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Sequential bubble growth and magma fragmentation in Plinian eruptions: the record in dacite pumice from Volcan Popocatepetl, Mexico.

N. Myers and J.E. Gardner

Dept. of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin, Austin, Texas, USA (gardner@mail.utexas.edu)

Volatile degassing during explosive Plinian eruptions is preserved physically in pumice and ash. Pumice vesicularities, vesicle-size distributions, and vesicle shapes are, however, culmination of myriad processes that occur during magma ascent, including bubble nucleation, growth, coalescence, and fragmentation. That complex record must thus be deciphered before pumice textures can be used to constrain models for the dynamics of Plinian eruptions. Here we examine pumice from 3-4 km^3 of uniform dacite magma erupted from Volcan Popocatepetl, Mexico, as the White Pumice deposit for their record of degassing and fragmentation. Bulk pumice vesicularities range from 55-88 vol.%, and average about 75 vol.%, as is typical for Plinian deposits. Scanning electron images reveal that less vesicular pumice are often coated with adhering ash and have often smoothed surfaces by what may be viscous flow. Highly vesicular pumice rarely have such ash coatings or smoothed surfaces. Regardless of bulk vesicularity, all pumice have a bimodal distribution of vesicles, with one group being less than 40 microns in size, and a second averaging 150-200 microns. By separating the two populations, we find that as bulk vesicularity increases the vesicularity of small bubbles is relatively constant at 40-50 vol.% and their number densities decrease slightly, whereas large vesicles greatly increase in volume from 10 to 40 vol.%, yet remain relatively constant in number density; hence changes in bulk vesicularity reflect those in the large vesicles, and most of those large vesicles are not the result small bubbles coalescing. Importantly, however, smaller bubbles become more spherical and show increased amount of local coalescence (failed bubble walls) as

bulk vesicularity increases. In order to explain both the textural and vesicle changes, we envision individual pumice being formed by a sequential fragmentation process that started at about 55 vol.% vesicles. The first fragmentation event broke the magma into relatively large magma blobs and minor pumice and ash, some of which was able to weld together and viscously deformed. On their small scale, those pumice were permeable, and hence stopped expanding, whereas the larger magma blobs continued to expand, mainly from expansion of larger bubbles. Continued fragmentation then broke the large magma blobs into smaller fragments, forming pumice of greater and greater vesicularity, depending on when they were permeable enough to stop expanding. The last fragmentation events liberate highly vesicular pumice, but those have limited time to interact with ash or viscously deform.