Petrological and geochemical features between large and small eruptions in Aso volcano

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Aso volcano has caused four large eruptions (eruption magnitude (M) = 6.9-8.0) since 266 ka and many small eruptions (M< 5.9) between the large eruptions (Ono et al., 1977). Geological and geochemical studies of the large eruptions have revealed that silicic magma was erupted followed by mafic magma (e.g., Ono and Watanabe, 1983) and the two magmas are generated from the same source material in each large eruption (Kaneko et al., 2015). However, transition of magma plumbing system including the small eruptions is not well understood. In this study, we carried out detailed geochemical analyses of volcanic ejecta in the large and small eruptions from Aso-2 (141 ka) to Aso-4 (89 ka) and aim to understand long-term evolution of magma plumbing system.

Small eruptions between Aso-2 and -3 and Aso-3 and -4 are collectively called Aso-3/2 and Aso-4/3, respectively, in which 6 and 47 units have been recognized. Most of the units consist of silicic pumice (63-69 wt.% SiO_2 in whole-rock (WR) composition) and some units consisting of mafic scoria occur only in a lower part of the Aso-4/3. Samples of the small eruption are pumices from 5 silicic units in the Aso-3/2, and pumices from 17 silicic units and scoriae from 4 mafic units in the Aso-4/3. In addition, we performed analyses of pumices (63-70 wt.% SiO_2) and scoriae (52-59 wt.% SiO_2) of the three large eruptions, Aso-2, -3, and -4. We obtained WR composition by XRF, plagioclase (Pl) composition by EPMA, and in situ Sr isotope ratio ($^{87}Sr/^{86}Sr$, referred as “R-Sr”) of Pl by micro-analysis by LA-ICPMS at JAMSTEC.

Important features of the large and small eruptions are as follows:
(1) The large and small eruptions have similar composition in WR composition. Specifically, WR compositions of the small eruption ejecta are within the variation of WR composition of the large eruption ejecta.
(2) In the small eruptions, An contents of Pl in all the pumices are An40-60. In addition, 80% of the analyzed pumices have high An Pl (> An70). In the pumice with High-An Pl, High- and Low-An Pl with the same R-Sr coexist.
(3) In the large eruptions, R-Sr range of Pl in the silicic ejecta (pumice) is the same as that of in the mafic ejecta (scoria).
(4) R-Srs of the large and small eruption ejecta fluctuate within a range of 0.7037 - 0.7043 regardless of eruption size. The R-Srs of the large eruption ejecta are not systematically different from those of the small eruption ejecta.

As shown in the above features, petrological and geochemical characteristics of the large and small eruptions are the same, suggesting that magmas for the large and small eruptions were generated by the same processes. The existence of high-An Pl (feature 2) indicates that Pls crystallized from mafic magma is mixed into the silicic magmas of the small eruptions, meaning that the mafic magma is active in the small eruptions like the large eruptions although the ejecta in the small eruptions are silicic. Features 1, 2, 3, and 4 indicate that WR and Sr-isotopic characteristics of the large and small eruption magmas are similar.

Kaneko et al. (2015) has concluded that the mafic and silicic magmas of each large eruption in Aso

volcano were generated by partial melting of the same lower crust due to intrusion of mantle-derived hot magmas, on the basis of the same R-Sr of the mafic and silicic magmas and no genetic relationship between the two magmas. The same R-Sr of the mafic and silicic magmas in the small eruptions (feature 2) and other same magmatic features mentioned above suggest that the mafic and silicic magmas of each eruption were generated by partial melting of the same lower crust regardless of eruption scale.

The R-Srs of the magmas fluctuate between 0.7037-0.7043 (feature 4). This can be interpreted as spatial isotopic heterogeneity of the source region of the Aso magmas (i.e., lower crust); heat-source magmas from the mantle were emplaced at various regions in the lower crust and produced magmas with different isotopic signatures.

Keywords: Aso volcano, caldera volcano, Sr isotope ratio, magma plumbing system

