Experimental study of Ni and Mn partitioning between olivine and siliceous melt: implications for high Ni-olivines in Hawaiian lavas

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Olivine is abundant in the Earth's upper mantle and ubiquitous in basaltic lavas, but rarely occurs in eclogite. Partial melts of eclogite are therefore not in equilibrium with olivine, but will react with peridotite until achieving olivine saturation. We investigated experimentally the reaction between olivine and siliceous eclogite partial melt, and the partitioning of Ni and Mn between olivine and the melt produced by this reaction. Our results show that high-Ni olivines similar to those in Hawaiian lavas can crystallize from magmas with moderate Ni contents depending on the major element composition of these melts. Therefore, an olivine-free mantle source is not required to explain high-Ni olivine phenocrysts from Hawaii.

Experiments were carried out at 1200-1350°C, 1 bar, QFM f_{O2} buffer using San Carlos olivine (SCO) crucibles and a mixture of eclogite melt (SiO_2 = ~63%, AK200 doped with Ni, [1]) and SCO powder (< 15 μm) as starting material. Our results for Ni and Mn partitioning between the melt (4.6 - 14.5 wt% MgO) and the equilibrated olivine ($Fo_{88.3-91.4}$) are in excellent agreement with previous studies ([2, 3]). More importantly, melts in equilibrium with these forsteritic olivines retain their high SiO_2 (57.9-62.8%) and low MgO characters. Therefore, these forsteritic olivines have significantly higher NiO content than those in equilibrium with typical basic melts (e.g., MgO > 16%).

Our results have direct implications for the origin of high-Ni olivines in Hawaiian lavas. A previous study calls upon an olivine-free mantle source to produce high-Ni parent melt of Koolau lavas that have high SiO_2 content, out of which high-Ni forsteritic olivines precipitate ([4]). Alternatively, theoretical modelling calibrated by our experimental data demonstrates that high-NiO olivines precipitate from a mixture of siliceous melt (e.g., eclogite/pyroxenite melt) and peridotite melt due to the significant increase in Ni partition coefficient with decreasing MgO, even though the total NiO content of the melt decreases during mixing. Thus, an olivine-free mantle source is not required beneath Hawaiian volcanoes.

References

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