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AFC model for compositional variation of mafic magmas for the Shirataka volcano, NE Japan

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The mafic inclusions, which are a minor but ubiquitous component of the calc-alkaline rocks, are thought to be quenched products of the co-genetic mafic magma. As basalts are scarcely observed in most of the volcanoes in the back arc of NE Japan, mafic inclusions are helpful in providing the information of mafic magmas. According to petrologic data of these inclusions from the Shirataka volcano, we found two types of mafic end-member magmas (high- and low-Cr) in the same geological group. In this study, we examine the relationship of these two magmas quantitatively based on the whole rock and Sr isotopic compositions.

Mafic inclusions are petrographically classified into following two types: the groundmass hbl-bearing type (type 1, 48.3-54.1 wt% in SiO2) and the hbl-free type (type 2, 53.0-57.5 wt% in SiO2). The phenocrysts are ol+/-opx+cpx+pl in type 1, and qtz+/-opx+cpx+pl in type 2. All of incluisons are mixing rocks judging from many aspects of petrography and mineral chemistry. Considering whole rock compositions, these incluisons are redivided by high-Cr (type1a) and low-Cr (type1b and 2) types. High-Cr inclusions are embraced in high-Cr host rocks, and low-Cr inclusions have low-Cr hosts. High-Cr inclusions and corresponding host rocks have low 87Sr/86Sr ratio, while low-Cr inclusions and their hosts are high 87Sr/86Sr ratio. The estimated mafic end-member for high-Cr products is magma A ((olv)+cpx+plg phenocryts, low 87Sr/86Sr ratio) and for low-Cr ones is magma B (cpx+plg phenocryts, high 87Sr/86Sr ratio). Magma A is poorer in SiO2 content and richer in Ni and MgO contents as well as Cr content than magma B, and the assimilation and fractional crystallization (AFC) of the magma A was proposed to be a possible process to poroduce the magma B.

We quantitatively examine the effect of AFC on the whole rock and Sr isotopic compositions of magma A and B of group 5 as an example. In group 5, liquidus temperature of magma A is calculated to be 1150 degrees C. We assumed a potential source for assimilation to be one of the Asahi plutonic rocks, because the Shirataka volcano is located on the Asahi Belt. The major elements model calculations were performed using MELTS programs. As a result of several attempts, if the magmatic pressure is 4kbar and H2O content is 0.5 wt%, an AFC model can successfully reproduce the major elements compositions of the magma B by assuming the r values (ratio of assimilation to crystallization rates) of less than 0.1. The fractionating assemblages are estimated to be cpx:plg=40:60 and the degree of the crystallization to be ca.15-20 %. Taking account of the results of MELTS calculations, we performed trace elements and Sr isotopic model calculations. The calculation assumed to be the following bulk distribution coefficients for the fractionating assemblages (cpx:plg=35:65): 0.04 for Rb, 0.08 for K, 0.28 for Zr, 1.21 for Sr, and 1.47 for Y. In result, the trace elements and Sr isotopic compositions of the magma B can be explained through fractional crystallization (ca.15-20 %) of magma A with the assimilation of plutonic rocks (r of less than 0.1) as well as the examination of the major elements compositions.