

The yttrotungstite group revisited

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The crucial importance of tungsten in our modern technologies explains why this element is included in the list of critical raw materials published by the European Union. In most geological contexts, only two mineral substances are carrying this rare element: scheelite, CaWO_4 , and "wolframite", that designate members of a solid solution between the two species hubnerite, MnWO_4 , and ferberite, FeWO_4 .

In the Central African tungsten province, that extends from southwestern Uganda to central Rwanda and eastern Congo, most tungsten-bearing minerals of economic value are constituted by varieties of ferberite. This species generally occurs as black platy crystals, showing a characteristic perfect cleavage plane, and crystallizing as a primary phase in mineralized quartz veins. A remarkable variety of ferberite, called "reinite", forms large pseudo-octahedral crystals without any cleavage plane, and shows a dull black colour and an earthy lustre. This unusual variety mainly occurs in the "tungsten belt" of central Rwanda, and is produced by a pseudomorphic replacement of scheelite by ferberite.

In such "reinite" pseudomorphs occur numerous late alteration phases, among which the new mineral species yttrotungstite-(Nd) that was found in the famous Nyakabingo tungsten mine, close to Kigali. The mineral, with an ideal formula $\text{NdW}_2\text{O}_7(\text{OH})(\text{H}_2\text{O})$, is the Nd-equivalent of yttrotungstite-(Ce) and yttrotungstite-(Y), has been named in agreement with the nomenclature of the yttrotungstite group. It has been approved by the Commission on New Minerals, Nomenclature, and Classification of the International Mineralogical Association (IMA-CNMNC) under number IMA 2023-064, and forms transparent crystals reaching a length of maximum of 100 μm , and frequently forming radiated groups. The dominant form is {010}, and a twinning has been observed parallel to (001). The streak of yttrotungstite-(Nd) is white, the lustre vitreous, and the mineral is non-fluorescent. The Mohs hardness is 1, the tenacity is brittle, and observed cleavage planes are (010) perfect, (100) and (001) excellent. The calculated density is $6.25 \text{ g}\cdot\text{cm}^{-3}$, and refraction indices are $\alpha = 1.90(2)$, β and $\gamma > 2.00$. The mineral is optically biaxial, its optical plane is parallel to (010), and the optical orientation is $X \wedge c = 6^\circ$, $Z \wedge a = 9^\circ$. Pleochroism is from light yellow (X) to yellow (Z). The empirical formula of yttrotungstite-(Nd), calculated on the basis of 15 positive charges assuming 1 (OH) group and 1 H_2O molecule per formula unit, corresponds to: $(\text{Nd}_{0.36}\text{Sm}_{0.13}\text{Ce}_{0.12}\text{Pr}_{0.08}\text{La}_{0.06}\text{Gd}_{0.06}\text{Y}_{0.05}\text{Dy}_{0.03}\text{Yb}_{0.02}\text{Ca}_{0.01})_{\Sigma 0.92}(\text{W}_{2.02}\text{P}_{0.02})_{\Sigma 2.04}\text{O}_7(\text{OH})(\text{H}_2\text{O})$.

The crystal structure of yttrotungstite-(Nd) was refined in space group $P2_1/m$, to the final R1 value 0.0362, and the measured unit-cell parameters are $a = 5.8534(3)$, $b = 8.6881(3)$, $c = 7.0488(4) \text{ \AA}$, $\beta = 105.336(5)^\circ$, $V = 345.70(3) \text{ \AA}^3$. The structure is characterized by edge-sharing WO_6 octahedra, forming kinked chains parallel to the b axis. The NdO_8 complex polyhedra connect three chains together, by sharing edges or corners with adjacent WO_6 octahedra. A view perpendicular to the b axis shows that the NdO_8 and WO_6 polyhedra occur in two different types of planes, stacked parallel to the $[-101]$ direction. Neodymium occurs in

a very large 8-coordinated site, which can be described as two tetragonal pyramids sharing one common basal edge, and sharing the opposite basal edge with a square.

According to the structural data, the end-member formula of yttrotungstite-(Nd) is written as $\text{NdW}_2\text{O}_7(\text{OH})(\text{H}_2\text{O})$, since it appears that the mineral contains 1 OH group and 1 water molecule per formula unit. In order to uniformize the nomenclature of minerals belonging to the yttrotungstite group, the formulae of yttrotungstite-(Ce) and yttrotungstite-(Y) were also modified to $\text{CeW}_2\text{O}_7(\text{OH})(\text{H}_2\text{O})$ and $\text{YW}_2\text{O}_7(\text{OH})(\text{H}_2\text{O})$, respectively.

Key words: yttrotungstite-(Nd), tungsten belt, Rwanda, new mineral, nomenclature revision