

**CHOPINITE-SARCOPSIDE SOLID SOLUTION, (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>, IN LODRANITE GRA95209**

E. S. Grew<sup>1</sup>, M.G. Yates<sup>1</sup>, R.J. Beane<sup>2</sup>, C. Floss<sup>3</sup> and C. Gerbi<sup>1</sup>.

<sup>1</sup>University of Maine, Orono 04469-5790 USA. E-mail: es-grew@maine.edu. <sup>2</sup>Bowdoin College, Brunswick 04011 USA

<sup>3</sup>Washington University, St. Louis 63130 USA

**Introduction:** Four phosphate minerals have the stoichiometry (M<sup>2+</sup>)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>. Sarcopside and graftonite, both Fe dominant, are found in meteorites and terrestrial rocks. Chopinite, the recently discovered Mg-dominant analogue of sarcopside occurring in terrestrial granulite-facies metasediments, is inferred to have formed at 800-860°C, 6-7 kbar [1] and is a high-pressure polymorph of farringtonite [2], which has been found only in meteorites. Unidentified (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phases with X<sub>Mg</sub> = Mg/(Mg+Fe) ranging from 0.01 to 0.87, together with chladniite, CaNa<sub>8</sub>(Ca<sub>4</sub>Na<sub>4</sub>)(Mg,Fe)<sub>43</sub>(PO<sub>4</sub>)<sub>36</sub>, or its Fe-dominant analogue, johnsomervilleite, have been reported as minor constituents in Graves Nunatak 95209, a lodranite containing Fe-Ni metal masses and forsterite-orthopyroxene aggregates [3, 4].

**Results:** To identify the unknown (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phases we determined the Fe-Mg-Mn distribution between contiguous grains of (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> and chladniite-johnsomervilleite and obtained electron backscatter diffraction patterns of the (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phases. Electron microprobe analyses of contiguous grains of (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> and chladniite-johnsomervilleite in three sections of GRA95209 give two trends for Mg-Fe, one for johnsomervilleite and chladniite with X<sub>Mg</sub> ≤ 0.738, the second for chladniite only with X<sub>Mg</sub> ≥ 0.738. The first trend is tightly constrained with a distribution coefficient, K<sub>D</sub> = (Mg/Fe)<sub>UNK</sub>/(Mg/Fe)<sub>C-J</sub> = 0.584, which is nearly identical to Mg-Fe distribution between terrestrial sarcopside and johnsomervilleite, K<sub>D</sub> = 0.588 [1]. This suggests that the unknown (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phase is sarcopside (for compositions X<sub>Mg</sub> = 0.28-0.43) and chopinite (for compositions X<sub>Mg</sub> = 0.57-0.65). Mn-Fe distribution is consistent with the (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phases being sarcopside or chopinite, not graftonite, which would have contained much more Mn. The second trend in Mg-Fe gives K<sub>D</sub> ~ 1.51. In this case, we infer that the unknown (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phase is farringtonite (X<sub>Mg</sub> = 0.80-0.89). Electron backscatter diffraction patterns and maps of magnesian (Mg,Fe)<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> phases confirm identification of chopinite and farringtonite.

In contrast to the phosphates, our analyses show that associated forsterite and enstatite vary little in composition, viz., X<sub>Mg</sub> = 0.93 and 0.92-0.93, respectively, except for fayalite overgrowths on forsterite (X<sub>Mg</sub> ≥ 0.2).

**Discussion:** Using the experimental data for the end-member reaction [2], an isopleth calculated as in [1] at 500-1050°C for chopinite X<sub>Mg</sub> = 0.65, but with measured K<sub>D</sub> = (Mg/Fe)<sub>FAR</sub>/(Mg/Fe)<sub>CHO</sub> = 2.10, gives 4-7 kbar for this chopinite-farringtonite pair, pressures far too high for any meteorite. We suggest that Fe-rich sarcopside initially formed by oxidation and replacement of P-rich metal; subsequent exchange with a large reservoir of Mg-rich silicates resulted in Mg enrichment of the phosphates and, consequently, Fe-rich overgrowths on forsterite. As GRA95209 cooled, Mg-enriched sarcopside failed to transform into farringtonite, leaving chopinite as a metastable phase.

**References:** [1] Grew E. et al. (2007) *Eur. J. Mineral.* 19:229-245. [2] Brunet F. & D. Vielzeuf (1996) *Eur. J. Mineral.* 8:349-354. [3] Floss C. (1999) *Am. Mineral.* 84:1354-1359. [4] McCoy T. et al. (2006) *Geochim. Cosmochim. Acta* 70:516-531.