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The relation between pre-eruptive bubble size distribution, ash particle morphology, and their internal density: Implications to volcanic ash transport and dispersion models

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Parameterization of volcanic ash transport and dispersion (VATD) models strongly depends on particle morphology and their internal properties. Shape of ash particles affects terminal fall velocities (TFV) and, mostly, dispersion. Internal density combined with particle size has a very strong impact on TFV and ultimately on the rate of ash cloud thinning and particle sedimentation on the ground.

Unlike other parameters, internal particle density cannot be measured directly because of the micron scale sizes of fine ash particles, but we demonstrate that it varies greatly depending on the particle size. Small simple type ash particles (fragments of bubble walls, 5-20 micron size) do not contain whole large magmatic bubbles inside and their internal density is almost the same as that of volcanic glass matrix. On the other side, the larger compound type ash particles (>40 microns for silicic fine ashes) always contain some bubbles or the whole spectra of bubble size distribution (BSD), i.e. bubbles of all sizes, bringing their internal density down as compared to simple ash. So, density of the larger ash particles is a function of the void fraction inside them (magmatic bubbles) which, in turn, is controlled by BSD. Volcanic ash is a product of the fragmentation of magmatic foam formed by pre-eruptive bubble population and characterized by BSD. The latter can now be measured from bubble imprints on ash particle surfaces using stereo-scanning electron microscopy (SSEM) and BubbleMaker software developed at UNH, or using traditional high-resolution X-Ray tomography.

In this work we present the mathematical and statistical formulation for this problem connecting internal ash density with particle size and BSD, and demonstrate how the TFV of the ash population is affected by variation of particle density.