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Bubble growth and resorption in magma: insights from dissolved water distributions in volcanic glass

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Volcanic eruptions are driven by the growth of gas bubbles in magma, which grow and shrink as volatile species exsolve from and dissolve back into the melt in response to changes in the local environment, particularly in pressure and temperature. This movement of volatiles, particularly water, is recorded in the glass around vesicles and recent studies have used this record to interpret natural samples. Here we investigate the processes that control bubble growth and resorption in magma, by measuring the distribution of dissolved water in experimentally-vesiculated volcanic glasses. Water concentration profiles obtained using SIMS-calibrated BSEM imaging and water speciation data obtained using FTIR spectroscopy, are interpreted in the context of the known pressure and temperature history of the samples.

Samples are found to have undergone partial bubble resorption during the quench to glass at the end of experiments, as a result of increasing water solubility with decreasing temperature. Analysis of the lengthscale and timing of the resulting water concentration profiles demonstrates that the majority of resorption occurs above the glass transition. This quench resorption is associated with a reduction in bubble volumes that creates characteristic textures, such as buckled melt films between adjacent vesicles and reoriented cracks around resorption halos. Highly disequilibrium water speciation ratios within resorption halos are found to be diagnostic of quench resorption and can preserve evidence of pre-quench bubble growth

Quench resorption can increase sample water concentrations and ratios of molecular to hydroxyl water species, and reduce bubble volumes and sample porosities. Studies based on these parameters must therefore consider the potential impact of quench resorption, which is expected to be greatest for samples with high water concentrations, slow quench and low initial sample porosities. Water speciation data offer a way to investigate these impacts in unconstrained natural samples and could provide a tool for forensic interrogation of their eruptive history.

キーワード: Bubble growth, Bubble resorption, Water speciation, FTIR, SIMS, Backscatter SEM
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