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The behavior of Co and Ni in olivine in planetary basalts: An experimental investigation

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Abstract

Cobalt and nickel in olivine from lunar, martian, and terrestrial basalts show systematic differences that appear to be related to planetary parentage. We present results from a series of 1 atm experiments designed to examine the partitioning of Co and Ni in olivine over a range of conditions relevant to planetary basalts. Our results confirm the suggestions of previous workers that the partitioning of Co is such that an increase in D_{Co}^{ol} with crystallization is balanced by a decrease in Co concentration in the melt, resulting in constant Co in olivine, either within olivine showing otherwise normal igneous zoning, or within a suite of basalts related by fractionation. It is evident that the partitioning of Co and Ni into planetary olivine is influenced by such intensive variables as temperature, oxygen fugacity, and composition. Although separating these effects is not possible, our data demonstrate that over the range of oxygen fugacity of lunar, martian, and terrestrial basalts, oxygen fugacity has no significant effect on Co and Ni partitioning into olivine. We propose that an increase in melt polymerization with decreasing temperature, coupled with the preference of Co and Ni for the octahedral sites in olivine, is the mechanism by which D_{Co}^{ol} and D_{Ni}^{ol} increase with crystallization.

With our experimental results as a baseline, we interpret data from Co and Ni in olivine from lunar, martian, and terrestrial basalts and conclude that the cause of increases in Co concentrations in olivine, either core-to-rim or within a co-genetic suite and observed primarily in martian and terrestrial basalts, is enrichment of the melt as crystallization progresses. We hypothesize that this enrichment is attributable either to crystallization of a phase in which Co is incompatible (such as plagioclase) or replenishment of the igneous system with Co-enriched melt.

Keywords: Nickel, cobalt, olivine, basalt, terrestrial, Earth, martian, Mars, lunar, Moon, oxygen fugacity, experimental petrology