Chivruaiite, Ca₄(Ti,Nb)₅[(Si₆O₁₇)₂(OH,OH)₅]·13–14H₂O, a new mineral from hydrothermal veins of Khibiny and Lovozero alkaline massifs

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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 Å³, 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 (+): α = 1.705(5), β = 1.627(2), γ = 1.612(2) (for λ = 589 nm), 2Vₘ₇₈ = 40 ± 5°, 2Vₑₘ₇₈ = 31.7°. Optical orientation: X = b, Y = a, Z = c, Dₑₘ₇₈ = 2.42 g/cm³, Dₐₘ₇₈ = 2.40–2.42 g/cm³. The mean chemical composition determined by electron microprobe is (wt%): SiO₂ 45.14; TiO₂ 20.63; Al₂O₃ 0.07; Fe₂O₃ 0.18; MnO 0.02; MgO 0.01; CaO 10.53; Na₂O 0.10; K₂O 1.30; SrO 0.28; Nb₂O₅ 3.63; H₂O 17.30; sum. 99.19. Empirical formula calculated on the basis of Si = 12 is (Ca₁₀₋ₓKₓNa₉₋₂ₓSn₁₋ₓ₂ክ₄ₓMnₓ₂ đã₉₋₁ₓ₂)(Ti₄.₁₃Nb₀.₄₄Fe₃₊ₓO₉₃.₁₃(Σ)(OＨ₄₊ₓΟ₂₋ₓ)₁₃.₀₈Η₂O. Simplified formula is Ca₂(Ti,Nb)₅[(Si₆O₁₇)₂(OH,OH)₅]·13–14H₂O. The strongest X-ray powder-diffraction lines [d in Å, (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 = 0.038 on the basis of 687 observed reflections. It is based upon an open framework of SiO₄ tetrahedra, TiO₆ octahedra, and TiO₅ pyramids. Framework cavities are occupied by Ca²⁺ and K⁺ cations, and H₂O 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 hainaeultite.

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

Introduction

Microporous titanato- and niobosilicates are promising materials for a wide range of industrial applications, including gas separation, catalysis, radioactive waste management, etc. (Rocha and Anderson 2000; Ferraris and Merlino 2005). The most famous representatives of the titanosilicate family are Engelhard Titanosilicates, ETS-4 and ETS-10. ETS-4 is a synthetic analog of zorite, Na₆[Si₆O₁₇](OH)₂·13H₂O, a rare mineral discovered by Mer’kov et al. (1973) in the aegirine-microcline-natrolite vein “Yubileinaya” within lujavrite at Mt. Karnasurt (the Lovozero alkaline massif, Kola Peninsula, Russia). In this paper, we report occurrence and structure of chivruaiite, a Ca analog of zorite.

Chivruaiite was first found by the first author in 1978 in an astrophyllite-aegirine-microcline vein in foyaitie at the Eveslogchorr Mountain, the Khibiny massif, Kola Peninsula, Russia. On the basis of its X-ray powder-diffraction pattern, it had initially been identified as zorite. However, subsequent finds of this mineral in 1999 (Mt. Eveslogchorr, the Khibiny massif) and 2004 (the Chivruai River valley, the Lovozero massif) and chemical studies of the samples showed chivruaiite to be a Ca analog of zorite and therefore to be a new mineral species. The mineral has been named after its type locality in the Chivruai River valley, the Lovozero massif, Kola Peninsula. Both the mineral and mineral name have been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association (proposal 2004-052). The holotype specimen of chivruaiite has been deposited at the Mineralogical Museum of St. Petersburg State University. The type is deposited at Geological and Mineralogical Museum of the Geological Institute of the Kola Science Centre of Russian Academy of Sciences, Apatity, Russia (no. 6281/1.07.2005).