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Crystal size distribution of plagioclase phenocryst of the Sessho lava of the Kusatsu Shirane volcano

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In this study, we present a detailed analysis of crystal size of plagioclase phenocryst in Sessho lava of Kusatsu-shirane volcano, central Japan, to discuss textual evolution of andesitic magma and to constraint crystallization and cooling process during eruption of the large volume andesitic lava flow. Plagioclase phenocryst in erupted volcanic materials can be a tracer of cooling and eruption process of magma, because its liquidus temperature, morphology and crystal size are very sensitive to the degree of supercooling at the crustal to surface pressure (e.g., Suzuki, 2006). The Sessho lava is estimated to have been erupted 3 ka from the Moto-shirane cone (Hayakawa and Yui, 1989) and exhibits andesitic composition with SiO2 content of 60-63 wt. % (e.g., Ueki and Terada, 2012). We corrected 5 different samples to cover the whole area of the Sessho lava.

Phenocryst assemblage of the Sessho lava is plagioclase, clinopyroxene, orthopyroxene, magnetite and rare olivine with glassy groundmass. We majored crystal size of plagioclase phenocryst and conducted EPMA analysis to determine chemical compositions of phenocrysts. Length of the major axis of plagioclase ranges form 0.04-0.5mm. We found that crystal size distribution of plagioclase in each sample shows variation in a single lava flow. The aspect ratio of plagioclase phenocryst shows systematics with the crystal size of plagioclase; larger plagioclase (>1mm in major axis) exhibits aspect ratio of near 1 (subequant morphology), whereas smaller plagioclase (<1mm in major axis) exhibits aspect ratio of 12-1 (tabular-subequant morphology). The large and subequant plagioclase phenocryst show wide range of variation in core composition (An#=55˜84). Both normal zoning and reverse zoning are observed. The wide range of zoning pattern and composition of plagioclase phenocryst suggest there existed a temperature or H2O heterogeneity in a magma chamber beneath the Kusatsu shirane volcano. Core composition of the olivine phenocryst show Mg# (molar ratio of Mg/(Fe+Mg)) of ˜83, which is too magnesian to be in equilibrium with its host andesite. The disequilibrium olivine are accounted for by mixing between olivine bearing mantle derived mafic magma and felsic magma.

As whole rock composition show relatively narrow variation, the textural variation in terms of plagioclase phenocryst may represent a variation in crystallization process, rather than chemical composition of host magma. The small and tabular shape plagioclase represents a crystallization by large degree of supercooling, whereas large and subequant shape represents small degree of supercooling (e.g., Hammer and Rutherford, 2002). Small and tabular plagioclase may have crystallized at shallower depth during ascent whereas larger and subequant plagioclase may have crystallized in a crustal magma chamber. The variation of the large/small plagioclase ratio in a single lava flow indicates that these exist a variation of degree of supercooling even in the single lava flow. We propose that andesite magma of the Sessho lava containing tabular smaller plagioclase may represent magma that stored in a shallower depth as a dyke before eruption. The smaller tabular plagioclase could be crystallized by cooling, degassing and crystallization in a shallower dyke. Magma without the smaller plagioclase may represent magma that ascended directly from the magma chamber by continuous eruption.

Keywords: Lava flow, Crystal size distribution, Eruption, Andesite, Active volcano