Experimental study on groundmass crystallization of the Izu-Oshima 1986 B basaltic andesite magma during conduit ascent

Ryoya Oida[2,3], *Hidemi Ishibashi[1], Akihiko Tomiya[3], Masashi Ushioda[3], Natsumi Hokanishi[4], Atsushi Yasuda[4]

1. Faculty of Science, Shizuoka University, 2. Graduate School of Integrated Science and Technology, Shizuoka University, 3. GSJ, AIST, 4. Univ. Tokyo, ERI

Melting and crystallization experiments were performed for H_2O-saturated basaltic andesite magma of the Izu-Oshima 1986 B eruption at 0.1-200 MPa pressure conditions, to constrain the pre-eruptive pressure condition and to simulate crystallization process during conduit ascent of the magma. The 1986 B eruption was sub-Plinian and erupted almost aphyric (<1 vol.% phenocrysts of plagioclase), microlite-rich basaltic andesite magma with bulk SiO_2 content of ~54.5 wt.%. Powdered samples of the basaltic andesite were used for the starting materials of our experiments. We performed high-temperature phase equilibrium experiments at 0.1 MPa and high-pressure conditions (1010-1200ºC and 20-200MPa), using the fO_2-controlled electric furnace and the internally heated pressure vessel (KOBELCO Dr. HIP) at GSJ, AIST, respectively. In both experiments, the samples were heated at experimental temperatures for 3 hours and then quenched. Redox conditions were controlled at Ni-NiO buffer during the experiments at 0.1 MPa, whereas the high-P experiments were performed under more oxidized conditions because fO_2 was not controlled. The quenched samples were processed to polished thin sections for microprobe analyses. BSE image observations and chemical analyses of microlites and glasses were done using FE-EPMA (JEOL JXA-8530FPlus) and EPMA (JEOL-8800R) at ERI, University of Tokyo, respectively.
First, H_2O-saturated liquidus of the basaltic andesite magma was experimentally constrained and formulated as a function of pressure as $10000/T = 8.5 + 0.0027P + 0.049P^{0.5}$. Assuming the magma was at 1070-1100 ºC (Fujii et al., 1988) and saturated with H_2O and plagioclase in its magma chamber, the pre-eruptive pressure is estimated to be ~70-115 MPa; the pressure corresponds to the depth of ~2.8-4.6 km, which is consistent with previous geophysical result (Ida, 1995).
Secondly, phase equilibrium experiments were performed at 1080 ºC, the eruptive temperature of the magma, and various pressure conditions from 75 MPa to 0.1 MPa, to simulate crystallization during conduit ascent of the magma. Plagioclase and Fe-Ti oxide are found in all samples, whereas pyroxene crystallized at pressure lower than 35 MPa. As pressure decreases, plagioclase content increases from 2.5 vol.% at 75 MPa to 42.5 vol.% at 0.1 MPa. At 20 MPa, plagioclase and total crystal contents are ~20 vol.% and ~40 vol.%, respectively, which are similar to those in the natural scoria samples. Considering the effects of fO_2 and crystallization kinetics on crystallinity, the results suggest that the pressure at which crystallization ended during conduit ascent of the magma was lower than 20MPa, corresponding to the depth < ~1km. We infer that fragmentation occurred at the depth because the crystallinity of >~40 vol.% corresponds to the critical crystallinity at which viscous-brittle transition occurs for melt-crystal-bubble system with bubble content of <30-50 vol.%.
Lastly, the effect of temperature on crystallinity was examined at 20MPa. As temperature increases from 1080 ºC to 1110 ºC, total crystal contents drastically decrease from ~40vol.% to ~5 vol.%. The result indicates that decreasing temperature facilitates viscous-brittle transition and fragmentation due to increase of crystallinity. Therefore, temperature is a critical factor controlling eruption style of mafic magma. We think that the difference of eruption styles between A and B magmas of the Izu-Oshima 1986 eruption was essentially caused by the difference of magmatic temperature.

Keywords: crystallization, microlite, mafic magma, Izu-Oshima, eruption style

