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Crystal habit (tracht) of groundmass pyroxene crystals recorded magma ascent paths during the 2011 Shinmoedake eruption

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Abstract

The morphologies and size distributions of groundmass crystals record conditions of magma ascent through volcanic conduits. However, morphological information (such as crystal shapes) has not been incorporated into crystal size distributions (CSDs). Here, we focused on the crystal habit, especially the shape variation due to the combination of (*hk*0) faces (hereafter "tracht") of pyroxene microlites and nano-crystals, and measured CSDs for each crystal habit (tracht) to more comprehensively characterize the crystallization kinetics. We refer to the CSDs measured for each tracht as "tracht-specific CSDs." Pyroclasts from the 2011 eruption of Shinmoedake (Kirishima volcano group, Japan) were examined by field-emission scanning electron microscopy, electron backscatter diffraction analysis, synchrotron radiation X-ray computed nanotomography, and transmission electron microscopy. The samples contain groundmass pyroxenes of two main trachts: octagonal prisms consisting of {100}, {010}, and {110} faces and hexagonal prism lacking {100} faces. The pumice clasts formed by different eruption styles showed different trends of tracht-specific CSDs. Sub-Plinian pumice clasts were characterized by octagonal microlites (1–10 μm wide) and numerous hexagonal nano-crystals (0.2–2 μm wide), and a Vulcanian pumice clast with the same glass composition showed the same characteristics. In contrast, Vulcanian pumice clasts with more evolved glass compositions contained mostly octagonal pyroxenes. The tracht-specific CSDs and growth zonations indicate a change from octagon-dominant to hexagon-dominant growth conditions during syneruptive ascent. We infer that the hexagonal tracht resulted from a large degree of effective undercooling due to rapid decompression in the shallow conduit. Moreover, the texture of the less-evolved Vulcanian pumice indicates that a portion of the magma erupted on the Vulcanian eruption followed almost the same ascent paths just prior to the fragmentation as those during the sub-Plinian eruptions, and thus the Vulcanian eruption may have involved the rapid ascent of deeper magma. We propose that tracht analyses of groundmass pyroxenes provide detailed information about time-evolution of magma conditions during syneruptive ascent.

Keywords: Pyroxene, crystal habit, crystal-size distribution, nanolite, magma ascent