Decompression Experiments: Insights into the Magma Ascent During 1991-1995 Unzen Eruption, Japan

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We aim to reproduce experimentally the texture, mineral assemblage and composition of volcanic rocks erupted at Unzen in 1991-1995. We have conducted isothermal multi-step decompression experiments from 300 to 50 MPa at 850°C in cold-seal pressure vessels. A synthetic analogue of a rhyodacitic melt corresponding to the groundmass composition of the 1991-1995 Unzen eruption was used as a starting material. Decompression rates varied from 0.0002 to 20 MPa/s. Two fluid-saturated experimental series were carried out: 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; XH_2O ca. 0.6).

The starting assemblages at 300 MPa, 850°C consist of amphiboles (Amph), oxides and glass (± pyroxenes). Additionally, plagioclase (Pl) microlites formed in the starting assemblage of the H_2O+CO_2-bearing system. But the equilibrium mineral assemblage at 50 MPa, 850°C shows that Pl microlites are stable in the both systems. Chemical analysis of the residual melt show that the SiO_2-content and the MgO-content of the melt change with decompression rate lower 0.1 MPa/s, becoming similar to the composition of natural matrix glasses of Unzen samples (SiO_2=78-80 wt%; MgO=0-0.35 wt%) at decompression rate of 0.0002 MPa/s. In the H_2O-saturated runs, the sizes of reaction rims on Amph decrease from 4 to 2 μm with increasing decompression rate from 0.0002 to 20 MPa/s.

Bubble number density (BND) decreases from 10^{14} m^{-3} to 10^{16} m^{-3} with decreasing decompression rate from 20 to 0.0002 MPa/s. Microlite number density (MND) decreases from 10^{17} m^{-3} to 10^{18} m^{-3} with decreasing decompression rates from 20 to 0.0002 MPa/s. 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 two log units higher than those of natural samples (MND=10^{14}-10^{15} m^{-3}). It has to be noted that the Pl crystallization in the H_2O-saturated system at decompression rates lower 0.0005 MPa/s seems to be responsible for an increase in BND and MND. The experimental Pls reach up to 50-150μm in length at 0.0005 MPa/s and up to 200-250 μm in length at 0.0002 MPa/s. The latter Pl sizes are consistent with Pl sizes in natural samples (Noguchi et al., 2008 in press).

Our experimental results indicate that not only H_2O but also CO_2 might have played an important role during the ascent of Unzen magmas. Furthermore, ascent rates might have been close to or lower than ca. 6 m/hour which is in the same order of magnitude as the estimated rate of 12-30 m/hour (Nakada and Motomura, 1999).

References

Nakada, S, Motomura Y (1999) Petrology of the 1991-1995 eruption at Unzen: effusion pulsation and groundmass crystallization, J. Volcano. Geothermal. Res. 89: 173-196

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