Permeability evolution during welding of hydrous rhyolitic glasses

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The welding of pyroclastics is the inverse process of magma fragmentation. Recent geological studies on lava flows revealed that some of the “typical” lava flows are clastogenic, i.e., the welded products of once-fragmented ashes and scoria/pumices (e.g., Yasui and Koyaguchi, 2004). The welding within the volcanic conduit may decrease the permeability and increase the mechanical strength of cap rocks, and thereby promotes the pressurization in the conduit. The welding may thus be one of the elementary processes to control the eruption style. In order to understand the kinetics of welding of the hydrous rhyolitic melts, we performed uniaxial compression experiments in a high-temperature compression apparatus. The starting glass-shards were prepared by crushing the raw (Obp-3) and foamed obsidian slabs with ca. 0.7 wt. % H_2O. The water content of the starting glass-shards was controlled by changing the preheating duration (Obp-1, 15min; Obp-2, 5min). The experiments were carried out in an open system pyrophyllite cells at 620-850 degC and 0-3 MPa differential stress for 10-240 minutes run duration.

A wide range of welding degree was observed from no-welding to complete welding. The lens-shaped melt droplets were sporadically formed in the moderately welded samples, and then homogeneous dense melt was formed as the welding proceeds. In the time-series experiments, welding proceeded via rearrangement and deformation of the fragments in 15 minutes, and then porosity decrease by sintering of the melts has become predominant. The small difference in the initial H_2O content resulted in a significant difference in the final degree of welding at a constant load. On the basis of these observations, we conclude that the feedback system including diffusive dehydration and deformation of the melts promoted bifurcation of the welding degree, i.e., the relatively high initial water content in the glass maintained low viscosity and facilitated the deformation and welding of the melts, resulting in the increase of diffusion distance and sustenance of water. The permeability of the run products from Obp-3 drops from $10^{-13.3}$ at a porosity of 18% (after 10 min welding at 850 degC) to $10^{-17.3}$ m^2 at 2.5 % (60 min), whereas the permeability of the welded run product from Obp-1 was kept high ($10^{-14.1}$ m^2) after the welding for 60 min. The sensitivity of permeability to the initial water content may cause complex pressurization behavior in the shallow volcanic conduit system.