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Experimental study on the textural relaxation of melt foam

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Vesiculation and outgassing of ascending magma control the style of volcanic eruptions. In a series of Vulcanian activity, dense lavas are formed in the volcanic craters in the interval between explosions. It is believed that this dense, less-permeable lava caps play a key role to accumulate overpressure within shallow conduits. Detailed mechanism of the lava cap formation is, however, poorly understood. The decrease of permeability in the foamed magma has generally been attributed to the compaction associated with permeable-flow outgassing (Westrich and Eichelberger, 1994, Okumura et al., 2010). The surface tension of melt is a primary force for textural development of vesiculated magmas such as bubble coalescence and textural relaxation (e.g., Saar and Manga, 1999), but its effect on the microstructure, density and permeability of magmas is not well constrained.

We carried out heating experiments of an andesitic pumice (Taisho eruption of Sakurajima volcano in 1914) to examine the process of surface tension-driven foam collapse. Its bulk water content is ca. 0.5 wt.%. We have conducted the experiments in two pressure conditions. One is low water vapor pressure experiment (0atm $<$ P_{total} = P_{O2}, NNO $<$ 1atm, LVP), and the other is higher (P_{total} = P_{H2O} = 20, 40 and 60 atm; HVP). The experimental temperature for the LVPs and HVPs were 400 to 1000 and 1000 deg.C , respectively. The run duration ranges from 0.5 to 32 hours. After the runs, run products were observed with scanning electron microscope (SEM). The geometry of bubble such as vesicularity, circularity, connectivity and bubble size distribution were analyzed on the BSE images.In the LVPs and HVPs at 1000 deg. C, the vesicularity and the connectivity decreased and the circularity increased. At $<$ 800 deg. C, however, no significant densification was observed. The melt viscosity was calculated to be 10^6, 10^8 and 10^{11} Pa s for the HVPs, LVPs at 1000 and 800 deg. C, respectively. The surface tension was calculated to be ca. 235 m N/m for all the experimental conditions. It is inferred that in the Vulcanian eruptions, the microstructure of the foamed melt quickly relax due to the surface tension of melt, resulting in the formation of impermeable lava caps in the crater.

Keywords: melt foam, surface tension, textural relaxation, permeability, viscosity