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The relation between pre-eruptive bubble size distribution and observed ash particle sizes

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Recent advances in measuring pre-eruptive bubble size distributions (BSDs) from ash particle surface morphology now make it possible to calibrate magma fragmentation models to better predict erupted ash characteristics such as particle size distribution and extent of ash cloud related volcanic hazards. A single magma body can generate various eruption products ranging from course bombs to fine ash, with a wide range of fractionation between these end members that in turn depends on decompression rates and the heterogeneity of pre-eruptive bubble size distributions as controlled by vesiculation dynamics.

We have devised a Monte Carlo method to produce spatial models of bubble textures that match inferred BSDs of pre-fragmentation magma in eruptions of the 1980 Mount St. Helens (MSH) lateral blast, and (b) the basaltic sub-plinian 1974 eruption of Fuego (Guatemala) using stereo-scanning electron microscopy (SSEM). The models are based on conditions of single-stage bubble nucleation and random nucleation site spacing, with either of two bubble growth schemes applicable for low and high vesicularity volcanic products- (1) unconfined growth in the absence of neighboring bubbles, and (2) limited growth in a melt volume shared with neighboring bubbles. These scenarios lead to different bubble spacing textures, thus controlling fragmentation thresholds and patterns. From those alternative textures we have calculated the ash fragmentation topology and predicted ash particle sizes as a function of BSD and decompression rate in a volcanic conduit at the point of magma fragmentation that produced fine volcanic ash. As such, it is possible to solve an inverse problem and parameterize the magmatic conditions that lead to eruptions with a high fraction of fine ash from SSEM analysis of their textures.