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Cation ordering, valence states, and symmetry breaking in the crystal-chemically complex mineral chevkinite-(Ce): Recrystallization, transformation, and metamict states in chevkinite

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Abstract

Annealing is commonly used in the recrystallization of metamict minerals in an attempt to reconstruct the original structure. Annealing at 750 °C of Nb-rich chevkinite-(Ce) from the Biraya rare-metal deposit, Russia, resulted in the structural transformation $C2/m \rightarrow P2_1/a$, which defines chevkinite stability in different environments. This transformation seems to be a rapid version of a naturally occurring process that possibly involves twinning of the crystals. Nb-rich chevkinite-(Ce) occurs naturally as two polymorphs, one with the $C2/m$ space group and the other with $P2_1/a$. The latter is the stable form under ambient conditions. There are some distinct differences in the values of the structural parameters, such as the average *M*-O distances or site scattering values of particular sites for both space groups, which can be associated with the redistribution of some lighter cations, mainly Mg^{2+}, within the crystal lattice. The use of complementary experimental techniques (electron probe microanalysis, X-ray diffraction, and photoelectron spectroscopy) has delivered information on the structure and transformation of a very complex, highly zoned and partially metamict solid solution. It should be useful in determining the structure of any mineral where cation disorder is present.

Keywords: Chevkinite, annealing, crystal structure, metamict, recrystallization