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Vesiculation and Microlite Crystallization induced by Decompression: Experimental Constraints for rhyodacitic Magma of Unzen Volcano, Japan

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Whether an eruption occurs effusive or explosive is controlled by different factors, e.g. the degree of magma degassing, the rate of magma ascent and groundmass crystallization. In the framework of the ICDP Unzen drilling project, we performed experiments at 850˚C to study heterogeneous nucleation and growth of bubbles and microlites in a rhyodacitic melt on decompression from 300 to 50 MPa. The decompression experiments have been conducted step-wise with decompression rates varying from 0.0005 to 20 MPa/s. As a starting material we used a synthetic analogue of the groundmass composition of the 1991-1995 Unzen eruption. Two experimental series were carried out in parallel: one using only water as a fluid component (H_2O-saturated) and the other using water and carbon dioxide fluid (H_2O+CO_2-bearing; with mole fraction of H_2O in the fluid ~0.6).

The experimental products consist of pyroxenes, amphiboles (Amph), plagioclases (Pl), oxides and glass. In H_2O-saturated magma, Pl microlites nucleate and grow only at very slow decompression (0.0005 MPa/s). On the other hand, Amph is absent in experiments with H_2O+CO_2-bearing fluids. Chemical analysis of the experimental products showed reaction rims on Pl and Amph microlites. The width of Amph reaction rims in water saturated samples increases with decreasing decompression rate and reaches up to 4 μm at decompression of 0.0005 MPa/s. On the other hand, the Mg numbers of Amph cores (Mg#=0.64-0.69) and reaction rims (Mg#=0.60-0.66) do not show systematic dependence on decompression rate and are slightly lower than the values of 0.65-0.75 in natural Amph in the Unzen groundmass. Even though quantitative determination of Pl reaction rim width was not successful due to small size of the rims, the anorthite contents of the experimentally grown Pl microlites (An $\sim$45-65 mol%) are consistent with An values of natural Pl microlites. The SiO_2-content of the residual melt increases with decreasing decompression rate pointing out that melts produced at slow decompression rate (H_2O+CO_2-bearing sample $\sim$79 wt%; H_2O-saturated sample $\sim$74.5 wt%) are close to the natural matrix glasses with SiO_2-content of 78-80 wt%.

We have determined the bubble number density (BND) and microlite number density (MND) for each sample. Our determined BND values range from 10^{14} m^{-3} to 10^{16} m^{-3} and our MND values range from 10^{16} m^{-3} to 10^{18} m^{-3} at slowand fast decompression, respectively, showing in general a negative dependence on decompression rate. The experimental BND values obtained at slow decompression are close to the values of natural samples (BND=10^{10}-10^{15} m^{-3}) while the experimental MNDs are at least one order of magnitude higher than that from natural samples (MND=10^{14}-10^{15} m^{-3}). The length of experimental Pl reaches up to 200-250 μm in experiments with H_2O fluids and at decompression rate of 0.0005 MPa/s. These lengths are consistent with Pl sizes in natural samples (*Noguchi et al., in press*). The water exsolution rates, calculated using the model of *Toramaru et al. (in press),* vary from 1.9x10^{-4} wt%/s at slow to 1.3x10^{-3}wt%/s at fast decompression whereas the water exsolution rates calculated for natural samples are lower ranging from 3.7x10^{-6} to 1.7x10^{-5}wt%/s. Thus, the experimental results indicate that ascent rates of Unzen magmas were close to or lower than $\sim$ 6 m/hour. This value is in the same order of magnitude as the estimated rate of 12-30 m/hour (*Nakada and Motomura, 1999)*. However, it has to be noted that ascent rates are probably not constant over the whole conduit and that the experimental dataset needs to be completed to better bracket the possible range of natural conditions.

References

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