Geochemistry of tholeiitic and calcalkaline volcanic rocks from Zao volcano, Northeastern Japan Arc

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It is well known that the magma genesis of co-existing tholeiitic series (TH) and calcalkaline series (CA) has been one of the important issues on the island arc magmatism. To elucidate the genetical relationship of TH and CA magma series, we analyzed Sr, Nd and Pb isotope and trace element compositions of Quaternary island arc volcanic rocks from Zao volcano, Northeastern Japan arc.

The Zao volcano is situated on the Tohoku Backbone Ranges. The volcanic activity started about 1 Ma and continues to the present, and is divided into Stage 1 to Stage 4 (Sakayori, 1991). According to Sakayori (1991), the rocks of Stage 1 belong to TH (low-K), and all the other to CA (midium-K). And on the Harker Diagrams, volcanic rocks of Stage 1 and Stage 3 show obvious different trend and those of the other stage plotted in between those two trends. Thus, we selected the five samples from Stage 1 and five from Stage 3 as a representative of TH and CA, respectively. The samples of TH and CA consist of basalt and basaltic andesite (SiO_2 = 51.2 to 54.4; K_2O = 0.36 to 0.54) and basalt, basaltic andesite and andesite (SiO_2 = 51.4 to 61.1; K_2O = 0.88 to 1.72), respectively. All the samples contain orthopyroxene, clinopyroxene and olivine as phenocryst.

The trace element compositions of the studied samples show the typical characteristics of island arc magma in the diagram of MORB normalized pattern, such as enrichment of LILEs and negative Nb spike. Positive Pb and Sr spikes are also apparent. The LILEs enrichment and negative spikes of Nb are relatively larger in CA than TH. In the diagram of MORB normalized rear earth elements (REE) pattern, light REEs show enriched pattern and the degree of the enrichments are larger in CA than TH.

The Sr, Nd and Pb isotopic compositions of TH are $^{87}Sr/^{86}Sr$ = 0.7042 to 0.7045, $^{143}Nd/^{144}Nd$ = 0.51274 to 0.51278, $^{206}Pb/^{204}Pb$ = 18.43 to 18.48, $^{207}Pb/^{204}Pb$ = 15.56 to 15.60 and $^{208}Pb/^{204}Pb$ = 38.42 to 38.58, and those of CA are $^{87}Sr/^{86}Sr$ = 0.7035 to 0.7042, $^{143}Nd/^{144}Nd$ = 0.51284 to 0.51288, $^{206}Pb/^{204}Pb$ = 18.38 to 18.43, $^{207}Pb/^{204}Pb$ = 15.54 to 15.58 and $^{208}Pb/^{204}Pb$ = 38.34 to 38.45. It is obvious that isotopic compositions of TH are more enriched compared to CA, although TH is relatively depleted in trace elements than CA. In all the diagrams presenting the relationship of the isotope compositions, TH and CA show different liner trends, which may be showing the mixing relation, except for Sr isotope of TH. Furthermore, Pb isotopic compositions suggesting the possibility that two depleted endmember are necessary to explain the trend of TH and CA by mixing model. On the other hand, tow enriched endmembers are required from the relationships between parent/daughter and the isotope ratios, because TH and CA show different linier trends in those relation and the liner trends are diverse in the direction of isotopically enriched side.

From the observations described above, it can be concluded that four components are necessary to explain the chemical characteristics of TH and CA from Zao volcano.