Crystal Size Distributions based on crystal habit of groundmass pyroxene crystals in the ejecta of the Shinmoedake 2011 eruption

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The 2011 eruption of Shinmoedake, Kirishima volcano, Japan, is characterized by the transition of eruption styles and was preceded by magma mixing (e.g., Suzuki et al., 2013). However, the condition in the volcano has not fully clarified yet, thus clarification of the transition processes needs more information about the magma ascent process from the chamber to the shallow conduit. Meanwhile, Marsh (1988) has proposed that Crystal Size Distributions (CSDs) reflect the kinetic and physical processes affecting crystallization. Mujin and Nakamura (2014) and Mujin et al. (2017) have studied the CSDs of the groundmass crystals in the products of the eruption, and found that the CSD plots exhibit kinks which divide the groundmass crystals into two groups; the coarser ones with the gentler slope and the finer ones with the steeper slope. They proposed that the CSDs reflect the difference of the physicochemical conditions of magma depending on eruption styles. In this study, we focused on pyroxene crystals in groundmass to obtain the information about the physicochemical conditions during ascent in the conduit.

The samples used were the gray pumice of sub-Plinian eruptions and Vulcanian explosions of Shinmoedake 2011 eruption. We determined the miller indices of the pyroxene groundmass crystals by X-ray CT at SPring-8 (BL47XU) and an electron backscatter diffraction (EBSD), analyzed the size and shape of them with a field emission scanning electron microscope (FE-SEM), observed their microtextures with a transmission electron microscope (TEM), and performed composition analysis by a scanning TEM with an energy dispersive X-ray spectrometer (STEM-EDS).

We found that many of the crystals were in a hexagonal or octagonal prism. The former consisted of {010} and {110} prismatic faces and the latter had {100} faces. There were more hexagonal crystals than octagonal ones in the sub-Plinian pumice. In the Vulcanian pumice, by contrast, octagonal ones were dominant and there were only a few of hexagonal ones. In both eruption styles, the hexagonal ones were distributed in finer part than the octagonal ones. The slopes of the CSD also differed according to the habits; that is, the slopes of the hexagonal ones were steeper than that of the octagonal ones. The TEM observation showed that these pyroxene crystals in groundmass were composite crystals composed of orthopyroxene (Opx) and clinopyroxene (Cpx) which was attached to both {100} faces of the Opx, and that the Cpx parts on the both sides were occasionally in twin orientation relationship each other. Their microtextures were symmetric with respect to *c*-axis, which indicated the concentric spreads of the textures.

We found that the size distributions and slopes of the hexagonal and octagonal ones were similar to those of the finer group and the coarser group in Mujin and Nakamura (2014), respectively. Marsh (1988) proposed that CSD slope is a measure of the product of growth rate and residence time. Assuming that the growth rates were almost the same regardless of habits, residence times could be estimated from the CSD slopes as similar durations to the magma ascent durations in the conduit estimated from geophysical data (Kozono et al., 2013, Sato et al., 2013). In particular, the estimated residence time of the hexagonal ones in sub-Plinian pumice was similar to the ascend duration in sub-Plinian eruption. Hence, the hexagonal habit is assumed to reflect the relatively rapid magma ascent rate, which indicates that the

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habits of pyroxene groundmass crystals may reflect the ascent rates in the conduits. Moreover, the TEM observation suggests that microtextures of the crystals may record the temporal change of conditions during the ascent, which indicates the possibility that pyroxene groundmass crystals contribute to reveal the behavior of magma.

Keywords: CSD, crystal habit, pyroxene, volcano

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