On the secondary nucleation of bubbles in decompressing magmas

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The secondary nucleation of bubble is the phenomenon that new bubbles nucleate in a magma bearing preexisting bubbles. The secondary bubble nucleation gives an influence on the bubble size distribution observed in natural samples and the magma flow in the conduit. Although the secondary nucleation has been postulated in some articles, the condition for the secondary bubble is not well understood. In this study, we carry out the numerical experiment to quantitatively evaluate the condition that the secondary nucleation can occurs, by the single bubble radius model with variable parameters representing the effective decompression rate, the effective surface tension and the initial radius of preexisting bubbles. As a result, it is found that the secondary nucleation can occur when the number density of preexisting bubbles is small or vice versa. The limit or maximum of number density of preexisting bubbles, $n_{pre}{}^{max}$, that the secondary bubble nucleation can occur, monotonically decreases with the effective decompression rate and the effective surface tension. If we introduce the number density of bubbles formed by the decompression without preexisting bubbles by n_0, we have nearly constant values of the ratio, $n_{pre}{}^{max}/n_0$, approximately equal to 0.2 to 0.5. This result can be understood by a simple analysis considering the competing effect of the supersaturation decrease by growth of preexisting bubbles and the supersaturation increase by decompression. Preliminary result by the model taking into account the bubble size distribution shows that the effect of bubble size distribution reduces the ratio $n_{pre}{}^{max}/n_0$, or the limit of the secondary bubble nucleation by factor. These numerical results suggest that, when the decompression rate abruptly changes, the secondary nucleation easily occurs even if the number density of preexisting bubbles is approximately one order of magnitude less than n_0. In natural magmas which possibly experience the repetition of retention and ascent, the secondary nucleation may occur. Thus the secondary nucleation should be taken into account in understanding the complex vesicle texture in volcanic rocks and in inferring the decompression history from bubble size distribution with multiple peaks.