Towards improved characterisation of volcanic ash

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Explosive volcanism can generate large volumes of volcanic ash, with potentially significant economic and environmental implications. Recent eruptions, such as that of Eyjafjallajokull in 2010, have highlighted gaps in our knowledge regarding both the fragmentation mechanisms that produce ash and their effect on the resulting size distributions and morphologies of erupted pyroclasts. Mafic eruptions, in particular, exhibit a wide range of eruption styles that generate pyroclasts with highly variable sizes, shapes, vesicularities and crystallinities. We are investigating links between eruption style and pyroclast characteristics, with the goal of using these data both to gain insight into the processes governing fragmentation and to develop characteristic source parameters for different eruption conditions.

The 2011 subglacial eruption of Grimsvotn, Iceland, involved the explosive interaction of volatile-rich basaltic magma with subglacial meltwater. The tephra produced in this eruption contains a high proportion of fine ash, with 90 percent of grains less than 100 microns in diameter, and is texturally diverse. The ash-fall samples used in this study were collected 50-115 km southwest of the vent immediately following the eruption. We explore variation in quantitative shape parameters as a function of both grainsize and transport distance using multiple image analysis techniques, including Morphologi and Scanning Electron Microscopy (SEM). Sample componentry comprises two dominant particle classes (dense/vesicular) that can be further subdivided (blocky and platy/highly, moderate, and elongate vesicular), with less than 5 percent crystalline material. Systematic trends in the relative proportions of each particle class are evident within the fine ash fraction (10-125 microns), the most striking of which is the increase in the percentage of dense relative to vesicular grains with decreasing grainsize.

Vesicle size distributions (VSDs) were measured on vesicular clasts and fragments where greater than 50 percent of individual bubble walls were preserved. VSD modes lie between 30 and 50 microns. By combining morphological data on particle shapes with textural data on vesicular fragments we can reconstruct the state of the magma at the point of fragmentation. Fragmentation style appears strongly controlled by the VSD: the dominant particle morphology, as measured by both componentry and shape parameters, changes significantly as the particle size approaches the modal size of the vesicle population. The presence of several different morphological components suggests fragmentation of an inhomogeneously vesicular primary magma, such as the internal textures commonly observed within Peles tears quenched from Hawaiian fire fountains. Determining how the particle size and shape distributions of volcanic ash are linked to the style of magma fragmentation will guide the development of characteristic input parameters for ash dispersion models.