

SwRI: Uranium Transport Studies of the Pena Blanca Natural Analog Project

Uranium transport at the Nopal I deposit has been studied to evaluate the mechanisms by which high-level waste components could be transported through silicic tuff over long time periods. Transport studies were initiated by clearing portions of Levels +10 and +00 of loose rock, soil, and debris. The clearing provided a nearly continuous bedrock exposure across the outcrop of the deposit and the surrounding tuff.

A reference location framework over the cleared areas was established by constructing a 1-m x 1-m grid with axes oriented NS and EW. The 1-m grid was used as a reference for mapping the occurrence of U minerals, host rock type, and host rock alteration, as well as fracture locations and forms.



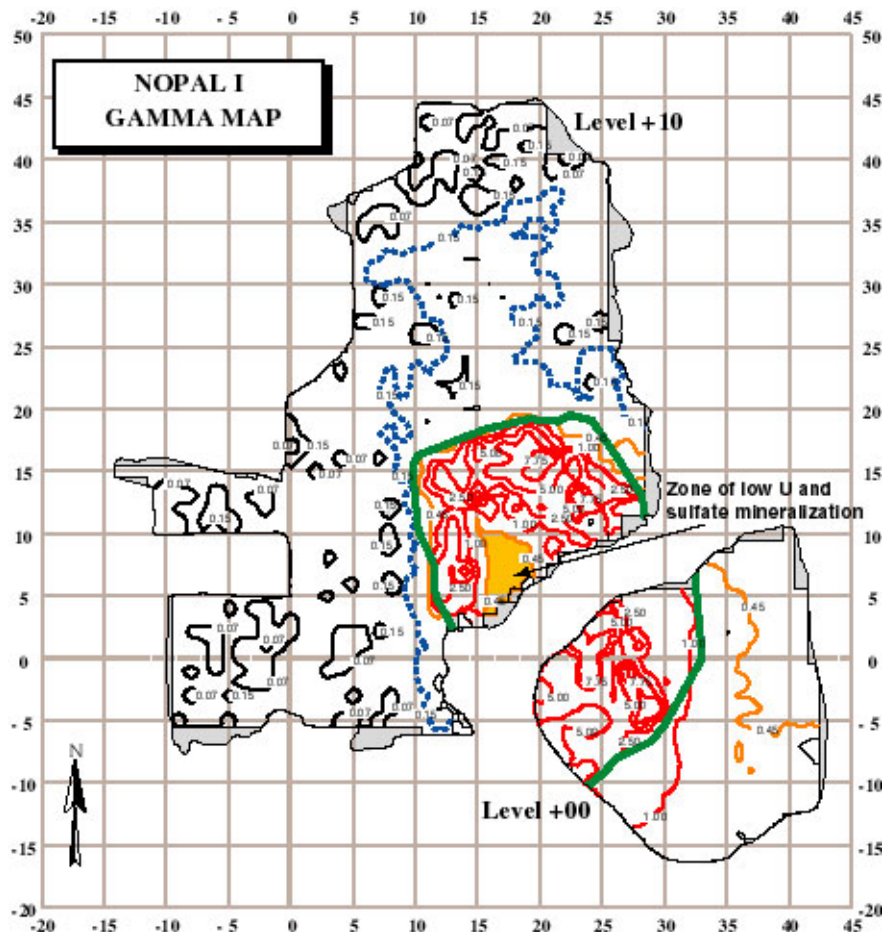
View of the cleared surface on the +10 m level of Nopal I.



View of the cleared surface on the +00 m level of Nopal I.



View of the 1 m by 1 m grid on the +10 m level of Nopal I.



Map showing results of a gamma survey conducted on the cleared areas of the Nopal I deposit. The green line indicates the limit of visible U mineralization and marks the nominal edge of the deposit. Contours have units of mR/h. Red contours have gamma values of 1.00 mR/h or greater. The 0.45 mR/h contour is shown in orange and on the Level +10 mimics the boundary of visible U mineralization. The dotted blue contour is the 0.15 mR/h boundary of the continuous area of anomalous U concentration. A zone of less than 0.45 mR/h gamma values and sulfate mineralization in the interior of the orebody on Level +10 is shaded yellow. Figure modified from Percy et al., 1995.

Transport of uranium from areas of primary mineralization were determined by radiometric surveying (see above figure) and analysis of uranium concentrations and distributions in bulk rock samples and minerals both within and outside the ore deposit. Uranium transport was studied along a major fracture set crosscutting the deposit, along transects through microfractured tuff adjacent to the major fracture set, along a transect through generally fractured tuff, and along micron-scale transects in tuff matrix adjacent to microfractures. Methods used to analyze uranium included gamma spectrometry, alpha spectrometry, autoradiography, and electron microprobe analyses. Results of uranium transport studies are published in *Applied Geochemistry* and the *Journal of Contaminant Hydrology*. The *Applied Geochemistry* article also contains results of geologic, contact gamma, and comprehensive fracture mapping on the cleared portions of Levels +10 and +00. The abstracts for these articles are shown below.

Applied Geochemistry, Vol. 10, pp. 685-704, 1995

Uranium transport through fractured silicic tuff and relative retention in areas with distinct fracture characteristics

English C. Percy, James D. Prikryl, and Bret W. Leslie
Center for Nuclear Waste Regulatory Analyses, San Antonio, Texas, U.S.A.

Abstract

The Nopal I uranium (U) deposit, in the Peña Blanca District, Chihuahua, Mexico, has been identified as analogous in some regards to the candidate U.S. high-level waste (HLW) repository at Yucca Mountain, Nevada. Uranium transport at the Nopal I deposit has been studied to investigate mechanisms by which HLW components could be transported through silicic tuff over long time periods. This investigation focused on approximately 1400 m² of essentially continuous bedrock outcrop spanning the Nopal I deposit and surrounding host tuff. Data collected document: (i) the distribution of U within and around the Nopal I deposit, (ii) the distribution and characteristics of the fracture network within and surrounding the deposit, and (iii) the transport of U away from the deposit mainly along fracture paths. Uranium-series isotopic measurements indicate mobilization of U along the margin of the deposit within the last 1 Ma and significant U transport at about 54 Ka. Transport of U away from the Nopal I deposit along a few relatively continuous mesofractures achieved maximum distances at least 20

times greater than transport through the general fracture network composed of thousands of less continuous microfractures within and surrounding the deposit. Uranium transport away from the deposit appears to be largely independent of variations in the general fracture network pattern. Transport of U away from individual micro- and meso-fractures into homogeneous, unfractured tuff matrix appears limited to distances less than 1 mm. At the Nopal I deposit, matrix diffusion does not appear to have been an important factor for retardation of U. This analysis suggests a ranking for U retention: (i) microfracture network retention >> mesofracture retention, and (ii) individual microfracture retention >> matrix retention.

The *Journal of Contaminant Hydrology* article presents data and analyses of a major fracture set that crosscuts the U deposit at Nopal I. Materials collected from this fracture set are absent of U minerals. However, Fe-oxides and Fe-hydroxides from the fracture were found to exhibit anomalous U concentrations. Detailed analyses of material collected from the fracture included: (i) petrographic and mineralogic characterization; (ii) U distribution; and (iii) U-series isotopic measurements. Results indicate a complex history of U mobilization and transport. The abstract for this article is shown below.



The trace of the major fracture set at Nopal I studied in relation to U transport is visible (see arrows on photo) in this photo of the Nopal I deposit looking to the southeast over the southern 2/3 of the cleared area on Level +10.



The major fracture that divides this photo was the focus of U transport studies.

Journal of Contaminant Hydrology 26 (1997) 61-69

Migration behavior of naturally occurring radionuclides at the Nopal I uranium deposit, Chihuahua, Mexico

James D. Prikryl, David A. Pickett, William M. Murphy, and English C. Pearcy
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute, 6220 Culebra Road
San Antonio, Texas 78238-5166, U.S.A.

Abstract

Oxidation of pyrite at the Nopal I uranium deposit, Peña Blanca district, Chihuahua, Mexico has resulted in the formation of Fe-oxides/hydroxides. Anomalous U concentrations (i.e., several hundred to several thousand ppm) measured in goethite, hematite, and amorphous Fe-oxyhydroxides in a major fracture that crosscuts the deposit and the absence of U minerals in the fracture suggest that U was retained during secondary mineral growth or sorbed on mineral surfaces. Mobilization and transport of U away from the deposit is suggested by decreasing U concentrations in fracture-infilling materials and in goethite and hematite with distance from the deposit. Greater than unity $^{234}\text{U}/^{238}\text{U}$ activity ratios measured in fracture-infilling materials indicate relatively recent (<1 Ma) U uptake from fluids that carried excess ^{234}U . Systematic decreases in $^{234}\text{U}/^{238}\text{U}$ activity ratios of fracture materials with distance from the deposit suggest a multistage mobilization process, such as remobilization of U from ^{234}U -enriched infill minerals or differential or diminished transport of U-bearing solutions containing excess ^{234}U .

For more information about natural analog studies in the Sierra Peña Blanca or CNWRA research at Nopal I, contact [James D. Prikryl](mailto:jprikryl@swri.org) at jprikryl@swri.org or call (210) 522-5667.

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