

## Parvo-mangano-edenite, parvo-manganotremolite, and the solid solution between Ca and Mn<sup>2+</sup> at the M4 site in amphiboles

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### ABSTRACT

This work reports the crystal-chemical characterization of Mn-rich amphiboles from the Grenville Marble of the Arnold mine, Fowler, St. Lawrence Co., New York (U.S.A.), which were previously described by Benimoff et al. (1991) as “manganoan silicic edenite.” According to the new nomenclature scheme for monoclinic amphiboles (Leake et al. 2004) the ideal composition of reference, <sup>A</sup>Na<sup>B</sup>(CaMn)<sup>C</sup>Mg<sub>5</sub><sup>T</sup>(Si<sub>7</sub>Al)O<sub>22</sub>(OH)<sub>2</sub> with Ca > 1 apfu, is an end-member of the newly defined Group 5, and is named parvo-mangano-edenite. Re-examination of the original rock specimen showed significant inter- and intra-crystalline compositional variations, which can be expressed by the <sup>A</sup>Na<sub>1</sub><sup>T</sup>Al<sub>1</sub><sup>A</sup>□<sub>1</sub><sup>T</sup>Si<sub>1</sub> and <sup>B</sup>Mn<sub>2</sub><sup>B</sup>Ca<sub>2</sub> exchange vectors. The first vector leads to parvo-manganotremolite, ideally <sup>A</sup>□<sup>B</sup>(CaMn)<sup>C</sup>Mg<sub>5</sub><sup>T</sup>Si<sub>8</sub>O<sub>22</sub>(OH)<sub>2</sub> with Ca > 1. The second mechanism was never found to reach Mn dominance; however, crystal-chemical analysis does not provide any evidence of structural limits, and thus the magno-calcic counterparts of the Group 5 amphiboles of this work may occur in similar but Mn-richer genetic environments. The presence of Mn at the B site helps to stabilize the charge arrangement of edenite.

The parvo-mangano-edenite crystal with composition closest to the end-member, i.e., <sup>A</sup>(Na<sub>0.74</sub>K<sub>0.02</sub>)<sup>B</sup>(Ca<sub>1.27</sub>Mn<sub>0.73</sub>)<sup>C</sup>(Mg<sub>4.51</sub>Mn<sub>0.28</sub><sup>2+</sup>Fe<sub>0.05</sub><sup>3+</sup>Fe<sub>0.03</sub><sup>3+</sup>Al<sub>0.12</sub>Ti<sub>0.01</sub>)<sup>T</sup>(Si<sub>7.07</sub>Al<sub>0.93</sub>)O<sub>22</sub>(OH)<sub>2</sub>, has *a* = 9.8260(5), *b* = 18.0487(9), *c* = 5.2840(4) Å, β = 104.55(1)°, *V* = 907.1 Å<sup>3</sup> (*Z* = 2); the calculated density is 3.11 g/cm<sup>3</sup>. The parvo-mangano tremolite crystal, with composition <sup>A</sup>(Na<sub>0.44</sub>K<sub>0.01</sub>)<sup>B</sup>(Ca<sub>1.13</sub>Mn<sub>0.83</sub>Na<sub>0.04</sub>)<sup>C</sup>(Mg<sub>4.69</sub>Mn<sub>0.21</sub><sup>2+</sup>Fe<sub>0.03</sub><sup>3+</sup>Fe<sub>0.01</sub><sup>3+</sup>Al<sub>0.06</sub>)<sup>T</sup>(Si<sub>7.52</sub>Al<sub>0.48</sub>)O<sub>22</sub>(OH)<sub>2</sub>, has *a* = 9.7807(5), *b* = 18.0548(9), *c* = 5.2928(4) Å, β = 104.19(1)°, *V* = 906.1 Å<sup>3</sup> (*Z* = 2); the calculated density is 3.08 g/cm<sup>3</sup>. The different compositions are virtually indistinguishable under the optical microscope, but can be identified by a measure of their unit-cell parameters. The single-crystal FTIR spectrum of parvo-mangano-edenite in the OH-stretching region shows two main absorptions at 3711 and 3671 cm<sup>-1</sup>, plus shoulders at 3695, 3660, and 3641 cm<sup>-1</sup>, respectively. FTIR spectroscopy indicates extensive short-range-order of cations in these amphiboles.

**Keywords:** Analysis, chemical (mineral), amphiboles, crystal structure, parvo-mangano-edenite, parvo-manganotremolite, IR spectroscopy, new minerals