Evolution of magma plumbing system in Aso caldera volcano: oxidation by mantle-derived magma

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Many caldera volcanoes undergo more than one calderaforming eruptions, in which 100-km^3-order silicic magma with or without mafic magma is discharged during short period. Some caldera volcanoes erupt magmas with petrologically different features in each calderaforming eruption. Mechanisms that generate such various magmas is important to understand the magma plumbing system of the caldera volcanoes and its evolution. Here, we show an idea that is possibly concerned with the evolution of the magma plumbing system on the basis of petrological change of magmas in Aso caldera volcano which has the largest caldera in SW Japan.

Activities of Aso volcano are characterized by four calderaforming eruption cycles (CEC) with 10^2 km^3 DRE and many minor eruptions between them after 300 ka. In particular, Aso volcano was vigorous between 141 ka and 90 ka and caused three calderaforming eruptions, Aso-2, Aso-3, and Aso-4, with 20-30 ky interval. In each of these three CECs, the eruptions occurred from a gravitationally stratified magma chamber with a silicic magma overlying a mafic magma. Our previous studies on geochemical and isotopic analyses of volcanic ejecta suggest that the magma generation processes are common in the three CECs in Aso volcano from Aso-2 to Aso-4; both of the silicic and mafic magmas in each of the CECs were produced with low and high degrees of partial melting of the same lower crust, respectively. A plausible scenario of simultaneous generation of the two magmas is as follows. A mantle-derived hot magma which repeatedly intruded into the lower crust melted the lower crust with various degrees of partial melting. The mafic magma formed by a high degree of partial melting was generated close to the intruded hot magma, whereas the silicic magma formed by a low degree of partial melting was generated around the mafic magma. Those magmas formed by various degrees of partial melting segregated from the lower crust to form a compositionally zoned magma chamber.

The petrological features of the three CECs in Aso volcano show a systematic temporal change as follows. (1) In relationship between K_2O and SiO_2 contents in whole-rock composition, the K_2O content of the silicic magma increases from Aso-2 to Aso-4, whereas that of the mafic magma does not change. (2) Redox states of the silicic magmas change to more oxidized condition from Aso-2 to Aso-4, whereas redox states of the mafic magmas only slightly change and are in similar oxidized condition to the silicic magma of Aso-3 and Aso-4 which show oxidized condition. The feature means that the magmas by crustal melting with high degree of partial melting were constantly produced under a highly oxidized condition from Aso-2 to Aso-4. On the other hand, the magmas by crustal melting with low degree of partial melting oxidized with time.

We hypothesize that the redox state of the mafic magmas by crustal melting with high degree of partial melting reflects the redox state of the mantle-derived hot magmas in this region. The oxidized mantle-derived hot magmas increasingly oxidized the crust as a whole. As a result the silicic magmas generated by crustal melting with a low degree of partial melting become more oxidized with time. Namely, a repeated supply of the mantle-derived hot magmas may evolve the petrogenesis in the crust beneath Aso volcano. In order to verify this hypothesis, we need to examine the generation processes of

magmas with different redox states from the same source crust and the oxidation processes of the crust by the oxidized mantle-derived magma.

Keywords: Caldera, Aso volcano, Magma plumbing system, redox state, crustal melting

