Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SVC52-02 Room:301A Time:May 21 14:00-14:15

Upper mantle and basaltic magmagenesis at an arc-arc junction: Chemical spatial variation of mafic rocks in Hokkaido

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Few studies are directly compared the spatial variation of volcanic rock composition and magma-generation processes in the Northeast Japan (NEJ) arc and Kurile arc. Previously, we have clarified the spatial chemical variation of mafic rocks from Hokkaido, which is located at the junction of these two arcs, and indicated that the southwestern part of Hokkaido can be considered as the northern end of the NEJ arc, but the central part of Hokkaido as the southern end of Kurile arc. Unmodified mantle, which refers to a mantle source before a subduction component (SC) addition, beneath the NEJ and Kurile arcs is heterogeneous. Enrichment increases toward the trench side of the NEJ arc and toward the southern side in the Kurile arc. In this study, we discuss the degree of melting (F), SC composition and the transfer process, as well as clarify the difference in magma-generation processes between the NEJ-arc side and Kurile-arc side in Hokkaido.

The $<$1.7Ma mafic rocks from Hokkaido can be divided by their distribution and composition into four volcanic fields: the eastern margin of the Japan Sea (EJS), the southwestern Hokkaido (SWH), the Taisetsu-Tokachi-Shikaribetsu (TTS) and the Akan-Shiretoko (AKS) volcanic field. While ^{143}Nd/^{144}Nd is same among EJS, TTS and SWH, it is higher at AKS. ^{87}Sr/^{86}Sr increases from EJS to AKS to TTS to SWH. EJS shows the highest contents of incompatible elements and the steepest REE pattern. AKS shows the lowest Nb and Ta contents. At the trench side of SWH and AKS, volcanoes contain low K. These trench-side volcanoes also have lower contents of incompatible elements, larger spikes of Pb and Ba, and flatter REE pattern than rear volcanoes. Moreover, trench-side volcanoes in AKS often show a depleted LREE pattern.

In a Nb/Y-Zr/Y diagram, four areas show linear and parallel trends that can be divided into three groups based on location (SWH, EJS and TTS, AKS: in descending order of Nb/Y at similar Zr/Y). This indicates the compositional heterogeneity of unmodified mantle, which cannot be explained by the degree of prior melt extraction from a single mantle source. According to these Nb/Y values at similar Zr/Y, we assume the Enriched-Depleted MORB Mantle (E-DMM), DMM and Depleted-DMM (D-DMM) of Workman and Hart (2005) for SWH, EJS and TTS, and AKS as unmodified mantle composition, respectively. F and prior melt extraction from assumed initial DMM are calculated by the contents of HFS elements that are conservative and not added from SC. The results indicate that the composition of trench-side volcanoes in SWH and AKS can be explained to some extents by prior melt extraction. In this case, AKS trench-side magma is generated from the most depleted mantle source in Hokkaido–a source that is D-DMM with prior melt extraction. Estimated F is 20% for SWH trench side, 12% for SWH rear side, 7~10% for TTS, 7~12% for AKS and 3~12% for EJS.

Using these estimated F, we determine metasomatized mantle source compositions of Hokkaido magma. Pb of a metasomatized mantle source shows positive correlation with F. In Ba, Th and U vs. F diagrams, several positive correlation trends can be recognized: EJS shows the highest trend and SWH and AKS frontal volcanoes show the lowest trend. The trends of TTS and rear-side volcanoes in SWH and AKS are in the middle. These data indicate the variation of SC composition in Hokkaido.

The difference of magma-generation processes between the NEJ-arc side and Kurile-arc side in Hokkaido are recognized as follows. Solute-rich SC is supplied on NEJ-arc side, as in EJS volcanoes, but not on the Kurile arc side. At the trench side in the NEJ-arc side, magma with the highest F in Hokkaido is generated. In contrast, magma at the trench-side of the Kurile-arc side is generated with relatively low F from the most depleted mantle source in this region. Such a feature of magma-generation processes in Hokkaido may reflect differences in mantle-slab geometry and thermal structure between the two arcs.