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Magma systems of the Kyoho eruption in Shinmoe-dake volcano, Kirishima volcanoes: 2

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The eruption from Shinmoe-dake, Kirishima volcanoes, occurred in January 2011. Although no activity is being observed currently, there is concern that the volcano might erupt again in the near future. From the similarities in the magma composition and the eruption sequence between the 2011 eruption and the early stage of the Kyoho (1716-17) eruption, to predict the next eruption, it is important to understand the magma process of the Kyoho eruption. Considering the above points, I analyzed the Kyoho eruption products to understand the magma systems of the Kyoho eruption.

The Kyoho eruption products are classified into eight units (Sm-KP1 to Sm-KP7, and Sm-MP) (Imura and Kobayashi, 1991; Tsutsui and Kobayashi, 2011). Pumice clasts in all the units are dark gray and rare yellow. Dark-gray pumices have lower bulk-rock SiO_2 content (57-58.5 wt.%) than the yellow ones (62 wt.%). There is a clear compositional gap between the two pumices. The heterogeneous texture on a scale from millimeters to tens of micrometers in both the pumices indicates that the dark-gray parts mingle with the yellow ones.

Mineral assemblages of phenocrysts in both the pumices are composed of plagioclase, orthopyroxene (Opx), clinopyroxene (Cpx), and Fe-Ti oxides. Olivine phenocrysts are contained only in the dark-gray pumice of Sm-KP4.

In dark-gray pumices, the distribution of the core $Mg^{\#}$ in Opx phenocrysts is bimodal in the $Mg^{\#}$ range of 64-66 and 73-76. Low-Mg core Opx has a thick rim with reverse zoning because the rim $Mg^{\#}$ is in the range of 72-74. Although the distribution of the core $Mg^{\#}$ in Cpx phenocrysts is not bimodal in a wide $Mg^{\#}$ range of 68-75, two kinds of phenocrysts with normal and reverse zoning are found. Low-Ca plagioclase (An_{50-75}) with extensive reverse zoning coexists with high-Ca plagioclase (An_{80-90}). The above mineralogical features in the dark-gray pumice are a result of mixing of mafic and felsic magmas. The dark-gray pumice in Sm-KP4 with olivine phenocrysts (Fo_{77-80}) includes the Cpx phenocryst with a high $Mg^{\#}$ (78-81). Because the olivine can equilibrate with the Cpx, mafic magma includes olivine and the Cpx as a phenocryst. On the other hand, the pyroxene phenocrysts characterized by bimodal distributions at core compositions are not in equilibrium with the olivine. The high-Mg pyroxene was derived from mixed magma without mafic magma, whereas the low-Mg pyroxene was from felsic magma. The pyroxene phenocrysts in the yellow parts with heterogeneous textures are homogeneous without zoning, and plagioclase is Ca poor.

Mafic magma did not erupt independently in the Kyoho eruption. The heterogeneous texture constituting the gray and yellow parts indicates that both mafic and felsic magmas ascended in conduit at the same time. In addition, the absence of isolated olivine and a thick reverse-zoned rim of Opx in the dark-gray pumice indicate that mixed magma was already produced before the Kyoho eruption. Because the chemical contrast of the Usp component between the core and the rim in a magnetite phenocryst was 0.09, deduced from the degree of zoning in magnetite, mafic magma injection occurred just prior to eruption. However, the various zoning profiles in each phenocryst indicate that mafic injection occurred repeatedly before eruption. The magnetite phenocrysts have significant compositional variation, which is larger than the zoning within each phenocryst. This shows that the pre-eruptive magma chamber was heterogeneous against the stable state in magnetite. In spite of the fact that the heterogeneous magmas blend on the magma ascent, the bulk chemical compositions of the mixed magma lie in a narrow range; this implies that the heterogeneity is derived not from the chemical composition but from physical conditions such as temperature and oxygen fugacity. The mafic magma injected just prior to eruption might not react directly with the mixed magma that erupted during the Kyoho eruption for the existence of large mixed magma .

Keywords: Kirishima volcanoes, Shinmoe-dake, Kyoho eruption, magma mixing, 2011 eruption