

Crystal vs. melt compositional effects on the partitioning of the first-row transition and high field strength elements between clinopyroxene and silicic, alkaline, aluminous melts

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ABSTRACT

The first-row transition element (FRTE) and high field strength element (HFSE) systematics are powerful tools for tracking the source and evolution of mantle-derived magmas. Clinopyroxene is generally considered a key fractionating mineral controlling the partitioning of trace elements between melt and residual solid during mantle melting. Although partitioning of FRTE and HFSE between clinopyroxene and basaltic melts has been well-studied, experimental constraints on their partitioning behavior in the presence of siliceous, aluminous, and alkali-rich melts are still lacking. Here we present clinopyroxene-silicic melt (67–69 wt% SiO₂) partitioning experiments at 1 bar pressure and 1070–1100 °C for Co, Mn, Ni, Cu, Zn, Fe, Sc, Cr, V, Ti, Zr, Hf, Nb, and Ta. Run products consist of diopsidic clinopyroxene coexisting with various melt compositions with non-bridging oxygen to tetrahedral cation ratio (NBO/T) ranging from 0.10 to 0.22. Using our new partition coefficients (*D*s) and combined with literature data, we assess some of the effects of crystal chemistry and the melt composition on the partitioning of FRTE and HFSE in this simple system.

We show that partitioning of FRTE varies from mildly incompatible (e.g., *D* = ~0.1–1 for V, Cu, and Zn) to highly compatible (e.g., *D* > 10 for Cr and Ni), with the highest compatibilities observed for Ni (*D*_{Ni} = 13–34). The partitioning of HFSE varies from highly incompatible (*D* = 0.01–0.08) for Nb and Ta to mildly incompatible (*D* = 0.18–0.82) for Zr, Hf, and Ti. Our measured clinopyroxene-melt *D*s are consistent with the theoretical predictions of the lattice strain model. *D*s data for most tri-, tetra-, and pentavalent elements tend to increase with increasing tetrahedrally coordinated Al content, in agreement with those anticipated from crystal-chemical considerations. In contrast to ^{iv}Al concentrations, the clinopyroxene Na concentration has very little effect on trace element partitioning due to its low concentrations in clinopyroxene at relatively low-pressure conditions. These data further support a significant control of melt composition/structure on partitioning for highly polymerized melts. In general, measured *D*s roughly increase to different extents with increasing polymerization of the melt (i.e., lower NBO/T or higher ASI). For our equilibrium melt compositions, *D*s for several FRTE, such as Co and Ni, correlate well with the melt molar Mg²⁺/(M⁺ + M²⁺), whereas *D*s for HFSE vary as a function of the melt alkali concentration. These well-defined trends support the role of melt NBO species (e.g., Mg²⁺) or complexing ligands (e.g., Na⁺ and K⁺) in controlling the partitioning of these elements.

Overall, our new *D*s data demonstrate that even very small changes in melt major-element compositions can greatly affect element partitioning in strongly polymerized silicic systems. These findings have important implications relevant to petrogenetic studies of the interaction between silicic melt and peridotite that occurs at shallow mantle conditions in various tectonic settings.

Keywords: Clinopyroxene, melt composition, FRTE, HFSE, partition coefficient