# Time-evolution of the number density of bubbling in viscous liquid

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Time-evolutions of bubbling in viscous liquid are characterized by two stages, i.e., the bubble nucleation stage and the bubble coalescence stage. We have focused on the former stage of bubbling and investigated numerically bubble formation in viscous liquid decompressed with a constant rate. Bubble formation consists of two important processes, that is, nucleation and growth of bubbles due to exsolution of volatile elements from liquid. To describe the growth processes, some authors used the growth model developed by Toramaru [1995]. This model describes bubble expansion due to decompression in viscous incompressible magma and also time-evolution of volatile concentration due to the diffusive flow of volatile to bubbles. However, it has some disadvantages: (1) all bubbles are assumed to be equal in size neglecting the bubble size distribution. (2) Bubbles grow in incompressible magma which can be approximated to be extended infinitely. If a bubble sphere enlarges its radius in incompressible liquid, infinite moment is needed to push its surrounding liquid. To overcome these difficulties, we have developed more realistic model of bubble growth, taking into account bubble size distribution and compressibility of surrounding liquid.

Numerical solutions show that formation of bubbles changes its behavior abruptly when viscous of liquid becomes larger than a critical value (noted as the critical viscosity below). If the liquid viscosity is higher than the critical viscosity, bubble growth processes are controlled principally by the liquid viscosity. If the liquid viscosity is lower than the critical viscosity, processes of nucleation and growth of bubbles are swayed by diffusivity of volatile in liquid.

In the case that the viscosity is as high as the critical viscosity, it is observed that size distributions of bubbles have wide dispersion at the time when the nucleation rate becomes maximum and gradually change to an unimodal size distribution as bubbles grow larger. In a case of extreme high viscosity, it maintains an exponentially decreasing function with increasing bubble size.

These characteristic time-evolutions of the number density and size distribution of bubbles would be useful in evaluating material quantities such as the diffusivity, the viscosity, and the surface tension of liquid from experimental results. Furthermore, such information would provide initial conditions in constructing a theoretical model on the bubble coalescence stage. Our results then indicate that bubbles begin to coalesce with each other from conditions that bubbles have almost an equal size.