

Ryabchikovite, $\text{CuMg}(\text{Si}_2\text{O}_6)$, a new pyroxene group mineral, and some genetic features of natural anhydrous copper silicates

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ABSTRACT

Ryabchikovite, ideally $\text{CuMg}(\text{Si}_2\text{O}_6)$, a new pyroxene-group mineral (IMA No. 2021-011) was discovered in exhalations of the active Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia. The associated minerals are diopside, hematite, cuprospinel, fluorophlogopite, anhydrite, johillerite, tilasite, and apthitalite-group sulfates. Ryabchikovite forms thin (up to 25 μm), light brown to reddish-brown epitaxial crusts on short-prismatic brownish-gray crystals of diopside (up to 0.5 mm). The new mineral is optically biaxial (+), $\alpha = 1.685(5)$, $\beta = 1.690(5)$, $\gamma = 1.703(4)$, and $2V(\text{meas}) = 60(15)^\circ$. The average chemical composition (wt%, electron microprobe data) is: MgO 18.05, CaO 0.77, CuO 26.46, ZnO 2.23, Al_2O_3 0.93, Fe_2O_3 1.89, SiO_2 50.10, total 100.43. The empirical formula calculated based on 6 O atoms per formula unit is $(\text{Mg}_{1.05}\text{Cu}_{0.78}\text{Zn}_{0.06}\text{Fe}_{0.06}^{3+}\text{Ca}_{0.03})(\text{Si}_{1.96}\text{Al}_{0.04}\text{O}_6)$. Electron backscattered diffraction and powder X-ray diffraction show that ryabchikovite is a Cu,Mg-ordered analog of clinoenstatite. Ryabchikovite adopts the space group $P2_1/c$ and has the following unit-cell parameters: $a = 9.731(9)$, $b = 8.929(8)$, $c = 5.221(4)$ Å, $\beta = 110.00(6)^\circ$, $V = 426.3(7)$ Å³, and $Z = 4$. Ryabchikovite is named in honor of the outstanding Russian geochemist and petrologist Igor Dmitrievich Ryabchikov (1937–2017). Our studies reveal that copper analogs of rock-forming minerals could be found in fumarolic systems. Their crystallization does not require high temperatures or/and pressures (below 500 °C/Pa).

Keywords: Ryabchikovite, new mineral, pyroxene, fumarole sublimate, copper silicate, gas transport reaction, Tolbachik volcano