

Theoretical model of bubble formation in a viscous liquid: Application to bubble nucleation in magmas

kou Yamada[1]; Hiroyuki Emori[2]; Hidekazu Tanaka[3]; Kiyoshi Nakazawa[4]

[1] Earth and Planetary Sci., titech; [2] Earth and Planetary Sci., Tokyo Tech.; [3] Dept. of Earth and Planetary Sci., Tokyo Inst. of Tech.; [4] Earth and Planetary Sci., Tokyo Inst. Tech

We have newly developed an accurate theoretical model of bubble formation in super-saturated viscous magma under the formulation by Toramaru [1995]. Such a model is essential in deriving considerable information from the data of bubble nucleation in the recent decompression experiments. We obtain analytical solutions for the time-evolution of the nucleation rate and the number density of nucleated bubbles in cases with constant decompression rates. The numerical solutions to the bubble number density show two regions, namely, the diffusion-controlled region and the viscosity-controlled region, in the nucleation process of bubbles. This result is consistent with that of Toramaru [1995]. In the diffusion controlled region, the bubble growth evolves as the parabolic law and the number density of bubbles is sensitive to the diffusion coefficient but not the viscosity. Both the bubble number density and the duration time of nucleation obtained in this study are larger than those obtained by Toramaru [1995] by a factor of 10. The duration time of nucleation and the supersaturation pressure required to trigger the bubble nucleation depend on only the surface tension of melt. On the other hand, in the viscosity-controlled region, the bubble number density is much sensitive to the viscosity and significantly increases with the melt viscosity. The duration time of nucleation lengthens with the increasing viscosity as well. In the case of magmas with the high viscosity, the bubble nucleation proceeds until the atmospheric pressure. Finally, we apply our model to the recent decompression experiments and indirectly estimate the surface tensions of the rhyolitic melt with only H₂O and with H₂O and CO₂. Our indirect estimates indicate that the surface tensions for 7wt. %H₂O dissolved in melt are 0.08±0.01N/m for samples with no CO₂ and 0.07±0.01N/m for samples with a considerable amount of CO₂, respectively. These estimations are consistent with the available experimental values of the surface tension.

