Geophysical Research Abstracts, Vol. 7, 06428, 2005
SRef-ID: 1607-7962/gra/EGU05-A-06428

Bubble number densities in rhyolitic magmas: importance for the dynamics of magma ascent and volatile exsolution

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The rate of decompression-driven volatile exsolution in ascending magmas controls the style and intensity of volcanic eruptions. Bubble nucleation is a critical aspect of the exsolution process but it is still poorly understood. Two nucleation parameters are specially important: (1) the degree of volatile supersaturation ΔP required to trigger bubble nucleation, which determines the depth at which bubbles form in an ascending magma; and (2) the number density of bubbles, N, that is, the number of bubbles formed per unit volume of melt. N controls the average distance between neighbouring bubbles: if this distance is short in comparison to the volatile diffusion length scale ($\approx[Dt]^{1/2}$, where D is the diffusion coefficient of volatile components and t is the duration of ascent/vesiculation), then near-equilibrium degassing may prevail; in the opposite case, large degrees of volatile supersaturation may build up during magma ascent and vesiculation.

In a recent experimental study of homogeneous bubble nucleation in a rhyolitic melt containing 7 wt. % H_2O [1], the decompression rate was shown to have a very small effect on ΔP but a very strong effect on N, suggesting that bubble number densities in silicic pumices could be used to estimate the ascent rate of magmas in volcanic conduits. However, the extrapolation of experimental densities to the typical ascent rates of silicic magmas yields values $\leq 10^{10}$ m^{-3}, which are orders of magnitude lower than the densities measured in pumices (up to 10^{16} m^{-3}). To explain this discrepancy, we performed two groups of controlled decompression experiments in an externally-heated pressure vessel at 800˚C. First, we determined the kinetics of bubble nucleation in a rhyolitic composition saturated in water at 200 MPa and crowded with micron-sized haematite crystals; the objective was to test whether heterogeneous bubble nucleation can lead to bubble number densities orders of magnitude larger than in the case of homogeneous nucleation. Second, we studied the case of homogeneous bubble nucleation in the system rhyolite-H_2O-CO_2 to test whether small amounts of CO_2 can significantly affect the number density of bubbles. The main results of these experiments will be summarized and the implications for the use of bubble number densities in pumices as markers of magma ascent rate will be discussed.

[1] C. C. Mourtada-Bonnefoi and D. Laporte, *Earth Planet. Sci. Lett.*, 218: 521-537, 2004