Mantle upwelling with progressive melt extraction constrained by the Kita-Matsuura basalt, the northwestern Kyushu, Japan.

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We made systematic geological, geochemical, and chronological investigations on an intraplate Cenozoic volcanism in southwestern Japan to reveal temporal and spatial changes of the melting processes on the time scale of ˜2Myr and the horizontal scale of 35km. The most extensive basaltic activity in the northwestern Kyushu occurred in the Kita-Matsuura area, the volume of which is nearly a half of Cenozoic basalts observed in southwestern Japan. We investigated four sections from the basement to the top to cover the whole distribution of the Kita-Matsuura basalt. In the central and western sections (Hirado, Senryu, and Ishimori sections), the volcanism initiated from mildly alkaline basalt (low- SiO_2 group) followed by major sub-alkaline basalt (medium to high- SiO_2 group) in the later stage, while the eastern section (Kunimi section) produced mildly alkaline basalt (low-SiO_2 group) almost all the way up to the upper most horizon. Each SiO_2 group is clearly distinguished by a specific assemblage of fractionated crystals to derive the major element variation, although the variation for each group cannot be explained from each other by crystal fractionation. Average segregation depths estimated for inferred primary melts of each group decrease in the order of SiO_2 enrichment, indicating temporal decrease of melt segregation depth in the central and western sections.

The relationship between Zr/Y and Nb/Th ratios of the Kita-Matsuura basalt cannot be explained by fractional crystallization with any extent of assimilation of crust materials around the Kyushu, indicating its mantle origin. In order to investigate melting process more precisely, we analyzed rare earth elements (REE). The chondrite-normalized REE patterns corrected for crystal fractionation show strong enrichment of LREE and almost linear inclination from LREE to HREE without Eu anomaly and with significant variation in LREE enrichment. Abundance of REE of low-SiO_2, medium-SiO_2, and high-SiO_2 lavas decrease in this order. These trace element variations cannot be explained by batch, fractional, accumulate, or stepwise melting of any depleted MORB mantle or primitive mantle assuming spinel, garnet, or transitional lherzolite melting, but is consistent with near fractional melting of an enriched mantle. In each section, both the Zr/Y and Nb/Th ratios, and REE elements decrease with time, which are attributable to an increase in degree of melting with time.

Lava flow activities can be divided by intercalations of differentiated lapilli tuff activity intervened at the horizon which corresponds to the horizons where the major and trace element characteristics change. The latest activity of high- SiO_2 group occurring above the volcaniclastics in Hirado, Senryu, and Ishimori sections characteristically form dome-like lavas in spite of their low $FeO*/MgO$ ratio, indicating decrease of eruption rate in the late stage of the Kita-Matsuura basalt. These temporal and spatial variations with evidence for temporal decrease of eruption rate and volume are most plausibly accounted for by progressive melt extraction during mantle upwelling.