A new theory of bubble formation in magma with low viscosity

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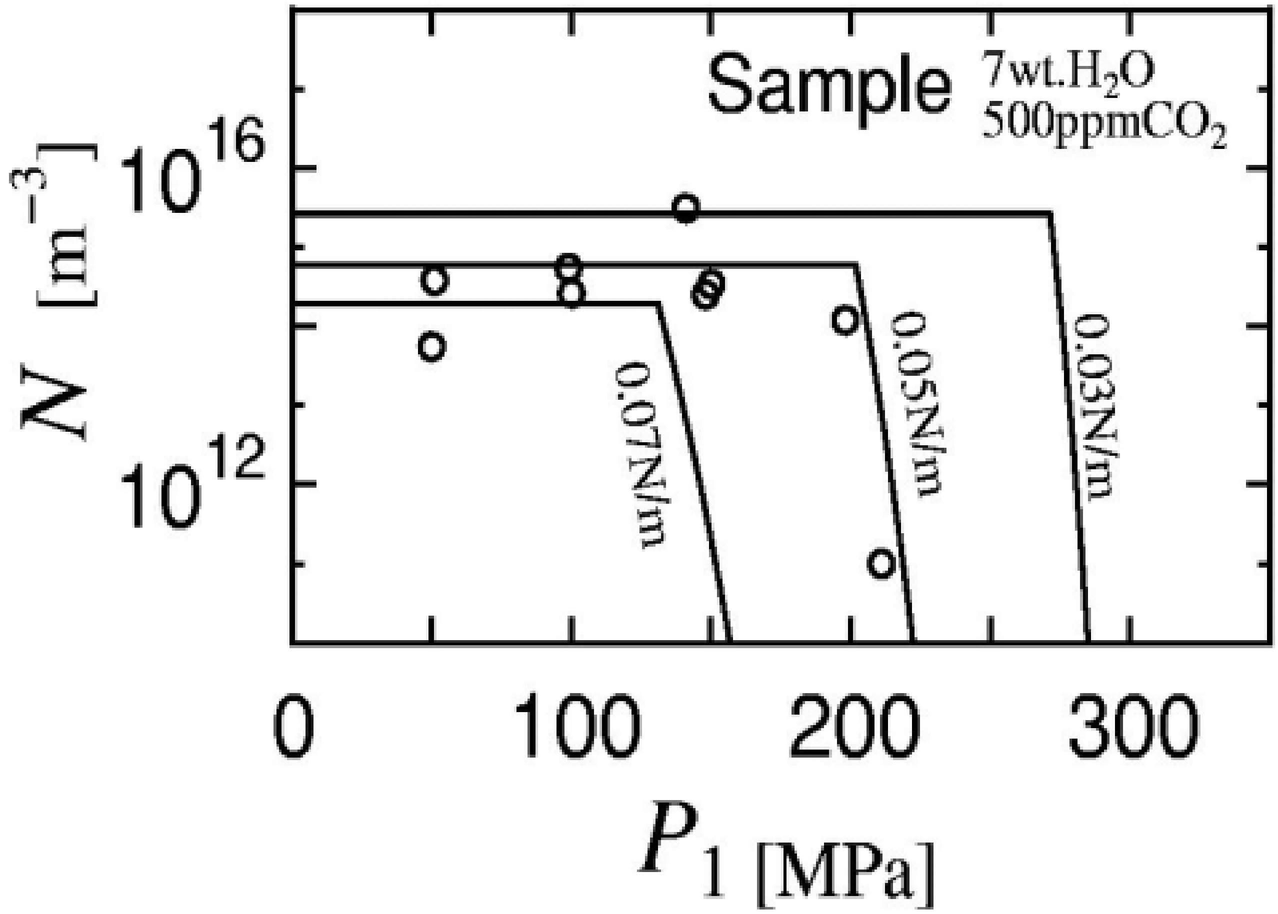
We newly develop an accurate theoretical model of bubble formation in super-saturated magma with a relatively low viscosity under the formulation by Toramaru [1995]. Such a model is essential in deriving much information from data of bubble nucleation in the recent decompression experiments. Using the method developed by Yamamoto and Hasegawa [1977], we obtain analytical solutions for the time-evolution of the nucleation rate and the number density of nucleated bubbles in cases with constant decompression and with constant supersaturation pressures. It has been reported that the classical nucleation rate has an uncertainty of several orders. We find that the uncertainty in the classical nucleation rate has little effect on the final number density of bubbles in the decompression case while it influences the number density in the constant pressure case. In the formulation by Toramaru [1995], a spatially uniform volatile concentration around growing bubbles is assumed. We construct the non-uniform concentration model and, as a result, show that the assumption of the spatially uniform concentration is valid for the evaluation of the bubble number density. Finally, by comparing our theoretical model with the data of the decompression experiments by Mourtada-Bonnefoi and Laporte [2002], we estimate the surface tension of rhyolitic melt as 0.05(+-)0.01N/m and the diffusion coefficient as 10^(-11)m^2/s. These results are consistent with the experimental values. This estimation is not influenced much by the uncertainty in the classical nucleation rate.



Sample
7wt.H2O
500ppmCO2
0.07N/m
0.05N/m
0.03N/m
10^16
10^12
N [m^-3]
0
100
200
300
P1 [MPa]