Estimation of slab-derived fluid contributions to arc magmas: a study of across-arc and along-arc variations of trace elements and isotopes of volcanic rocks from Java island, Sunda arc

Esti Handini[1], Toshiaki Hasenaka[1], Haryo Edi Wibowo[4], Tomoyuki Shibata[2], Yasushi Mori[3], Agung Harijoko[4]

[1]Graduate School of Science and Technology, Kumamoto University, Japan, [2]Beppu Geothermal Research Laboratory, Kyoto University, Japan, [3]Kitakyushu Museum of Natural History and Human History, Japan, [4]Department of Geological Engineering, Gadjah Mada University, Indonesia

E-mail: esti.handini@yahoo.com

We compiled a dataset of chemical composition of volcanic rocks from Java island, Sunda arc, for the purpose of understanding material transfer process in subduction zones. The analyzed samples are basalt to basaltic andesite in composition to avoid the effect of crustal contamination. We observed across and along arc variation of slab-derived fluid contributions to arc magmas, both from sediment (SED) and from altered oceanic crust (AOC) by examining ratios of fluid-mobile elements to HFS (High Field Strength) elements (e.g. B/Nb, B/Zr, Ba/La). Lateral Nb depletion along this island, which characterizes arc magmas, is also evaluated by using Nb/HFSE (e.g. Nb/Ta, Nb/Zr) ratios. To estimate the contribution of SED and AOC to arc magma source, Sr-Nd isotopes were determined as well.

Based on volcano distribution and tectonics, Java island is divided into western, central and eastern sections. Our result shows lavas from this island are distinguished by LILE and LREE enrichment, which is accompanied by negative anomalies of Nb and Ti. The values of Nb/HFSE ratios are evenly low along the island, with distinct increasing trend toward back arc in central and eastern sections, which implies particular mantle source enrichment in these parts. The ratios of B/HFSE and Ba/HFSE across the western section show very little variation, whereas they significantly decrease from volcanic front toward back arc in the central and eastern sections. This negative correlation between incompatible elements ratio and the depth of Wadati-Benioff zone suggests a recognizable influence of slab-derived fluid along this island. However, the decreasing trends of these ratios, particularly in central and eastern sections, positively indicate a reduced influence of slab-derived fluid from volcanic front toward back arc. In terms of isotopic ratios, samples from all sections are shifted from Indian Ocean MORB field toward higher $^{87}Sr/^{86}Sr$ and lower $^{143}Nd/^{144}Nd$ ratios. The back arc alkaline lavas from central and eastern sections exhibit relatively low values of $^{143}Nd/^{144}Nd$ ratios, which confirm particular back arc source enrichment in these sections. On the other hand, some volcanic front samples from central section are plotted overlapping with Indian Ocean sediment values. This isotopic ratio pattern suggests involvement of slab fluid in all sections of this island, including the back arc mantle source of central and eastern sections.

These findings suggest that even though observed all along the island, the greatest enrichment of subduction components is found in central section, which implies strongest slab-derived fluid contributions in this section. It raises questions of (1) the main factor that controls different magma characteristics of the three sections, (2) the responsible hydrous phase in this arc, and (3) the mechanism of slab fluid-mantle interaction that results in such variation.

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