

## Armbrusterite, $K_5Na_6Mn^{3+}Mn^{2+}_{14}[Si_9O_{22}]_4(OH)_{10}\cdot 4H_2O$ , a new Mn hydrous heterophyllosilicate from the Khibiny alkaline massif, Kola Peninsula, Russia

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### ABSTRACT

Armbrusterite, ideally  $K_5Na_6Mn^{3+}Mn^{2+}_{14}[Si_9O_{22}]_4(OH)_{10}\cdot 4H_2O$ , is a new silicate of potassium, sodium, and manganese found in a thin cancrinite-aegirine-microcline vein within urtite at Mt. Kukisvumchorr. The mineral occurs in intimate association with raite. Other associated minerals are lamprophyllite, mangan-neptunite, pectolite, vinogradovite, calcite, molybdenite, galena, sphalerite, and fluorite. Armbrusterite occurs as split, curved crystals and spherulites ( $\leq 2$  mm diameter). The mineral is translucent (transparent in thin fragments), dark reddish-brown. It has vitreous luster and light-brown streak. Cleavage is perfect on (001) and the fracture is uneven. Mohs hardness is about 3.5. In transmitted light, the mineral is reddish-brown, with strong pleochroism:  $X$  = light yellowish-brown,  $Y$  and  $Z$  = dark reddish-brown; dispersion  $r > v$ , weak. Armbrusterite is biaxial (–):  $\alpha = 1.532(2)$ ,  $\beta = 1.560(2)$ ,  $\gamma = 1.564(2)$  (for  $\lambda = 589$  nm),  $2V$  varies from  $10^\circ$  to  $20^\circ$ . Optical orientation:  $X$  is perpendicular to (001). The mean chemical composition determined by electron microprobe and the Penfield method (for  $H_2O$ ) is (wt%):  $Na_2O$  5.26,  $MgO$  0.19,  $Al_2O_3$  0.04,  $SiO_2$  56.02,  $K_2O$  6.13,  $CaO$  0.26,  $TiO_2$  0.04,  $MnO$  23.62,  $Mn_2O_3$  2.07,  $FeO$  0.65,  $ZnO$  0.20,  $H_2O$  4.1, sum. 98.58. Empirical formula calculated on the basis of  $Si = 36$  is  $K_{5.03}Na_{6.55}(Mn^{2+}_{12.86}Mn^{3+}_{1.01}Fe^{2+}_{0.35}Mg_{0.18}Ca_{0.18}Zn_{0.09}Al_{0.03}Ti_{0.02})_{\Sigma=14.72}[Si_{36}O_{88}](OH)_{10.10}\cdot 3.75 H_2O$ . Armbrusterite is monoclinic,  $C2/m$ ,  $a = 17.333(2)$ ,  $b = 23.539(3)$ ,  $c = 13.4895(17)$  Å,  $\beta = 115.069(9)^\circ$ ,  $V = 4985.4(11)$  Å<sup>3</sup>,  $Z = 2$ . The strongest X-ray powder-diffraction lines are [ $d$  in Å, (I), ( $hkl$ )]: 12.28 (100) (001), 4.10 (10) (003), 3.562 (10) (113, 261), 3.260 (18) (114), 3.117 (13) (203), 3.077 (54) (004), 2.622 (10) (371). The crystal structure of armbrusterite was refined to  $R_1 = 0.085$  on the basis of 3960 unique observed reflections. The structure is based upon double silicate [ $Si_9O_{22}$ ] layers consisting of 5-, 6-, 7-, and 8-membered tetrahedra rings. The layers are linked via octahedral sheets formed by Na and Mn octahedra. The interior of the double silicate layers is occupied by  $K^+$  cations and  $H_2O$  molecules. The mineral is named in honor of Thomas Armbruster (b. 1950; University of Berne) for his outstanding contribution to structural mineralogy and crystallography, especially to the study of Mn-rich minerals.

**Keywords:** Armbrusterite, new mineral, sodium-potassium-manganese silicate, crystal structure, Khibiny massif, Kola Peninsula