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Analogue experiments on degassing from deformable bubbly fluid by decompression

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Bubbles in magma affect eruption styles, since rapid expansion of bubbles in magma causes explosive eruptions. If volcanic gas in bubbles escapes quietly to atmosphere (which is a process called as degassing), an explosion may be suppressed. Degassing is thus an important process in conduit, but its details have not yet been well understood. Since it is difficult to observe bubbly magmas inside a conduit directly, we here perform an analogous experiment.

We simulate the magma ascending in a conduit by vacuuming a tank with internal dimensions of 900 x 600 x 40 mm^3 in which bubbly fluid is enclosed. For our magma analogue, we use three kinds of syrup whose viscosities are 10, 1000, and 4000 Pa s which cover the viscosity ranges of basaltic to low viscosity andesitic magmas. Bubbles in syrup are created by chemical reactions. The decompression rate depends on the sealing of the experimental tank. We measured the pressure inside and outside the bubbly syrup by pressure transducers attached to the bottom and top of the experimental tank, respectively. We can calculate the pressure gradient inside the bubbly syrup by these two measurements.

In experiments, we find that bubbles expand through decompression and the bubble films finally break such that bubbles become interconnected. The gas inside bubbles escapes from the surface of the bubbly syrup. Observed volume of bubbles in the syrup (V_a) is significantly smaller than the estimated one assuming that bubbles initially included in the syrup expands without degassing (V_i), indicating the occurrence of degassing. Degassing begins when volume fraction of bubbles reaches at around 0.8~0.9. We calculate degassing rates by using values of V_a and V_i ,and find correlations with pressure gradient within the bubbly syrup suggesting that pressure gradient drives degassing. Although the shape of the interconnected bubbles is subject to deformation and the apertures on bubble film may close eventually, degassing observed in our experiments apparently follows classical Darcy's law. We estimate permeability and obtain values 10^{-7}~10^{-10} m^2. These are larger than those measured with solidified magmas. We also find that permeability for less viscous syrup is larger than that for more viscous syrup. In our experiments, pressure differences between inside and outside the bubbly syrup becomes larger for more viscous syrup and higher decompression rates. We infer that bubbles are unable to expand sufficiently fast to allow the pressure inside bubbles to equilibrate with the pressure outside bubbles as it has been suggested.

We thus conclude that deformable magma could be degassed more efficiently than that it has been estimated and degassing becomes more efficient for less viscous magma with higher decompression rate.

Keywords: volcano, eruption, degassing, bubble, analogue experiment, conduit