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Cooling process of mafic magma by texture analysis of mafic inclusions in An-ei lava, Sakurajima volcano

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The origin of mafic inclusions is interpreted as relics of mafic end-member magma associated with magma mixing. So, the mafic inclusions record the important information about mafic end-member magma and the mixing processes. Yanagi et al. (1991) suggested binary magma mixing process in the historical eruptions of Sakurajima volcano, according to the fact that plagioclase phenocrysts show a bimodal compositional distribution with two distinctive peaks at about An58 and An85, and reported the presence of mafic inclusions in An-ei lava of 1779 eruptions. Therefore, in order to obtain insights into the behavior of mafic inclusion (especially, magma cooling process) during the magma mixing processes in Sakurajima volcano, we conduct sampling, petrographic description and texture analyses of mafic inclusion in An-ei lava.

Most of mafic inclusions in the An-ei lava are elliptic in shape, the length of the major axis is about 10-20cm. The boundary to the host An-ei lava is sharp. The mafic inclusions show porphyritic texture, the phenocrysts are mainly plagioclase, orthopyroxene, clinopyroxene, oxide and olivine in minor amounts. The microlites in mafic inclusions are plagioclase, orthopyroxene, clinopyroxene and oxide. The host An-ei lava also show porphyritic texture, the phenocrysts are mainly plagioclase, orthopyroxene, clinopyroxene and oxide, but not olivine. The microlites in host An-ei lava are mainly plagioclase and orthopyroxene. Two types of plagioclase phenocrysts are found in mafic inclusions and host An-ei lava: (1) honeycomb plagioclase phenocrysts with large inclusions in heterogeneous mozaic cores with An75-90 and An55-70; and (2) clear plagioclase phenocrysts without any inclusions in homogeneous core from grain by grain, and this plagioclase phenocrysts show an unimodal compositional distribution with a major single peak at about An85, and small fraction of about An60, whereas those in host An-ei lava show a bimodal compositional distribution with two similar peaks at about An60 and An85 plagioclase. The length of plagioclase and pyroxene microlites in mafic inclusions are $\sim$300μm, whereas those in the host An-ei lava are $\sim$50μm.

We conduct microlite number density analyses in order to quantitatively estimate the cooling rate by using plagioclase microlite number density(MND)-cooling rate meter. As a result of application to measured data, the cooling rate (dT/dt) is calculated as 0.19 to 4.18×10^{-4} K/s. We estimate initial and final temperatures during microlite crystallization with core and rim compositions for the plagioclase- and alkali feldspar-liquid thermobarometer. By assuming a constant cooling rate, we calculate the crystallization-time-scale of microlites in mafic inclusions as several days to dozen days. In addition, as a result of crystal size distribution (CSD) analysis, the typical CSD plot of plagioclase microlites in mafic inclusion shows a log-linear trend. This result suggests that the annealing process is not effective and the time interval from the termination of microlite crystallization to the eruption is negligibly short. Thus, we conclude that the time scale from initial microlite crystallization in mafic inclusion to the eruption is about several days to dozen days.

Keywords: Sakurajima volcano, mafic inclusion, texture analysis, microlite number density, magma mixing process, magma cooling process