Geophysical Research Abstracts
Vol. 21, EGU2019-6913, 2019
EGU General Assembly 2019

Interaction between mafic magma and lithospheric mantle: Evidence from the geochemistry of olivines and olivine-hosted melt inclusions in lavas from Kibblewhite Volcano, Kermadec arc

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During German R/V SONNE cruise (SO-255) mafic basaltic to magnesian andesitic lavas were recovered from the Kermadec arc front volcano Kibblewhite (Hirai et al., EGU2018). Notably, these primitive lavas contain forsteritic olivines and olivine-hosted melt inclusions, which were re-homogenized using a heating stage. Here, we present the chemical variations of the melt inclusions and their host olivines and discuss the interaction between mafic melts and subarc lithospheric mantle.

The olivines are divided into two groups based on their occurrence in different host rock and NiO contents. Olivines ($Fo_{90.3-92.4}$) found as phenocrysts in ankaramites (olivine-clinopyroxene rich basalts; 50.4–50.6 wt.% SiO_2; 13.1–13.5 wt.% MgO; Mg# = 71.8–72.1) show unusually low Ni contents (912–1462 ppm). Olivines ($Fo_{91.0-92.2}$) occurring as xenocrysts in magnesian andesites (57.5–57.6 wt.% SiO_2; 5.5–5.6 wt.% MgO; Mg# = 56.8–57.3) show higher Ni contents (1108–3057 ppm) than olivines in ankaramites.

All re-homogenized melt inclusions have primitive basalt compositions (49.6–52.0 wt.% SiO_2; 12.7–15.9 wt.% MgO, 0.36–0.58 wt.% TiO_2, 1.2–2.0 wt.% Na_2O+K_2O, 0.06–0.37 wt.% SO_3, and 0.05–0.20 wt.% Cl), which could represent parental melts for the ankaramites. However, melt inclusions hosted by olivines in ankaramites have lower Al_2O_3 and higher CaO contents than those hosted by olivine xenocrysts in magnesian andesites; CaO/Al_2O_3 values are 1.2–1.6 and 0.9–1.3 respectively, indicating that there is a negative correlation between Ni contents in host olivines and CaO/Al_2O_3 values in their melt inclusions.

The variable Ni and constant Fo contents in the host olivines could be explained by an interaction of primary mafic melts with lithospheric mantle, which causes assimilation of pyroxenes in the lithosphere and simultaneous fractional crystallization of olivines (AFC; Kelemen, 1990; Tamura et al., 2018). Moreover, the high CaO/Al_2O_3 values in the melt inclusions hosted by the ankaramite olivines cannot be produced by partial melting of lherzolite (e.g. as compilation by Médard et al., 2004). These melts have most likely extensively interacted with the subarc lithospheric mantle. In addition, a negative correlation between Ni content in the host olivine and CaO/Al_2O_3 ratio in their melt inclusions supports the melt-mantle interaction. Conversely, xenocrystic olivines in the andesites with high Ni contents must have been crystallized from more primitive basaltic melts within lithospheric mantle prior to significant melt-mantle interaction. These olivines were then trapped by primary magnesian andesite magmas as xenocrysts.