Three types of magmas relating to production of the Aso-4 mafic magma: a melt inclusions approach.

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Aso volcano on the volcanic front of SW Japan arc is one of the largest caldera volcanoes in Japan and have caused four large pyroclastic eruptions. Each large eruption roughly began with discharge of silicic magma and ends ejection of mafic magma. Previous works have concluded that the magmas of the large pyroclastic eruptions were generated by melting of lower crust due to heat from mantle-derived hot magmas. On the other hand, detail processes of the magma genesis in the lower crust and subsequent differentiation of the magma are poorly understood. In order to clarify the above points, we focus on melt inclusions (MI) in phenocrysts, which record instantaneous melt composition in various magmatic stages and give us detail information about magmatic processes. We used SEM-EDS and carried out compositional analyses of melt inclusions trapped in phenocrysts and groundmass (GM) in scoriae of the Aso-4 large eruption cycle of Aso volcano. The scoriae are basaltic-andesitic and correspond to the mafic magma of the Aso-4 cycle.
Most of the magmas of Aso volcano including the Aso-4 mafic magma have higher K2O content in K2O-SiO2 relationship than other volcanoes on the volcanic front of the SW Japan arc. The phenocrysts in the Aso-4 mafic magma are olivine (compositional peak in frequency diagram is at Mg#74), clinopyroxene (Mg#78), orthopyroxene (Mg#75), hornblende (Mg#70) and plagioclase (An55-An90).
The important petrological features are as follows;

1. We classify MIs into three types: high-K series MI (HK-MI) (55-68 wt.% SiO2), medium-K series MI (MK-MI) (60-63 wt.% SiO2), and basaltic MI (B-MI) (45-54 wt.% SiO2).

(a) HK-MIs are in Ol, Cpx, Opx, Hb and Pl (An55) phenocrysts. HK-MIs increases in SiO2 content in a following order: Ol, Cpx, Hb, and Opx.
(b) MK-MIs are in Ol and High-An Pl (An80-90) and do not coexist with HK-MI in one phenocryst.
(c) B-MIs are only in Ol and characterized by lower SiO2 content and higher MgO content (8-14 wt.%; 8 wt% MgO for 55 wt% SiO2) than whole-rock composition of the Aso-4 volcanic ejecta (< 5 wt.%; 5 wt.% MgO for 50 wt% SiO2). Furthermore, the most magnesian B-MI is in equilibrium with Fo87. In some Ol phenocrysts, B-MI coexists with either the HK-MI or MK-MI.

2. GM composition is 62-68 wt.% SiO2 and this compositional variation can be explained by mixing of the most silicic HK-MI (68 wt.% SiO2) and MK-MI. Calculation of crystallization from MK-MI by rhyolite-MELTS does not reproduce the compositional variation of the GM.

The above features tell us some new insights about the mafic magma and magma system of the Aso-4 cycle as follows.
Feature 1-a suggests that the HK-MI magma precipitated Ol, Cpx, Hb and then Opx in order of crystallization, and differentiated from 55 to 68 wt.% SiO2 due to the crystallization. Subsequently, the differentiated HK-MI magma (68 wt.% SiO2) mixed with the MK-MI magma (features 1-b and 2).
On the other hand, it is suggested that the B-MI is trapped in Ol crystallizing from partial melt of the mantle(feature1-c). The fact that the B-MI coexists with either HK-MI or MK-MI in host Ol suggests that the Ol from the mantle melt mixed into the HK-MI and MK-MI magmas or that the mantle melt has genetic

relationship with the HK-MI or MK-MI magmas. The present Ol phenocryst has lower Fo content than that in equilibrium with the mantle melt, suggesting that Fo content decreased due to chemical diffusion in the differentiated magmas.
The HK-MI form a trend with the whole-rock composition of the Aso-4 scoriae on variation diagrams, suggesting that the HK-MI is a main magma which was produced by melting of lower crust. On the other hand, the two magmas, the B-MI and MK-MI, are newly recognized in our study. The B-MI magma may be a heat source for crustal melting. Genesis of the MK-MI magma is unknown at the present stage. In any case, the above new findings are important constraints to reveal the magma system of Aso volcano.

Keywords: Aso volcano, Melt inclusion, Magma mixing

