

Kangite, (Sc,Ti,Al,Zr,Mg,Ca,□)₂O₃, a new ultra-refractory scandia mineral from the Allende meteorite: Synchrotron micro-Laue diffraction and electron backscatter diffraction

CHI MA,^{1,*} OLIVER TSCHAUNER,^{1,2} JOHN R. BECKETT,¹ GEORGE R. ROSSMAN,¹ AND WENJUN LIU³

¹Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125, U.S.A.

²High Pressure Science and Engineering Center and Department of Geoscience, University of Nevada, Las Vegas, Nevada 89154, U.S.A.

³Advanced Photon Source, Argonne National Laboratory, Argonne, Illinois 60439, U.S.A.

ABSTRACT

Kangite (IMA 2011-092), (Sc,Ti,Al,Zr,Mg,Ca,□)₂O₃, is a new scandia mineral, occurring as micrometer-sized crystals with REE-rich perovskite and spinel in a davisite-dominant ultra-refractory inclusion from the Allende CV3 carbonaceous chondrite. The phase was characterized by SEM, EBSD, synchrotron micro-Laue diffraction, micro-Raman, and EPMA. The mean chemical composition of the type kangite is (wt%) TiO₂ 36.6, Sc₂O₃ 26.4, ZrO₂ 11.3, Al₂O₃ 7.0, Y₂O₃ 5.4, CaO 3.9, MgO 3.14, Dy₂O₃ 1.8, SiO₂ 1.7, V₂O₃ 1.31, Er₂O₃ 0.92, FeO 0.8, Gd₂O₃ 0.60, Ho₂O₃ 0.40, Tb₂O₃ 0.18, Cr₂O₃ 0.09, ThO₂ 0.04, O –0.3, sum 101.28, which leads to an empirical formula calculated on the basis of 3 O atoms of [(Sc_{0.54}Al_{0.16}Y_{0.07}V_{0.03}Gd_{0.01}Dy_{0.01}Er_{0.01})_{Σ0.83}(Ti_{0.66}Zr_{0.13})_{Σ0.79}(Mg_{0.11}Ca_{0.06}Fe_{0.02})_{Σ0.19}□_{0.19}]_{Σ2.00}O₃. Synchrotron micro-Laue diffraction (i.e., an energy scan by a high-flux X-ray monochromatic beam) on one type domain at submicrometer resolution revealed that kangite has a cation-deficient *Ia* $\bar{3}$ bixbyite-type cubic structure. The cell parameters are $a = 9.842(1)$ Å, $V = 953.3(1)$ Å³, $Z = 16$, which leads to a calculated density of 3.879 g/cm³. Kangite is a new ultra-refractory mineral, likely originating through low-temperature oxidation of a Sc-, Ti³⁺-enriched high-temperature condensate oxide dating to the birth of the Solar System.

Keywords: Kangite, (Sc,Ti,Al,Zr,Mg,Ca,□)₂O₃, new ultra-refractory mineral, scandia, Allende meteorite, CV3 carbonaceous chondrite, synchrotron micro-Laue diffraction, EBSD, nano-mineralogy, REE