Lateral variation of chemical composition of volcanic rocks in Central Japan with the double subducting plates

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We have sampled 417 Quaternary volcanic rocks of almost all volcanoes in Central Japan. Chemical compositions of 340 samples have been analyzed for 65 major, trace and rare earth elements using XRF and ICP-MS. Sr, Nd, and Pb isotope ratios of the selected 50 samples have been analyzed by Multiple-Collector ICP-MS and Thermal Ionization Mass Spectrometer (TIMS). .

In Central Japan, Quaternary volcanoes are located in the area corresponding to the depth contours between ~150km to ~300km of the Wadati-Benioff Zone (WBZ). Specially, volcanoes in the back-arc (the Ryohaku Mountains) are located at ~300km above the WBZ of the Pacific plate. This anomalous feature is attributed to the thermal influence caused by the overlapping Philippine Sea Plate on the Pacific Plate, interfering dehydration process of the Pacific Plate (e.g., Iwamori, 2000). However, there are a few models for the origin of the chemical variations of the volcanic rocks in this area (e.g., Kaneko, 1995). Here, we propose a model of magma generation in the mantle wedge by estimating the source mantle composition in order to constrain the subduction zone magmatism in an unusual area.

We have found the difference between the source mantle compositions beneath Northeast Japan and Central Japan in trace element ratios using a method to estimate the source mantle for volcanoes (Nakamura, 2004). In the model, we assume that highly incompatible trace element ratios behave similarly during melting and crystallization processes. The element ratios in the source mantle rocks and those in the erupted lavas can be expressed by a relatively simple equation. The elemental ratios are preserved when the bulk partition coefficients (D) are less than the degree of melting (E) and the fraction of crystallized solid (F) from 0 % to ~70 %. Y, K, Rb, Zr, Nb meet the conditions. Relative element abundances in the source mantle beneath the back-arc of Central Japan is about 2.2 times than those of Northeast Japan in Rb, 1.4 times in K, 0.3 times in Y, and 0.8 times in Nb, assuming the same abundance of Zr. The same model calculation is applied to all the volcanoes in Central Japan. The estimated source mantle abundance of Y decreases from north to south and from east to west.

There are co-variations between isotope ratios and trace element ratios in Central Japan. The Nd isotope ratio of each volcano at the same longitude tends to decrease gradually from south to north (e.g., minimum value with 2 sigma 0.512959 +- 0.0000142 in Kurofuji Volcano – 0.512928 +- 0.0000100 in Azumaya Volcano – 0.512851 +- 0.0000117 in Myoko Volcano). The ratios also decrease along the same latitude toward the back-arc side (e.g., minimum value with 2 sigma 0.512959 +- 0.0000142 in Kurofuji Volcano – 0.512786 *1 in Ontake Volcano – 0.512473 +- 0.0000095 in Eboshiwashigatake Volcano). Sr isotope ratios counter-correlated with Nd isotope ratios. The variation in Central Japan is different from that in Northeast Japan, where the Sr isotope ratio of the Quaternary volcanic rocks at the same latitude decreases from the volcanic front to the back-arc (e.g., Nohda et al., 1988). There is a significant correlation between the Zr/Y ratio and Nd, Sr isotope ratios. The change of these ratios from the east to the west is large, whereas the change from the south to north is small. The observed geochemical lateral variations may reflect isotopically heterogeneous lithospheric mantle and effects of slab-derived fluids of various chemical components from the Pacific Plate and the Philippine Sea Plate slabs.

*1 (Ujike and Stix.,2000)