

Incorporation mechanism of tungsten in W-Fe-Cr-V-bearing rutile

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ABSTRACT

Rutile is a common mineral in many types of ore deposits and can carry chemical or isotopic information about the ore formation. For closer understanding of this information, the mechanisms of incorporation of minor elements should be known. In this work, we have investigated natural rutile crystals with elevated concentrations of WO_3 (up to 17.7 wt%), $\text{Cr}_2\text{O}_{3,\text{tot}}$ (7.5), $\text{V}_2\text{O}_{3,\text{tot}}$ (4.1), FeO_{tot} (7.3), and other metals. X-ray absorption spectroscopy (XAS) of rutile at the Fe *K*, Cr *K*, V *K*, and W *L*₁ and *L*₃ edges shows that all cations are coordinated octahedrally. The average oxidation state of V is +3.8, and that of Cr is near +4. Shell-by-shell fitting of the W *L*₃ EXAFS data shows that W resides in the rutile structure. Raman spectroscopy excludes the possibility of hydrogen as a charge-compensating species. High-resolution TEM and electron diffraction confirm this conclusion as the entire inspected area consists of rutile single crystal with variable amounts of metals other than Ti. Our results show that rutile or its precursors can be efficient vehicles for tungsten in sedimentary rocks, leading to their enrichment in W and possibly later fertility with respect to igneous ore deposits. Leucoxene, a nanocrystalline mixture of Ti and Fe oxides, is an especially suitable candidate for such a vehicle.

Keywords: Rutile, tungsten, incorporation, X-ray absorption spectroscopy, transmission electron microscopy, ore deposits