

Short time scales of pre-eruptive magma mixing processes: petrographic evidence from the 2011 eruptions of Shinmoedake volcano, Kirishima volcanic group, southern Kyushu, Japan

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We estimated the time scales of magma mixing processes prior to the 2011 sub-Plinian eruptions of Shinmoedake volcano, Kirishima volcanic group, southern Kyushu, Japan, to constrain the triggering process of the eruptions, on the basis of zoning profiles of magnetite phenocrysts and diffusion calculations.

The eruptive products are comprised mainly of phenocryst-rich (28 vol%) gray pumice ($\text{SiO}_2 = 57$ wt%) with minor amount of white pumice ($\text{SiO}_2 = 62$ wt%) (Geshi *et al.*, 2011). We found that the gray pumice was formed by mixing between high-temperature nearly aphyric magma (basalt or basaltic andesite) and low-temperature mushy magma (andesite) (e.g., Saito *et al.*, 2011). The depth of the magma chamber, at which the magma mixing occurred, was about 6 to 8 km, deduced from MELTS calculation (Miyagi *et al.*, 2011).

Most of the magnetite phenocrysts (type-A₁) were originated from the low-temperature magma and their zoning profiles showed considerable increase in Mg and Al contents toward the rims of the phenocrysts, due to mixing with the high-temperature mafic magma. We calculated the time for diffusion to form these zoning profiles (i.e., the time from the magma mixing to the eruption) to be only about 1-2 days. The short time scale suggests that the mixing of high-temperature magma triggered the sub-Plinian eruptions.

This mixing process was not accompanied by a significant change in the volume of the magma chamber because no significant crustal deformation was observed several days before the eruptions (Japan Meteorological Agency, 2011). We propose magmatic overturn or melt accumulation within the magma chamber as a possible process.

Some magnetite phenocrysts (type-A₀) showed almost no increase in Mg and Al, indicating that they were not affected by the magma mixing and were incorporated in the magma during the ascent. The time for diffusion of type-A₀ magnetite was less than 0.4 days. This time scale corresponds to the duration of magma ascent from the magma chamber to the surface. This means that the average ascent velocity was more than 15 to 20 km/day.