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Structure and evolution of magma plumbing system during the historic eruptions since 8th century of Sakurajima volcano

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Dense geophysical monitoring for the Sakurajima volcano has been able to make model for the magma plumbing system. However, the model has not been fully supported by petrological studies. Yanagi {i}et al.{i/} (1991) revealed whole-rock and mineral chemistry of four eruptions since 15^{th} century, indicating that the magma plumbing system was composed of two magma storage systems. They also suggested that magma mixing between these two magmas has occurred. However, except for the reports of whole-rock chemistry, additional petrological studies focusing on structure of the magma plumbing system have not been carried out since then. We re-investigated temporal evolution of the historic eruptive materials since 8^{th} century of the volcano to revise the previous petrological model.

SiO_2 contents of the historic eruptive rocks from 8^{th} to 20^{th} eruptions range from 59 to 66 %. Major phenocrystic minerals in these rocks are plagioclase, orthopyroxene, clinopyroxene, and magnetite, whereas many of lavas of 8th and 20^{th} century eruptions also contain olivine phenocrysts. Core of phenocrystic plagioclase ranges from An=45 to 90 in each sample, showing bimodal compositional distributions. Ratio of An-rich phenocrysts in a single sample increases with time since 15^{th} eruption. Mg-values of core of phenocrystic pyroxenes are 60 - 75 in orthopyroxene and 65 - 80 in clinopyroxene. These pyroxene phenocrysts have changed more mafic with time from 15^{th} eruption. Comparing chemical compositions between core and rim of the single phenocryst, that with An-rich or magnesian core shows normal zonation, whereas that with An-poor and less magnesian cores does reverse one. This indicates that magma mixing between two magmas occurred as mentioned in Yanagi {i}et al.{i/} (1991). On the basis of chemical compositions of reversely and normally zoned phenocrysts, it can be estimated that end-member magmas of mixing are dacitic and andesitic ones. However, olivine phenocysts in many rocks of 8^{th} and 20^{th} eruptions are much magnesian (Fo=80), being disequilibrium with coexisting pyroxene phenocrysts. This suggests that olivine-bearing rocks are the products of mixing between additional basaltic magma and the above two magmas. Although mixing of dacitic and andesitic magmas played an important role in 15^{th} and 18^{th} century eruptions, basaltic magma has sometimes injected into the mixed magma in 8^{th} and 20^{th} century eruptions. This is consistent with difference of whole-rock chemistry between olivine-bearing and olivine-free rocks.

Rims of phenocrystic minerals in olivine-free rocks are nearly uniform, whereas those of olivine-bearing rocks show wide compositional variations. These can be explained by difference of timing between mixing and eruption. In the case of olivine-free rocks, there should exist possible interval between mixing and eruption. If dacitic and andesitic magmas had formed a zoned magma chamber before eruption, mixed magma would become nearly homogeneous. However, the injection of basaltic magma into mixed magma could occur just before the eruption to produce heterogeneity in eruptive rocks. Geophysical monitoring of the Sakurajima volcano during the last several tens years reveals the presence of major magma system beneath the adjacent caldera, from which voluminous magma migrated beneath the volcano before the eruption. In addition, the monitoring also suggests that distinct magma ascended from the opposite side of the caldera, and injected into the shallower system beneath the volcano. On the basis of petrological analysis, it can be speculated that the voluminous magma from the caldera could be mixed magma between dacitic and andesitic ones. On the other hand, the ascending magma from the south would be basaltic magma. It is also noted that the present magma plumbing system would not exist during 15^{th} and 18^{th} century eruptions.