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背弧域上部マントルダイナミクスとプレート内火山：韓国Chugaryong火山からの制約

Back arc mantle dynamics and within-plate volcanisms: constraints from Chugaryong volcano, Korea

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In back arc regions, many petrological studies of mantle xenoliths and geophysical studies suggest that the lithosphere is at high temperature and the upper mantle is influenced by fluid supplied from the subducting slab. The distribution of volatile components, the thermal structure, and their relationship with magmatisms, together with the thermal and material transportation mechanisms are, however, still unknown. We have conducted comprehensive major and trace element, and isotope analyses, as well as geochronological investigations on intra-plate back arc volcanism in the central part of the Korean Peninsula to address the issue of mantle dynamics in back arc regions.
Chugaryong volcano is a Quaternary intraplate basaltic volcanism filling the valley of the basement of Precambrian gneiss and Jurassic granite. We have revealed two stratigraphic flow units: the Chongok and the Chatan basalts: the K-Ar ages are ~0.50 Ma and ~0.15 Ma, respectively. Both the basalts are aphyric (~5 vol%) and have olivine phenocrysts and clinopyroxene and plagioclase microphenocrysts. Although there is no large difference in Fo#, NiO, MnO, and CaO contents of olivine phenocrysts between the two basalts, spinel inclusions in olivine phenocryst of the Chatan basalt (Cr#=30-40) show systematically higher Cr# than those of the Chongok basalt (Cr#=20-30).
The two basalts have discrete whole rock chemical compositions in major and trace elements and isotope ratios, although those geochemical variations of both the lavas fall within limited range. The Chongok basalt (9.1-10.0 wt% in MgO) is higher in TiO_2, Al_2O_3, Na_2O, K_2O P_2O_5, Cr_2O_3, large ion lithophile elements, high field strength elements, and rare earth elements and lower in FeO*, SiO_2, and CaO than the Chatan basalt (9.2-10.4 wt% in MgO) for a given MgO content. The Chongok basalt is also higher in $K_2O/TiO_2$and Zr/Y and lower in CaO/Al_2O_3, Zr/Rb, and Zr/Nb than the Chatan basalt. The Chongok basalt shows higher $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, $^{208}Pb/^{204}Pb$, and $^{206}Pb/^{204}Pb$ ratios than the Chatan basalt, trends of which are from DMM+EM2-like characteristics toward EM1-like component.
Precise kai-square test for the major element concentrations revealed that the chemical variation within each basalt can be reproduced by fractionation of olivine, clinopyroxene, and plagioclase. Crystal fractionation and assimilation of any crustal material or presumed partial melt of the crustal material can, however, be ruled out from the possibility to reproduce one basalt from the other, since those processes cannot consistently reproduce the entire geochemical data sets.

Variation of primary melts of the two basalts estimated by adding plausible fractionated crystals to the least differentiated samples need to be produced by distinction of both melting condition and source mantle heterogeneity. The differences in major element compositions can be reproduced by temporal decrease of melting pressure and temperature from the Chongok to Chatan basalts. Variation of trace element concentrations and isotope ratios require relatively lower degree of melting of more depleted mantle for older Chongok basalt than those for Chatan basalt. These lines of evidence suggest that melting in the upper mantle beneath Korean Peninsula proceeded progressively in the upwelling mantle as suggested in northwestern Kyushu. Melt segregation temperature is, however, estimated to be at most 1500°C at ~2.7GPa, which is ~100°C less than that estimated for northwestern Kyushu basalt, even if we assume melting of anhydrous peridotite. This might reflect difference of upwelling and melting mechanisms in the mantle between central Korean Peninsula and northwestern Kyushu.

Keywords: Chugaryong volcano, Korea, geochemistry, back arc alkaline basalt, progressive melting, mantle upwelling, Quaternary