Chemical composition of the mantle estimated by a model using primitive to fractionated rocks of Ryohaku mountains, Central Japan

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Volcanoes of Central Japan are located from about 150km to 300km above the inclined Wadati-Benioff zone (WBZ)(e.g., Umino et al.,2002). Especially, the Ryohaku mountains are located 300km above the WBZ of the subducting Pacific plate. This anomalous feature is attributed to the thermal influence caused by Philippine sea plate on the dehydration process of subducting Pacific plate (e.g.,Iwamori,2000).

However, there are a few models for reproducing the chemical compositions of the volcanic rocks in this arc. Here, we present a model of magma generation in mantle wedge by estimating the source mantle composition, to explain and constrain the subduction zone magmatism in such an unusual area, based on the chemical composition of the volcanic rocks in Central Japan quantitatively.

In general, in order to discuss the generation of magmas in the upper mantle, it is common to use the most primitive volcanic rock. Strictly speaking, the bulk compositions of primitive volcanic rocks are defined as those in equilibrium with the composition of the mantle. However, such primitive rocks are rare in Central Japan.

In this study, we tried to estimate the trace element composition of source mantle using primitive to more fractionated volcanic rocks. In the model, batch melting in the mantle and subsequent fractional crystallization are assumed. Consider two trace elements to behave as incompatible elements during the relevant processes (e.g., melting, crystallization). It has been found that the ratio of concentrations of the two incompatible elements in the source rock and the volcanic rock as the end product of the processes can be expressed by a relatively simple equation.

Model calculation shows that the abundance ratios of the incompatible elements in volcanic rocks preserve a trend as those of the source rocks, within the parameter ranges that the bulk partition coefficients (D) are more than 0.001 to less than 0.5, when the degree of melting (E) ranges from 0 % to 20 % and the fraction of crystallized solid (F) from 0 % to about 70 %. The model calculation is applied to the estimation of trace element concentrations in the source mantle between the Ryohaku mountains and Northeast Japan. The pairs of trace elements which have linear correlation and passes through the origin are chosen.

As a result, the estimated source mantle abundance of the Ryohaku mountains is about 0.3 times smaller than that of Northeast Japan in Y and is about 1.4 times larger in K and about 2.2 times larger in Rb, assuming the same abundance of Zr in the source rock.

Furthermore, this model calculation is applied to all volcanoes in Central Japan, including Y, K, Rb, Zr, Nb. The estimated source mantle abundance of Y of each volcano in Central Japan decreases from north to south and from east to west. For example, the abundance of Y of Kenashi Volcano in the northern part of Central Japan is 5.71ppm, and that of Minami-Yatsugatake Volcano in the southern part of Central Japan is 2.87ppm, and that of Kyogatake Volcano in the western part of Central Japan is 1.82ppm, assuming the abundance of Zr (10ppm) in the source rock. These results suggest that the estimated concentration of Y in the source mantle is systematically decreased from north to south and from east to west.