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# Chivruaiite, $Ca_4(Ti,Nb)_5[(Si_6O_{17})_2[(OH,O)_5]\cdot 13–14H_2O$, a new mineral from hydrothermal veins of Khibiny and Lovozero alkaline massifs

**Yuri P. Men'shikov,[1] Sergey V. Krivovichev,[2,*] Yakov A.Pakhomovsky,[1] Victor N. Yakovenchuk,[1] Gregory Yu. Ivanyuk,[1] Julia A. Mikhailova,[1] Thomas Armbruster,[3] and Ekaterina A. Selivanova[1]**

[1]Geological Institute of the Kola Science Center of the Russian Academy of Sciences, Apatity 184200, Russia
[2]Department of Crystallography, Faculty of Geology, St. Petersburg State University, St. Petersburg, Russia
[3]Laboratorium für chemische und mineralogische Kristallographie, Universität Bern, CH-3102 Bern, Switzerland

## Abstract

Chivruaiite is a new Ca titanosilicate [orthorhombic, *Cmmm, a* = 7.17(2), *b* = 22.98(9), *c* = 6.94(2) Å, *V* = 1144.4 Å$^3$, *Z* = 1], chemically and structurally related to zorite. The mineral is found in three different hydrothermal veins within the Khibiny and Lovozero alkaline massifs, Kola Peninsula, Russia. It is associated with microcline, eudialyte, natrolite, astrophyllite, aegirine, etc. Chivruaiite occurs as elongate-prismatic crystals (up to 3 mm long) with {100}, {010}, {001}, {101}, and {011} as dominant faces, as well as radiating aggregates. The mineral is transparent, pale-pink to colorless, with vitreous luster and white streak. Cleavage is distinct on {100} and {010}; fracture is step-like. Mohs hardness is about 3. In transmitted light, the mineral is pale-pink, with a faint pleochroism: *Z* = pale-pink, on *X* and *Y* = colorless; dispersion $r < v$. Chivruaiite is biaxial (+): $\alpha$ =1.705(5), $\beta$ = 1.627(2), $\gamma$ = 1.612(2) (for $\lambda$ = 589 nm), $2V_{meas} = 40 \pm 5°$, $2V_{calc} = 31.7°$. Optical orientation: $X = b$, $Y = a$, $Z = c$, $D_{calc} = 2.42$ g/cm$^3$, $D_{meas} = 2.40–2.42$ g/cm$^3$. The mean chemical composition determined by electron microprobe is (wt%): $SiO_2$ 45.14; $TiO_2$ 20.63; $Al_2O_3$ 0.07; $Fe_2O_3$ 0.18; MnO 0.02; MgO 0.01; CaO 10.53; $Na_2O$ 0.10; $K_2O$ 1.30; SrO 0.28; $Nb_2O_5$ 3.63; $H_2O$ 17.30; sum. 99.19. Empirical formula calculated on the basis of Si = 12 is $(Ca_{3.00}K_{0.44}Na_{0.05}Sr_{0.04}Mn_{0.01})_{\Sigma=3.54}(Ti_{4.13}Nb_{0.44}Fe^{3+}_{0.04}Al_{0.02})_{\Sigma=4.63}[Si_{12}O_{34}|(OH)_{4.51}O_{0.49}]\cdot 13.08H_2O$. Simplified formula is $Ca_4(Ti,Nb)_5[(Si_6O_{17})_2|(OH,O)_5]\cdot 13–14H_2O$. The strongest X-ray powder-diffraction lines [*d* in Å, (I), (*hkl*)] are 11.6 (100) (020), 6.91 (90) (110, 001), 5.23 (50) (130), 3.41 (50) (220), 3.35 (50) (061, 151), 3.04 (80) (221, 240). The structure of chivruaiite was refined to $R_1 = 0.038$ on the basis of 687 unique observed reflections. It is based upon an open framework of $SiO_4$ tetrahedra, $TiO_6$ octahedra, and $TiO_5$ pyramids. Framework cavities are occupied by $Ca^{2+}$ and $K^+$ cations, and $H_2O$ molecules. The mineral is named after its type locality in the Chivruai River valley (the Lovozero massif, Kola Peninsula, Russia). Chivruaiite is a Ca-analog of zorite and ETS-4 and is closely related to haineaultite.

**Keywords**: Chivruaiite, zorite, titanosilicate, new mineral, crystal structure, Kola Peninsula