusion of hydrothermal activity by DOE from consideration in the TSPA as an FEP was based on an erroneous assumption and a modeling exercise wrongly interpreted as corroborating the assumption. The assumption was that any significant

hydrothermal activity in the Yucca Mountain region was causally related to large-scale silicic volcanism, which ended at 10-11 million years ago and has, therefore, an exceedingly small probability of recurrence. To reconcile the discrepancy between the age of silicic volcanism and that of hydrothermal circulation, a phenomenological model was advanced by the USGS researchers [4] which proposed that the secondary minerals were deposited by infiltrating meteoric waters that were heated upon contact with the bedrock; the latter they hypothesized were conductively heated by a shallow silicic magma body emplaced some 7 km to the north of the site. Numeric thermal simulations reportedly corroborated the model [4]; however, the model and simulations have not been presented in the form consistent with the DOE quality assurance guidelines. Recently, it was discovered [5] that the simulations reported in [4], in fact, invalidated the model rather than supported it. Independent modeling also failed to corroborate the USGS phenomenological model [6]. Causes and mechanisms of circulation of thermal waters through the proposed repository zone in the past remain, thus, unexplained in the DOE safety case, and the circulation is omitted from the performance assessment of the planned repository.

In order to avoid a situation that inaccurate and/or incomplete scientific information affects the quality of the decisions concerning safety of the proposed high-level nuclear waste disposal facility at Yucca Mountain, the FEP Hydrothermal Activity must be reinstated and duly evaluated in the TSPA prior to submittal, by DOE, of the license application to the U.S. Nuclear Regulatory Commission.

[1] Dublyansky et al. 2001. Chem. Geol. **173**, 125-149. [2] Wilson et al. 2003. Geochim. Cosmochim. Acta. **67** (6), 1145-1176. [3] Neymark et al. 2002. Appl. Geochem. **17**, 709-734. [4] Marshall, Whelan 2001. GSA Abstracts **33** (6), A-375. [5] Bechtel SAIC LLC, 2004. Technical Basis Document No. 2: Unsaturated Zone Flow. [6] Dublyansky, Polyansky 2006. Geoph. Res. Abstr. (this volume).