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Fractal Distribution of Experimentally Generated Pyroclasts

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Despite recent advances by means of experiments and high-resolution surveys and the adjacent growing understanding of the physical processes before and during volcanic eruptions, their duration and the type of activity remain highly unpredictable. This uncertainty hinders hazard assessment tremendously. In an effort to counter this problem, a comparison of natural deposits and pyroclasts from laboratory experiments has been undertaken in order to enable estimation of the physical conditions during volcanic eruptions.

Three sample sets of Unzen volcano, Japan, have been investigated in order to evaluate the influence of open porosity in combination with applied gas overpressure on the fragmentation behaviour and on the pyroclast generation (fragmentation efficiency). All experiments have been performed at 850 °C and at initial pressure values above the respective fragmentation threshold (Spieler et al. EPSL, 2004). The set-up allowed for accurate simulation of explosive volcanic fragmentation whilst investigating the resulting pyroclast generation. The generated pyroclasts have been analysed for their grain-size distribution and the fractality of that distribution. The grain-size distribution was analysed by dry sieving for particles bigger than 250 μm and laser refraction of the suspended particles smaller than 250 μm. Laser refraction was found to be applicable to the size analysis of pyroclasts from natural samples.

The grain-size analysis exhibits a clear dependence of applied pressure and open porosity on the resulting pyroclasts: i.e. the fragmentation efficiency was found to have increased with increasing potential energy for fragmentation (gas fraction $\times$ applied pressure).

The fractal fragmentation theory was applied to the achieved grain-size distribution. The fractal dimension of fragmentation (D_f) was calculated for all experiments for samples with different open porosity. Results show a general linear increase of D_f, i.e. intensity of fragmentation, as the pressure increases. An additional important point is the variation of intercept of linear fitting of data. In particular, the intercept increases with the open porosity of the samples indicating that the intensity of the fragmentation process increases with the open porosity of the samples. These results indicate that fractal fragmentation theory may allow for quantifying fragmentation processes during explosive volcanic eruptions, a feature that is difficult to study by using classical statistical methods.

The results may help in evaluating volcanic risk by estimating the explosivity (e.g. pressure in the conduit and possibly other parameters) from the value of fractal dimension of grain-size distribution of natural deposits. This may give the opportunity to draw iso-D_f or iso-explosivity contour maps based on fractal statistics.