Petrological study of the 7.3 ka Kikai caldera-forming eruption (K-Ah), southern Kyushu, Japan

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Kikai caldera, located in southern Kyushu, is one of the youngest caldera volcanoes in Japan. The catastrophic caldera-forming eruption occurred ca. 7.3 ka (K-Ah eruption). It was started by a plinian eruption, followed by intraplinian pyroclastic flows (Stage 1). After that, a large ignimbrite eruption occurred, accompanied with caldera collapse (Stage 2) (Maeno & Taniguchi, 2007). This eruption was preceded by a volumetric rhyolite lava flow (Nagahama lava: NL). Although eruptive sequence of K-Ah eruption has been understood, there are few petrological studies about K-Ah eruption and therefore its magma plumbing system is still unclear. In order to understand the magma plumbing system of a large caldera-forming eruption, we carried out the petrological and geochemical investigation of K-Ah eruption including preceding activity.

The juvenile materials of K-Ah eruption are composed mainly of white pumice, and heterogeneous scoriae are also found in the upper part of Stage 2. Phenocrystic minerals are common to both juveniles of K-Ah eruption and NL, consisting of plagioclase, orthopyroxene, clinopyroxene, and magnetite. K-Ah pumice and NL have also a small amount of ilmenite. On mineral chemistry, core compositions of plagioclase in pumices show slightly wide (An40-64) with a peak of An55. In contrast, scoriae exhibit a clear bimodal distribution, mainly composed of An64-90 with a peak of An74, and a small amount of low-An plagioclase (An48-62). Pyroxenes in pumice have relatively Mg-poor cores (Mg#64-69 of opx and Mg#68-73 of cpx) and those in scoria show higher Mg# (Mg#68-73 of opx and Mg#69-78 of cpx). The plagioclase and pyroxenes in pumices show normal and reverse zoning, whereas those in scoriae exhibit weak zoning. Comparing to K-Ah pumices, NL have slightly lower-An plagioclase (An39-60), lower-Mg# pyroxenes (Mg#64-65 of opx and Mg#66-73 of cpx). On whole-rock chemistry, K-Ah pumices are rhyolitic and dacitic (SiO_2 = 70.4-73.6 wt.%), and they draw one linear trend in many Harker diagrams. Scoriae (SiO_2 = 58.1-69.0 wt.%) exhibit linear trends, which different from those of pumices. In SiO_2 vs. TiO_2 and Al_2O_3 plots, scoriae draw one linear trends, converging to dacitic end of the linear trends formed by pumices. NL are also rhyolitic (SiO_2 = 71.7-72.4 wt.%), but they are clearly different from K-Ah pumices in FeO*/MgO and Y. On Sr-Nd-Pb isotopic compositions, pumice and scoria are similar, but the former show slightly wider ranges than the latter. NL are similar to K-Ah pumices.

The heterogeneous texture of scoria and the co-existence of compositionally disequilibrium phenocrysts suggest that magma mixing is the main magmatic process in K-Ah eruption. The two distinct linear trends converging to dacitic pumice on whole-rock chemistry indicated the existence of three end-member magmas: rhyolitic, dacitic, and andesitic ones. The mixing relationship between andesitic and dacitic magmas, not rhyolitic one, as well as the co-existence of phenocrysts showing normal and reverse zoning in K-Ah pumices, suggest that there exists the silicic zoned magma chamber, in which dacitic magma stagnated beneath rhyolitic one. Andesitic magma was injected into this silicic zoned magma chamber and mixed with dacitic magma probably just before the eruption.

According to Rayleigh fractionation model, these two silicic magmas cannot be produced by simple fractionation of andesitic one. The two silicic magmas would have been generated by partial melting of crustal materials. The wide variations of isotopic chemistry of K-Ah pumices might reflect the

heterogeneity of crustal materials. The preceding activity (NL) also provided rhyolitic magma. The similarity of isotopic compositions and the difference in whole-rock chemistry suggest that NL rhyolitic magma stagnated separately from K-Ah silicic ones although their source materials are similar. In this way, the existence of multiple silicic magmas might be common in the large silicic magma system.

Keywords: Kikai caldera, large silicic magma system, multiple silicic magmas