# Assessing the abrasivity of volcanic ash from the Eyjafjallajökulll volcano eruption using the Morphologi G3

## Introduction

Volcanic eruptions can result in a significant amount of volcanic ash in the air. The resulting volcanic ash can be very abrasive and, for example, can result in significant damage to jet engines. The possibility of damage can result in significant disruptions in air travel, such as cancelations or modifications of routes. The resulting travel disruptions can not only be an inconvenience, but they can also be costly for business and other travelers. A recent example was from the eruption of Eyjafjallajökull in Iceland in 2010. This resulted in airport closures throughout Europe and affected hundreds of thousands of travelers.

The potential for damage from volcanic ash is related to the particle size and shape. The shape of the particles is closely related to the abrasive properties of the particles. Particles that are round and smooth are going to be less abrasive than particles with sharp rough edges. The size of particles is also related to the damage potential, both in terms of the greater damage potential of larger particles and the length of time particles stay in the atmosphere.

## Image Analysis: Morphologi G3

Image analysis is ideally suited for determining both size and shape of particles. In image analysis, images of each particle are saved and individually analyzed for size and shape.

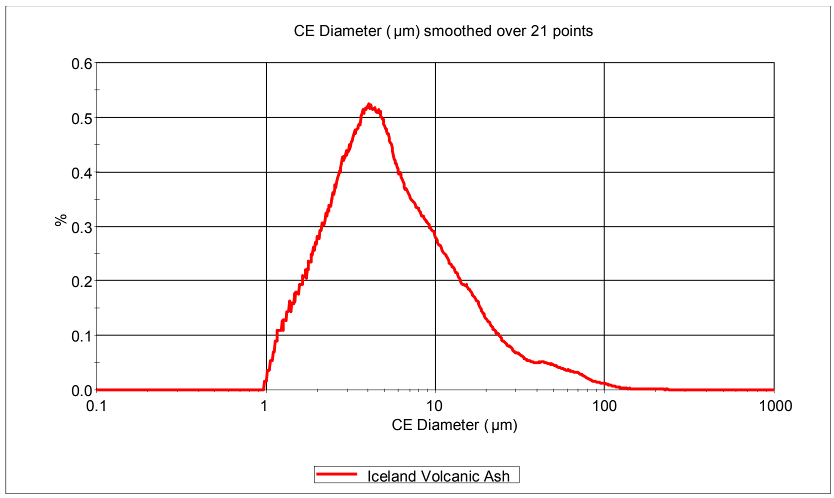


**Figure 1:** Number-weighted CE diameter distributions for volcanic ash from Eyjafjallajökul.

The Morphologi G3 is an automated particle characterization system that is SOP driven. The G3 includes integrated dry powder dispersion that disperses a dry powder onto a glass plate. This dispersion method results in a consistent particle orientation due to particles settling in their most mechanically stable orientation. In general, this means that the largest face of the particle is imaged.

## Results

Shown in Figure 1 is the number-weighted circle-equivalent (CE) diameter distribution for a sample of volcanic ash from Eyjafjallajökul in Iceland. In a number-weighted distribution, each particle is counted equally when building up the distribution.

The volume-weighted CE diameter distribution is shown in Figure 2. When constructing a volume-weighted distribution, each particle is weighted by its volume, assuming a spherical shape. This provides size information similar to what is typically found using an ensemble technique such as laser diffraction.

The CE diameter distributions show that there is a wide range of particle size present, with particles as small as 1 μm up to several hundred microns.

As shown, the number- and volume-weighted results differ fairly significantly. In a volume-weighted distribution, a single 100 μm particle has the same contribution as one

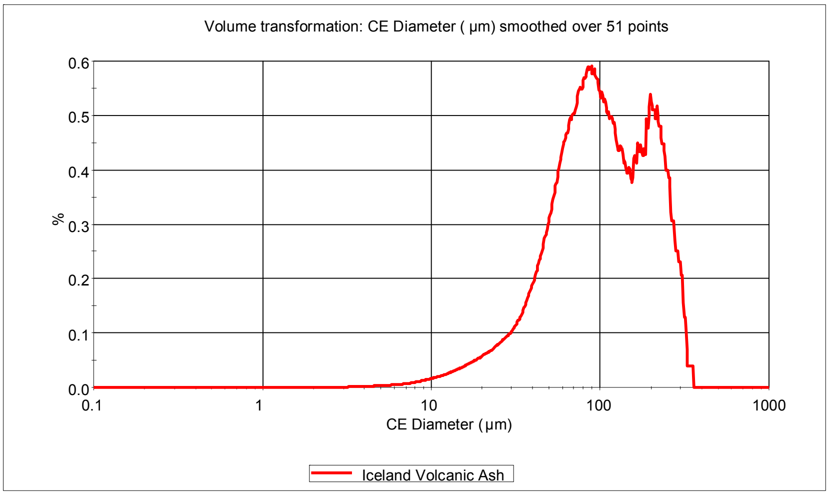


**Figure 2:** Volume-weighted CE diameter distributions for volcanic ash from Eyjafjallajökul.

thousand 10 µm particles. For this reason, the fine material is much more obvious in the number-based distribution while the volume-weighted distribution emphasizes the large material.

Image analysis also characterizes the shape of the particles. One such shape parameter is high sensitivity (HS) circularity, which is a measure of the closeness of the particle shape to that of a circle. A circle has an HS circularity of 1, and the closer the shape is to that of a circle the closer the HS circularity is to 1.

Since each image is saved, the shape analysis can be limited to a subset of particles. For example, particles smaller than 20 µm could be filtered to only examine the shape of the large particles. This can then be compared to the shape distribution of all particles to determine how shape differs for different particle sizes. Shown in Figure 3 are the HS circularity distributions of the volcanic ash including all particles and only those > 20 µm.

The larger particles are less circular than the sample as a whole. The circularity can be related to the abrasive nature of the particles. Spherical particles will have higher circularity values and are expected to be less abrasive. Figure 3 suggest that the larger particles are more abrasive than the smaller particles.

A similar comparison of the solidity distributions is shown in Figure 4. Solidity is a measure of the edge roughness, where a perfectly smooth surface will have a solidity of 1.

As for HS circularity, the large particles have rougher edges than the sample as a whole. This again suggests that the larger particles are more abrasive.

Shown in Figure 5 are example images of particles larger than 100 µm and smaller than 10 µm. The images indicate that the smaller particles appear much more spherical and smoother than the larger particles.

The dependence of shape on size can be important for determining how long to prevent flight. Larger particles should settle sooner than smaller particles. If the larger particles are the most abrasive and the most dangerous to aircraft, then this information can be very valuable in determining when it is safe to fly.

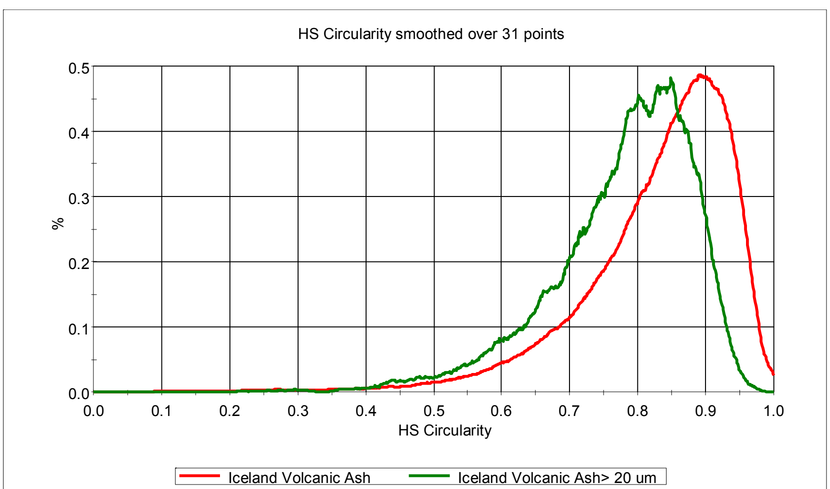


**Figure 3:** Number-weighted HS circularity distributions for volcanic ash from Eyjafjallajökul including all particles and only particles > 20 µm.

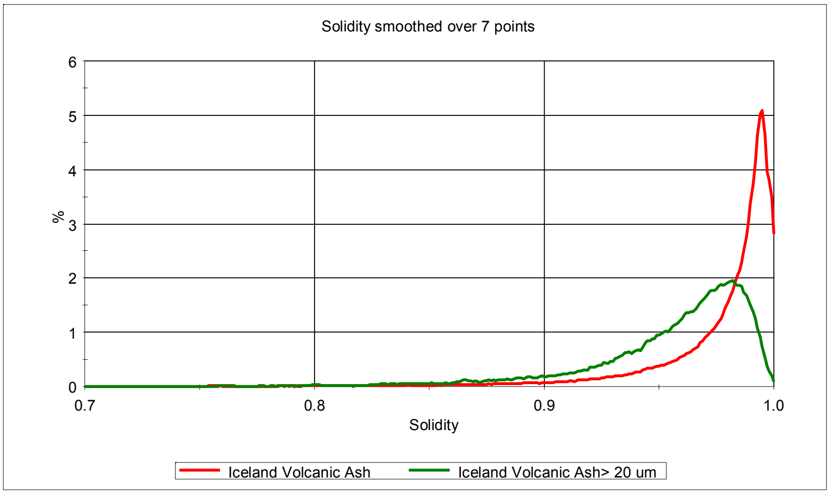


**Figure 4:** Number-weighted solidity distributions for volcanic ash from Eyjafjallajökul including all particles and only particles > 20 µm.

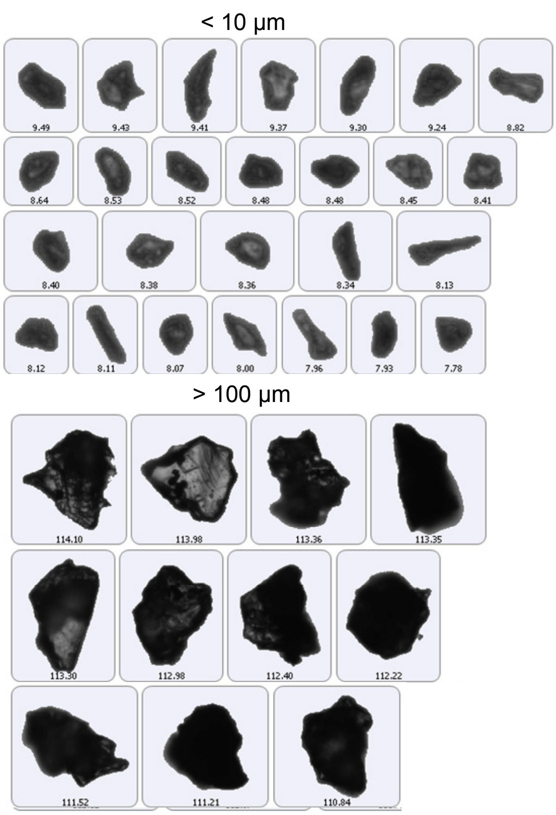


**Figure 5:** Images of particles < 10 µm and > 100 µm from Eyjafjallajökul volcanic ash.

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