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Geochemical variations in primitive lavas from the Kibblewhite volcano, Kermadec arc

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Kibblewhite is one of the submarine volcanoes in the volcanic front of the southern segment of the Kermadec arc. Samples were collected from this volcano by dredging during the RV SONNE Vitiaz (SO-255) cruise in March-April 2017. The recovered lavas range from basalt to rhyolite (SiO_2 = 49.9-70.9 wt.%; Mg# = 78.2-28.8) and belong to the Low-K to Medium-K series of Gill (1981), consistent with previous observations (Wright et al., 2006). Here, we focus on mafic lavas with Mg# >55, and those geochemical compositions are consistent with the presence of at least three types of primary magmas beneath the Kibblewhite volcano.

The primitive lavas (Mg# >55) can be divided into ankaramites, rift-type basalts, and magnesian andesites. Ankaramites contain abundant (∼40 vol.%), centimeter-sized clinopyroxene (cpx) and olivine phenocrysts and show high CaO/Al_2O_3 ratio (0.9 to 1.4), which is similar to "island arc ankaramite" of Vanuatu Arc (Barsdell and Berry, 1990). Rift-type basalts (containing ∼3 vol.% olivines and ∼1 vol.% plagioclase and cpx) have higher wt.% TiO_2, Al_2O_3, and lower FeO* and Ba/Nb values (∼20.8) compared with the other types (Ba/Nb = 155-570) and are similar to basalts from Havre Trough (Todd et al., 2011), suggesting smaller contributions from subduction components. Magnesian andesites (SiO_2 = 57.4-58.8 wt.%; MgO = 5.3-5.7 wt.%; Mg# = 56-58) are aphyric with skeletal olivine and cpx microphenocrysts and sometimes contain olivine xenocrysts.

Olivines in the ankaramites are forsteritic (Fo = ∼92), but have unusually low NiO contents (∼0.15 wt.%), and are not in equilibrium with mantle peridotite. On the other hand, olivines in the rift-type basalts show positive correlation between NiO (0.11-0.28 wt.%) and Fo contents (85-89). This trend is consistent with olivine maximum fractionation model, which suggests that ∼12% olivine should have been fractionated from the primary melts in equilibrium with MORB residual mantle (Fo = ∼91; Warren et al., 2016). Olivine microphenocrysts in the magnesian andesites have restricted compositions (Fo = 84-85; NiO = 0.13-0.17), which are in equilibrium with host rocks. The olivine xenocrysts extend to more forsteritic compositions (Fo = 86-93) and have higher NiO contents (0.19-0.35 wt.%) that can be in equilibrium with residual arc mantle (Ishii et al., 1992). Fractionation of 15% olivine with the same amount of cpx from the primary melts explains the continuous trends in major and compatible trace element composition.

The high CaO/Al_2O_3 of the ankaramites and the unusually low NiO contents in their olivines cannot be explained by partial melting of a peridotite source, however, experimental studies suggest that olivine-clinopyroxene cumulate could have been the source. Estimated primary melt of the magnesian andesite is also andesitic (SiO_2 = 54.8 wt.%) with 12.7 wt.% MgO, and its normative composition is consistent with melting experiment of hydrous lherzolite at 1 GPa (Hirose and Kawamoto, 1995). All three types of lavas have a very restricted range of Nd and Pb isotopic compositions (e.g. $^{143}Nd/^{144}Nd$ = 0.51295-0.51300; $^{206}Pb/^{204}Pb$ = 18.84-18.89), suggesting that they have been derived from a similar source.