

## CHOPINITE-SARCOPSIDE SOLID SOLUTION, $(\text{Mg,Fe})_3(\text{PO}_4)_2$ , IN LODRANITE GRA95209

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**Introduction:** Four phosphate minerals have the stoichiometry  $(\text{M}^{2+})_3(\text{PO}_4)_2$ . Sarcopsidite and graptoneite, both Fe dominant, are found in meteorites and terrestrial rocks. Chopininite, the recently discovered Mg-dominant analogue of sarcopsidite 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  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phases with  $X_{\text{Mg}} = \text{Mg}/(\text{Mg}+\text{Fe})$  ranging from 0.01 to 0.87, together with chladniite,  $\text{CaNa}_8(\text{Ca}_4\text{Na}_4)(\text{Mg,Fe})_{43}(\text{PO}_4)_{36}$ , 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  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phases we determined the Fe-Mg-Mn distribution between contiguous grains of  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  and chladniite-johnsomervilleite and obtained electron backscatter diffraction patterns of the  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phases. Electron microprobe analyses of contiguous grains of  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  and chladniite-johnsomervilleite in three sections of GRA95209 give two trends for Mg-Fe, one for johnsomervilleite and chladniite with  $X_{\text{Mg}} \leq 0.738$ , the second for chladniite only with  $X_{\text{Mg}} \geq 0.738$ . The first trend is tightly constrained with a distribution coefficient,  $K_D = (\text{Mg/Fe})_{\text{UNK}}/(\text{Mg/Fe})_{\text{C-J}} = 0.584$ , which is nearly identical to Mg-Fe distribution between terrestrial sarcopsidite and johnsomervilleite,  $K_D = 0.588$  [1]. This suggests that the unknown  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phase is sarcopsidite (for compositions  $X_{\text{Mg}} = 0.28-0.43$ ) and chopininite (for compositions  $X_{\text{Mg}} = 0.57-0.65$ ). Mn-Fe distribution is consistent with the  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phases being sarcopsidite or chopininite, not graptoneite, which would have contained much more Mn. The second trend in Mg-Fe gives  $K_D \sim 1.51$ . In this case, we infer that the unknown  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phase is farringtonite ( $X_{\text{Mg}} = 0.80-0.89$ ). Electron backscatter diffraction patterns and maps of magnesian  $(\text{Mg,Fe})_3(\text{PO}_4)_2$  phases confirm identification of chopininite and farringtonite.

In contrast to the phosphates, our analyses show that associated forsterite and enstatite vary little in composition, viz.,  $X_{\text{Mg}} = 0.93$  and  $0.92-0.93$ , respectively, except for fayalite overgrowths on forsterite ( $X_{\text{Mg}} \geq 0.2$ ).

**Discussion:** Using the experimental data for the end-member reaction [2], an isopleth calculated as in [1] at 500–1050°C for chopininite  $X_{\text{Mg}} = 0.65$ , but with measured  $K_D = (\text{Mg/Fe})_{\text{FAR}}/(\text{Mg/Fe})_{\text{CHO}} = 2.10$ , gives 4–7 kbar for this chopininite-farringtonite pair, pressures far too high for any meteorite. We suggest that Fe-rich sarcopsidite 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 sarcopsidite failed to transform into farringtonite, leaving chopininite 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.