American Mineralogist, Volume 96, pages 709–715, 2011

Krotite, $CaAl_2O_4$, a new refractory mineral from the NWA 1934 meteorite

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Abstract

Krotite, $CaAl_2O_4$, occurs as the dominant phase in an unusual Ca-,Al-rich refractory inclusion from the NWA 1934 CV3 carbonaceous chondrite. Krotite occupies the central and mantle portions of the inclusion along with minor perovskite, gehlenite, hercynite, and Cl-bearing mayenite, and trace hexamolybdenum. A layered rim surrounds the krotite-bearing regions, consisting from inside to outside of grossite, mixed hibonite, and spinel, then gehlenite with an outermost layer composed of Al-rich diopside. Krotite was identified by XRD, SEM-EBSD, micro-Raman, and electron microprobe. The mean chemical composition determined by electron microprobe analysis of krotite is (wt%) Al_2O_3 63.50, CaO 35.73, sum 99.23, with an empirical formula calculated on the basis of 4 O atoms of $Ca_{1.02}Al_{1.99}O_4$. Single-crystal XRD reveals that krotite is monoclinic, $P2_1/n$; a = 8.6996(3), b = 8.0994(3), c = 15.217(1) Å, β = 90.188(6), and Z = 12. It has a stuffed tridymite structure, which was refined from single-crystal data to R_1 = 0.0161 for 1014 $F_o > 4\sigma F$ reflections. Krotite is colorless and transparent with a vitreous luster and white streak. Mohs hardness is ~6½. The mineral is brittle, with a conchoidal fracture. The calculated density is 2.94 g/cm^3. Krotite is biaxial (–), α = 1.608(2), β = 1.629(2), γ = 1.635(2) (white light), $2V_{meas}$ = 54.4(5)°, and $2V_{calc}$ = 55.6°. No dispersion was observed. The optical orientation is X = **b**; $Y \approx$ **a**; $Z \approx$ **c**. Pleochroism is colorless to very pale gray, $X > Y = Z$. Krotite is a low-pressure $CaAl_2O_4$ mineral, likely formed by condensation or crystallization from a melt in the solar nebula. This is the first reported occurrence of krotite in nature and it is one of the earliest minerals formed in the solar system.

Keywords: Krotite, $CaAl_2O_4$, new mineral, refractory inclusion, NWA 1934 meteorite, CV3 carbonaceous chondrite, XRD, EBSD