American Mineralogist, Volume 111, pages 60–72, 2026

Pfaffenbergite, $KNa_3(Al_4Si_{12})O_{32}$, a polymorph of sodic feldspar isostructural with kokchetavite and wodegongjieite, found in crystallized melt inclusions in metamorphic garnet

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ABSTRACT

Pfaffenbergite, $KNa_3(Al_4Si_{12})O_{32}$, is a new mineral found in nanogranitoids included in garnets from HP and UHP eclogites in the Saxo-Thuringian Zone of the Bohemian Massif (Saxony, Germany). The occurrence of a new mineral phase was initially inferred from its unique micro-Raman spectrum, characterized by a very strong vibrational mode at 412 cm^{-1} and minor peaks at 105, 832, 130, and 470 cm^{-1}. Subsequently, three-dimensional electron diffraction revealed that pfaffenbergite is a hexagonal mineral, crystallizing in space group $P6/mcc$, isostructural with kokchetavite ($KAlSi_3O_8$) and wodegongjieite [$KCa_3(Al_7Si_9)O_{32}$]. These two sheet silicates have feldspar stoichiometry and chemical composition, and pfaffenbergite corresponds chemically to an unmixed binary K-Na feldspar. Microstructural and experimental constraints suggest that it formed as a result of melt crystallization during cooling, after entrapment within metamorphic garnets. The precise pressure-temperature conditions of formation of pfaffenbergite are currently unknown. However, they must have been below the P-T conditions of entrapment of the inclusions, i.e., 1000–1050 °C and 2.2–4.5 GPa, as determined in the present work, based on the values estimated for each individual case study.

We interpret pfaffenbergite as a metastable phase crystallizing rapidly in a silicate melt enclosed in a small pore under non-equilibrium conditions, also based upon previous studies reporting the occurrence of other metastable phases in the same or neighboring nanogranitoids (kokchetavite, kumdykolite, dmisteinbergite, etc.). The increasing number of findings of metastable phases in the last years suggests that these minerals are more common than expected. We propose that it is even possible they may represent rock-forming minerals in natural rocks that experienced rapid cooling/rapid crystallization, for instance, lavas and ignimbrites, along with experimental products involving silicate melts.

Keywords: Pfaffenbergite, nanogranitoids, polymorph, feldspar, wodegongjieite, Bohemian Massif, Waldheim