# Model experiments of degassing process in a crystal bearing magma

*橋本 佳菜[1]、隅田 育郎[1]
*Kana Hashimoto[1], Ikuro Sumita[1]

1. 金沢大学
1. Kanazawa University

Degassing from an ascending volatile-rich magma affects the style of volcanic eruption. Eruption is considered to become explosive when the magma viscosity is high because degassing is difficult. However as solidification progresses, cracks may form in the pathway of the bubbles such that the degassing is promoted. Then the eruption may become effusive. Magma contains crystals and becomes non-Newtonian such that the viscosity decreases with the strain rate (a shear-thinning property). Divoux *et al.* (2011) conducted degassing experiments using a non-Newtonian fluid (a diluted solution of a commercial hair-dressing gel), and showed that several distinct styles of degassing styles exist. However, there have been no degassing experiments in which ascending bubbles are directly observed in a fluid containing liquid and particles. In this study we inject bubbles into a transparent mixture of liquid and particles which models a crystal-bearing magma. We vary the particle volumetric fraction *phi* to understand how the degassing regimes transition as *phi* increases.
A transparent model fluids are made by mixing a silicone powder (particles) and a silicone oil which has the same refractive index. The volumetric fraction *phi* of the particles range from 0 to 0.5. From the rheology measurements, we find that the viscosity and the yield stress increases with phi. In addition the fluid becomes increasingly shear thinning with *phi*.
In this study, we conduct two types of experiments. Experiment 1 is conducted to study how the bubble ascent velocity (*U* ) depend on its volume (*V* ). Experiment 2 is conducted to observe the pattern of the bubbly flow and the fluctuations of differential air pressure at several flow rates *Q*. From experiment 1 (*phi* = 0-0.4), we find that *U* decreases with *phi*. We fit the data to a power-law relation (*U proportional to* $V^n$ ) and obtain the power-law exponents *n*, for each fluids with different *phi*. From the Stokes' law, *n* in a Newtonian fluid is *n* = 2/3 ˜ 0.67. At *phi* = 0, 0.1 we find that *U* is smaller than the Stokes' velocity and that *n* < 0.67. Reynolds number (*Re* ) in these experiments are *Re* ˜ 100 which is much larger than 1, and we consider that the turbulent drag is the cause of this deviation. On the other hand for *phi* = 0.3-0.4, *U* becomes sufficiently small such that *Re* < 1. The value of the exponent *n* is *n* > 0.67 and the measured *U* agree well with the Stokes' velocity calculated using the shear-thinning viscosity. Here we note that *n* increasing with *phi* implies that the coalescence of bubbles with different sizes are enhanced, which we confirmed in our experiments. For fluid with *phi* = 0.5, we find that the bubble ascent is strongly inhibited because the yield stress becomes comparable to the bubble buoyancy. From experiment 2 (*phi* = 0.4-0.5), we observe that the generation and coalescence of the bubbles occur continuously. As *Q* increases, the bubbles become larger and vertically elongated (slugs). Furthermore, at *phi* = 0.5, narrow cracks form near the orifice where the bubbles form. The style of the differential pressure fluctuations also change with *phi*. At *phi* = 0.4, the pressure fluctuates regularly having a short period. However at *phi* = 0.5, the fluctuation becomes irregular with a longer period.
Our experiments suggest that as the magma cools and *phi* increases, the bubble ascent velocity becomes slower, such that the bubbles may even become trapped. However if the bubble size exceeds a critical value such that they can ascend, at large *phi* coalescence of bubbles with different sizes are enhanced which promotes degassing. Our experiments also show that whenever a bubbly flow occurs, an increase in *phi* results in an irregular, long period pressure fluctuations, which may excite volcanic tremors having similar temporal features.

 

キーワード：マグマ、脱ガス、ずり流動化、モデル実験、体積分率、気泡
Keywords: magma, degassing, shear-thinning, model experiment, volumetric fraction, bubble