Ferro-papikeite, ideally NaFe₂²⁺(Fe₃²⁺Al₂)(Si₅Al₃)O₂₂(OH)₂, a new orthorhombic amphibole from Nordmark (Western Bergslagen), Sweden: Description and crystal structure

FRANK C. HAWTHORNE^{1,*}, MAXWELL C. DAY¹, MOSTAFA FAYEK¹, KEES LINTHOUT², Wim. J. LUSTENHOUWER², AND ROBERTA OBERTI³

¹Department of Earth Sciences, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada ²Geology & Geochemistry Research Cluster, Vrije Universiteit, Amsterdam, The Netherlands ³CNR-Istituto di Geoscienze e Georisorse, sede secondaria di Pavia, via Ferrata 1, I-27100 Pavia, Italy

ABSTRACT

Ferro-papikeite, ideally NaFe²⁺(Fe³⁺₃Al₂)(Si₅Al₃)O₂₂(OH)₂, is a new mineral of the amphibole supergroup from the Filipstad Municipality, Värmland County, Central Sweden, where it occurs in a medium-grade felsic metavolcanic rock. Ferro-papikeite is pale brown with a translucent luster, has a colorless to very pale-brown streak, and shows no fluorescence under long-wave or short-wave ultraviolet light. Grains are subhedral, 0.4–3.0 mm in size, and show well-developed {210} cleavage. It has a Mohs hardness of ~6 and is brittle with a splintery fracture, has the characteristic perfect {210} cleavage of orthorhombic amphiboles, intersecting at ~56°, and the calculated density is 3.488 g/cm³. In transmitted plane-polarized light, ferro-papikeite is moderately pleochroic X = very pale brown, Y = Z = honey brown; X < Y = Z. Ferro-papikeite is biaxial (+), $\alpha = 1.674(2)$, $\beta = 1.692(2)$, $\gamma = 1.716(2)$, $2V_{meas} = 86.2(9)$ and $2V_{cule} = 88.3°$, dispersion is r < v, weak. The orientation is: X || a, Y || b, Z || c.

Ferro-papikeite is orthorhombic, space group *Pnma*, a = 18.628(4), b = 17.888(4), c = 5.3035(11) Å, V = 1767.2(6) Å³, Z = 4. The strongest ten X-ray diffraction lines in the powder pattern are [*d* in Å(*l*) (*hkl*)]: 8.255(100)(210), 3.223(39)(440), 3.057(68)(610), 2.824(28)(251), 2.674(41)(351), 2.572(56) (161,621), 2.549(38)(202), 2.501(50)(261,451), 2.158(25)(502), and 1.991(31)(661). Chemical analysis by electron microprobe gave SiO₂ 36.50, Al₂O₃ 22.24, TiO₂ 0.09, FeO 31.54, MnO 0.65, MgO 5.48, CaO 0.08, Na₂O 2.35, F 0.22, H₂O_{calc} 1.85, O=F –0.09, sum 100.91 wt%. The formula unit, calculated on the basis of 24 (O+OH+F) with (OH) = 2 apfu and Fe³⁺ = 0.13 apfu (determined from the <M2–O> distance) is ^A(Na_{0.70}Ca_{0.01})^{B+c}(Mg_{1.25}Fe²⁺_{3.90}Mn²⁺_{0.18}Al_{1.62}Fe³⁺_{0.13}Ti⁴⁺_{0.19})_{26.99}^T(Si_{5.60}Al_{2.40})₂₈O₂₂(OH_{1.89}F_{0.11})₂. The crystal structure of ferro-papikeite was refined to an R-index of 3.60% using 2335 unique observed reflections collected with MoKa X-radiation. ^{[41}Al³⁺ is ordered over the four *T* sites as follows: *T*1B > *T*1A > *T*2B >> *T*2a, ^[6]Al³⁺ is completely ordered at *M*2, and Fe²⁺ is strongly ordered at *M*4. The *A* site is split with Na⁺ strongly ordered at *A*1. End-member ferro-papikeite is related to end-member gedrite, $\Box Mg_2(Mg_3Al_2)(Si_6Al_2)O_{22}(OH)_2$, by the substitutions Na⁺ $\rightarrow \Box$, Fe²⁺ \rightarrow Mg, and Al³⁺ \rightarrow Si⁴⁺. The description of ferro-papikeite as a new species further emphasizes the compositional similarities between the monoclinic calcium amphiboles and the orthorhombic magnesium-iron-manganese amphiboles.

Keywords: Ferro-papikeite, new amphibole, electron-microprobe analysis, optical properties, crystal-structure refinement, Bergslagen, Sweden