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 \((\text{M}^2\text{Fe})_3(\text{PO}_4)_2\): 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 \((\text{Mg,Fe})_3(\text{PO}_4)_2\) phases with \(X_{\text{Mg}} = \text{Mg}/(\text{Mg}+\text{Fe})\) ranging from 0.01 to 0.87, together with chladnite, \(\text{CaNa}_2(\text{CaNa}_2)\text{Fe}_4(\text{PO}_4)_6\) 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 chladnite-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 chladnite-johnsomervilleite in three sections of GRA95209 give two trends for Mg-Fe, one for johnsomervilleite and chladnite with \(X_{\text{Mg}} \leq 0.738\), the second for chladnite only with \(X_{\text{Mg}} = 0.738\). The first trend is tightly constrained with a distribution coefficient, \(K_D = (\text{Mg/Fe})_{\text{North}}/(\text{Mg/Fe})_{\text{C-J}} = 0.584\), which is nearly identical to Mg-Fe distribution between terrestrial sarcopside and johnsomervilleite, \(K_D = 0.588\) [1]. This suggests that the unknown \((\text{Mg,Fe})_3(\text{PO}_4)_2\) phase is sarcopside (for compositions \(X_{\text{Mg}} = 0.28-0.43\)) and chopinite (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 sarcopside or chopinite, not graftonite, 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 chopinite 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 \((X_{\text{Mg}} = 0.2)\).

**Discussion:** Using the experimental data for the end-member reaction [2], an isopleth calculated as in [1] at 500-1050°C for chopinite \(X_{\text{Mg}} = 0.65\), but with measured \(K_D = (\text{Mg/Fe})_{\text{Farr}}/(\text{Mg/Fe})_{\text{CHO}} = 2.10\), 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.