Experimental study on textural relaxation of deformed melt foam

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The surface tension of melt is a primary force for textural development of vesiculated magmas such as bubble coalescence and textural relaxation, but its effect on the microstructure and permeability development of magmas is not well constrained. In flowing viscous magmas, shear stress overwhelms surface tension (e.g., Okumura et al., 2006), whereas textural relaxation driven by surface tension becomes the dominant process, once the magma stops flowing. In this study, we examined the textural relaxation of deformed melt foam driven by surface tension. We carried out heating experiments of andesitic pumice cubes of the 1914 Plinian eruption of the Sakurajima volcano by assuming that the pumice approximates conduit magma in terms of bubble microstructure and water content just after the explosion. The sample size was ca. 3 mm on a side. Two series of experiments have been conducted: evacuated experiments (P_{H2O} < 0.1 MPa) and high water vapor pressure experiments (2.0–6.0 MPa). The experimental temperature was set to be 800 to 1000℃. The run duration ranges from 3 minutes to 32 hours. After the runs, the microstructure of pores and bubbles was analyzed on the BSE images of polished cross sections. At a temperature of 1000℃ and P_{H2O}< 0.1 MPa, the vesicularity and bubble connectivity decreased and the circularity increased within 3 minutes. The decrease in the vesicularity occurred via disappearance of open pores connected to sample surface due to the surface tension, resulting in "self-compaction." The decrease in the pore connectivity and the increase in the circularity in the initial stage reflect the breakup of tortuous pore networks. Bubble size increased with time owing to bubble coalescence. At temperatures of 800℃ and P_{H2O}< 0.1 MPa, however, no significant textural change was observed until 32 hours. At a temperature of 1000℃ and higher vapor pressures, the degree of the decrease in the vesicularity was smaller than that of the experiments at P_{H2O}< 0.1 MPa. The circularity increased and connectivity decreased first, and then oscillated with time owing to bubble coalescence and relaxation. These results suggest that melt viscosity is the primary controls the degree of relaxation. Our experiments shows that the relaxation of melt foam decreases small-scale bubble connectivity and hence decreases local gas permeability. The effects of sample size (i.e., specific surface area) should be considered for the larger scale permeability.