

Mapping Phyllosilicates in Sandstone-Hosted Uranium-Vanadium Deposits of the Paradox Basin: Implications for Geology and Geometallurgy

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Vanadian chlorite, illite, and smectite constitute a major component of the vanadium (V) resource in tabular uranium-vanadium ore deposits, which in turn make up the largest US resource of both USGS critical minerals. This study aims to gain insights into ore formation and extraction by mapping mineralogical and textural relationships of vanadian clays and chlorite within the irregularly shaped orebodies in Salt Wash Member sandstone of the Jurassic Morrison Formation and tracking their decomposition during acid leaching.

Alteration mapping of Salt Wash-hosted deposits, focused on 10m-scale ore exposures, reveals systematic spatial patterns of quartz, calcite, and phyllosilicate cements in the rock. The high-grade central zones of orebodies show a mix of V oxides and phyllosilicates, whereas V-phyllosilicates are more abundant in their lower-grade peripheries. Illite crystallinity decreases with proximity to orebodies. Within orebodies, supplemental infrared spectroscopy shows that chlorite, smectite, and illite occur without a clear relationship to other geologic factors.

Vanadium from V-chlorite is difficult to recover using traditional metallurgical methods, whereas V-illite shows low but variable recovery in acid leaching processes. Hyperspectral imaging of phyllosilicate-rich ore samples during 6 weeks of sulfuric acid and oxidant leaching shows progressive decrepitation in the sequence: (1) loss of V from oxide during the first hour, (2) decrease in the infrared band ratio that reflects the octahedral Al-OH bond abundance from 1 hour to 6 weeks, and (3) decrease in the band ratio that tracks octahedral Fe-OH bond abundance, and decreasing indices of illite crystallinity, from 1 to 6 weeks. Step (1) is associated with decreased V measurements in leach residues due to V-oxide leaching, and step (3) is concurrent with K and V-loss from solids. Mapping these results onto deposits at the orebody scale can help elucidate complex geological and metallurgical aspects of domestic U-V ores.