Textural relaxation and permeability evolution of bubble-bearing magmas

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Textural relaxation driven by interfacial tension is one of the fundamental processes in the microstructural evolution of bubble-bearing magma. A series of heating experiments of andesitic pumices by Otsuki et al. (2015) revealed that expulsion of bubbles to the outside of the system results densification and self-contraction of magma glob. In larger system, extracted vapor from the contracted melt glob may form “inter-glob pore” inside the system. Because this process may effect on the evolution of gas permeability of bubble-bearing magma, the textural relaxation process controls the outgassing within a volcanic conduit.

In this study, we examined the 3D bubble microstructure and gas permeability of the pumices after heating experiments to investigate the outgassing process from magma. The andesitic pumices of the 1914 Plinian eruption of Sakurajima were used for the starting materials. We prepared two types of the starting materials to investigate the size effect; cubes of pumice with sides 9 mm and non-shaped pumice pieces with 3–6 cm^3 in volume. The pumices were heated in silica glass tubes at a temperature of 1000°C under 0.1 MPa vapor pressure for up to 32 hours (Otsuki et al., 2015), and then their gas permeability and 3D bubble microstructure were examined. The permeability of the run products was determined with the method of Takeuchi et al. (2009) and bubble microstructure was investigated using micro X-ray CT (Otsuki et al., 2015).

Gas permeability of the pumice clasts ranges between 10^{-13} and 10^{-11} m^2. We found that time evolution of the gas permeability depends on sample size. The permeability of the run products from cube-cut pumice with 9 mm side concentrates in relatively low value (10^{-16}–10^{-15} m^2) after 8–32 hour heating, while the permeability of the run products after <2 hour run shows wider and lower ranges (10^{-16}–10^{-11} m^2). The 3D analysis of the bubble microstructure shows the development of inter-glob pores formed by multiple-contraction in a run product with short heating time (~30 min). No remarkable inter-glob pore is recognized in the run products after longer run duration (8–32 h). Some run products from the large pieces of pumice kept high permeability up to 10^{-11} m^2 after 8–32 hour heating. The 3D analysis shows that some inter-glob pores still survive in these samples. Based on the 3D analysis of bubble microstructure we infer that the time scale of permeability reduction were longer due to the larger (longer) size of inter-glob pores in larger samples. Therefore, the relaxation time of the inter-glob pores seems to control the evolution of gas permeability in relaxing magma at a shallow part of a volcanic conduit.

Keywords: Textural relaxation, Gas permeability, magma

