Generation process of alkaline basalt magma: a case study of the Kannabe monogenetic volcano

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1.Introduction
Alkaline basaltic volcanism widely occurred in the Chugoku area, southwestern Japan, from Paleogene to Quaternary. Although major, trace, and isotopic compositions of these volcanic rocks have been intensively analyzed, detailed magma differentiation processes have not been examined on the basis of a petrologic study. Here, we conducted thin section observations and determined bulk-rock and mineral compositions of Quaternary-Kannabe alkaline volcanic rocks in order to reveal crystallization differentiation process. Consequently, we concluded that H_2O content in Kannabe magma was ~1.6wt%, which is half as low as the estimation in the previous study.
2. Kannabe volcano
Eruption age of Kannabe volcano acted between 25ka–7.3ka because Kannabe volcano is sandwiched between AT and K-Ah tephra. Kannabe volcano consists of four lava flows erupted from different volcanic centers: Hidaka Lava, Arakawa Lava, Jugo Lava, and Shiwagano Lava in order of age. Four lavas have relatively small amount of phenocrysts (<~10vol%). Most of those phenocrysts are olivine, and any olivine phenocrysts do not show kink bands. Some olivine and plagioclase phenocrysts form glomeroporphyritic texture. All the olivine and plagioclase phenocrysts show normal zoning. Cores of olivine and plagioclase phenocrysts show Fo# [=100Mg/$(Mg+Fe)_{mol}$] = 70–86 and An# [=100Ca/$(Ca+Na)_{mol}$] = 60–78, respectively. In the frequency diagram of An# of plagioclase, cores of plagioclase phenocrysts have two peaks at 78 and 66. Plagioclase crystals with An# = 66 core are euhedral and pristine, whereas plagioclase crystals with An# = 78 core are subhedral to anhedral and contain dusty zone. Olivine and plagioclase crystals forming glomeroporphyritic texture show Fo# = 70–78 and An# = 60–68, respectively: plagioclase with An# = 78 never forms aggregates with olivine. This result suggests that the plagioclase crystals with An# = 78 core are not phenocrysts crystallized from the same magma as olivine phenocrysts did. Bulk-rock SiO_2 contents of Hidaka, Arakawa, Jugo, and Shiwagano Lavas are 48.8–49.1wt%, 48.9–49.8wt%, 49.3–50.8wt%, and 48.7–50.6wt%, respectively, and MgO contents of those lavas are 6.8–7.3wt%, 6.5–6.9wt%, 6.3–6.6wt%, 6.3–7.2wt%, respectively. MgO contents monotonically decrease from Hidaka Lava, through Arakawa Lava, to Jugo Lava, whereas Shiwagano Lava covers whole compositional range of the other three lavas. In addition, Zr/Y, Nb/Y, and Sr–Nd–Pb isotopic ratio tend to be higher as MgO contents monotonically decrease in Kannabe Lava. Compositional trend of major elements observed for four lavas can be reproduced by fractional crystallization of olivine, clinopyroxene, plagioclase, and titanomagnetite.
3. Consideration
We considered AFC process (DePaolo, 1981) of upper crust and lower crust in Kannabe Lava. Consequently, compositional trend of Zr/Y, Nb/Y, and Sr–Nd–Pb isotopic ratio observed for four lavas can’t be reproduced by the process. We estimated H_2O content of magma for Hidaka Lava, which had the highest bulk MgO content and the smallest amount of plagioclase phenocrysts (<~1vol%) in the four lavas. We presumed bulk compositions as a melt composition in equilibrium with the cores of olivine and plagioclase phenocrysts, and applied plagioclase-liquid hygrometer (Lange *et al.*, 2009) and a geothermometer for olivine-saturated melts (Sugawara,2000 ; Medard and Grove,2008) to Hidaka Lava. When the pressure was assumed to be 0.5GPa and 1.0GPa, H_2O content of the magma was estimated to

be 1.3wt% and 1.7wt%, respectively. Our estimation is less than that by Zellmer *et al*. (2014) probably because Zellmer *et al*. (2014) hypothesized plagioclase with An# = 82 as phenocrysts in equilibrium with bulk composition. We estimated generation process of primary magma for Kannabe Lava. Consequently, The generation process was 2.0GPa (depth: 65–70km), 1390℃ (H_2O = 1.0wt%). Philippine Sea slab exists 60–80km depth in Chugoku area. If melting occur at the depth, there is a possibility of slab melting. But, adakite rocks that have the origin of slab-melting don’t vomit around Kannabe volcano. Nd–Pb isotopic ratio ($^{143}Nd/^{144}Nd$, $^{207}Pb/^{204}Pb$) of slab-derived fluid is systematically various between Pacific slab and Philippine Sea slab (Nakamura *et al*., 2008). We suggest that an origin of primary magma in Kannabe volcano is Pacific slab because Nd–Pb isotopic ratio of alkaline basalt in Kannabe volcano matches one of Pacific slab-derived fluid.

Keywords: generation process, Chugoku area, alkaline basalt