Model of bubble coalescence in initially mono-dispersed system and experimental observations

ATSUSHI TORAMARU[1] AND MATTEO MASOTTA[23]

[1] Department of Earth and Planetary Sciences, Kyushu University, Fukuoka, Japan
toramaru.atsushi.518@m.kyushu-u.ac.jp
[2] Bayerisches Geoinstitut, University of Bayreuth, Bayreuth, Germany
[3] National Institute of Geophysics and Volcanology, Rome, Italy.
matteo.masotta@ingv.it

Bubble coalescence deeply affects the dynamics of conduit flow during volcanic eruptions by modifying the rheology of the magma and through the development of structural heterogeneity. To model bubble coalescence in silicate melts, we present a new set of equations that describe the efficiency of the coalescence process as a function of the timescales for diffusive growth and melt-film drainage from bubble-bubble interfaces. The frequency of bubble coalescence is controlled by the timescales of these two processes, which is in turn regulated by the composition and viscosity of the silicate melt. When the vesicularity is less than half, coalescence efficiency varies as a function of the diffusivity of degassing volatiles in melts. At higher vesicularity, the coalescence efficiency is controlled by the melt film drainage. The model predicts an exponential decay of the bubble number density (BND) with time and the exponential bubble size distribution (BSD) function at stagnant conditions, and is in good agreement with in-situ experimental observations of bubble coalescence in basaltic, andesitic and rhyodacitic melt for lower vesicularities. The formulation can be used to estimate an original value of BND formed by a nucleation event using BSDs measured by the textural analysis for pyroclasts which experienced the bubble coalescence. In addition, from values of slopes of approximated exponential BSDs, we can estimate the timescale of magma ascent or the laps time from the onset of bubble coalescence to the quenching.