

Phosphorus partitioning between olivine and melt: An experimental study in the system $\text{Mg}_2\text{SiO}_4\text{-Ca}_2\text{Al}_2\text{Si}_2\text{O}_9\text{-NaAlSi}_3\text{O}_8\text{-Mg}_3(\text{PO}_4)_2$

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ABSTRACT

The partitioning of phosphorus between olivine and melt was measured by conducting partitioning experiments within the system $\text{Mg}_2\text{SiO}_4\text{-Ca}_2\text{Al}_2\text{Si}_2\text{O}_9\text{-NaAlSi}_3\text{O}_8\text{-Mg}_3(\text{PO}_4)_2$, using olivines crystallized with cooling rates in the range 1 to 10 °C/h. Partition coefficients, $D_p^{\text{ol/melt}}$, vary from 0.05 to 1.41 and are strongly influenced by melt composition, with high partition coefficients observed for more polymerized melts. Correlations between elemental abundances in the olivines demonstrate that phosphorus substitutes on a near one for one basis for Si, charge-balanced by Mg vacancies; no correlation between P and Al concentration in the olivine was observed. A complete understanding of the controls on $D_p^{\text{ol/melt}}$ is required to model quantitatively the zoning of P in olivine that has recently been shown to be a common feature of igneous olivine crystals. The strong melt compositional dependence observed in this study implies that both changing concentrations of P in the melt during fractionation, and changing values of $D_p^{\text{ol/melt}}$ can contribute to core-to-rim variations in P when the surface composition of a growing olivine crystal is in equilibrium with the melt. The common observation of zones in natural olivines where high P is correlated with high Al and Cr must be explained by processes other than equilibrium growth and, as suggested previously, such zones are probably related to solute trapping during episodes of rapid growth.

Keywords: Phosphorus, olivine, partitioning, zoning, experimental petrology