Arc magma genesis: evidence from Kibblewhite Volcanic Complex in the Kermadec arc, New Zealand

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It has been proposed that basaltic and andesitic primary magmas could be produced simultaneously in the mantle wedge of subduction zones where the overlying crust is thin (Tamura et al., 2016; 2019). To examine this hypothesis and further investigate arc magma genesis, Kibblewhite Volcanic Complex in the southern Kermadec arc, New Zealand, has been studied. Recent seismic studies reveal that the Kermadec arc is one of the oceanic arcs which have the thinnest crust in the world (9-12 km; Bassett et al., 2016). Dredge surveys during the R/V SONNE SO-255 expedition in 2017 recovered volcanic rocks showing variable SiO_2 contents (48-71 wt.% SiO_2) and degree of differentiation (100*Mg/[Fe+Mg] = 28-78) from the Kibblewhite Volcanic Complex. To investigate arc magma genesis beneath the Kibblewhite Volcanic Complex, extensive studies (petrography, mineral and whole-rock chemistry, and olivine-hosted melt inclusion analyses) have been performed on these samples.

A key conclusion is that both basaltic and andesitic primary melts are produced in the upper mantle beneath Kibblewhite Volcanic Complex. We show that olivine-saturated andesite lavas (magnesian andesites) of the volcano are derived from andesitic primary melts and their origin is closely related to the thin crustal thickness of the Kermadec arc. Primary basaltic melts are also discovered from melt inclusions in forsteritic olivines (Fo_{91-92}). Trace elemental characteristics and fractional crystallization models imply that the two primary melts generate two differentiation trends; basaltic primary melts produce low-Mg andesitic magmas (basaltic andesites to andesites), and andesitic primary melts produce more silicic magmas (dacites to rhyolites) by fractional crystallization processes, respectively. Thus, we suggest that the differentiation of basaltic and andesitic primary melts could result in the bimodal magmatism of the southern Kermadec arc in general.

In the Izu-Ogasawara arc, it has been suggested that the middle crusts have magnesian andesite compositions (Tamura & Tatsumi, 2002). Occurrence of magnesian andesites beneath the arc which has thin crustal thickness could grow the middle crusts in the early stage of arc evolution (Tamura et al., 2016). Therefore, we propose that the magmatic evolution of the Kibblewhite Volcanic Complex represents the development of incipient oceanic arc and the formation of juvenile continental crust.

Keywords: Petrology, Subduction Zone, Arc Magmatism, Kermadec Arc, Kibblewhite Volcanic Complex

