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3D imaging of natural volcanic ash fragments and comparison with experimentally-vesiculated volcanic glass

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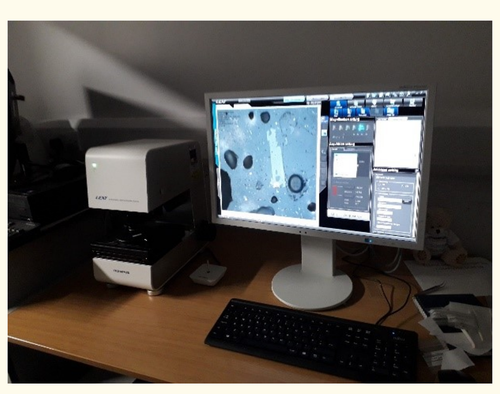
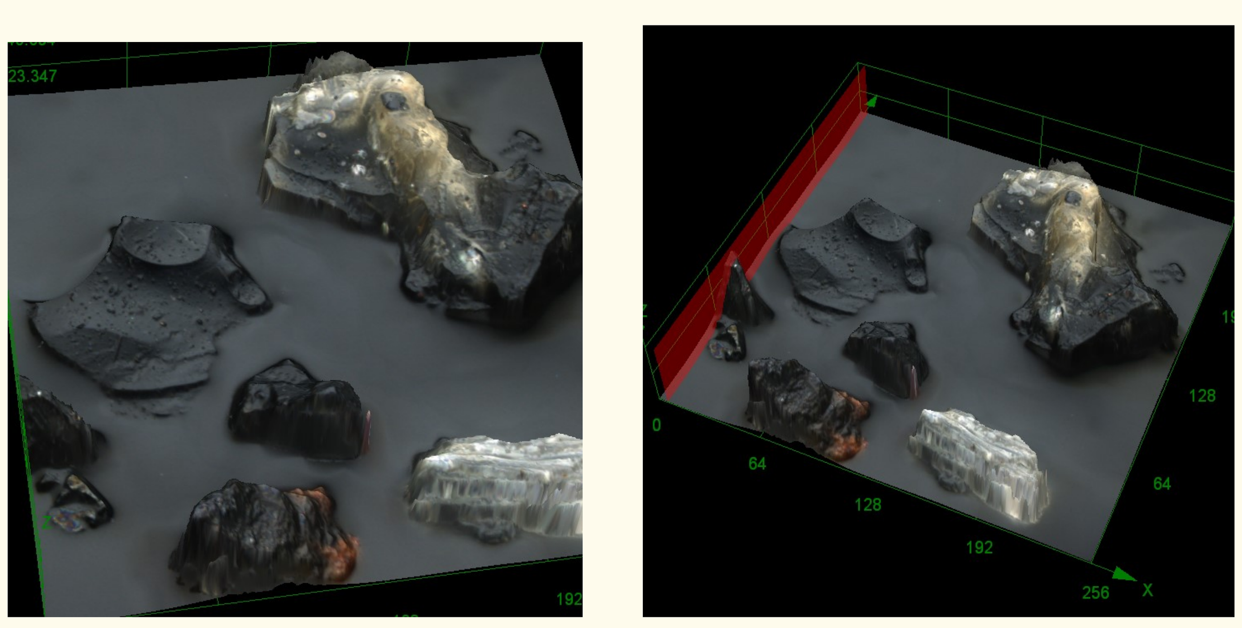
Introduction

- The Eyjafjallajökull eruption (14th April – 20th May 2010) caused more than 100,000 flights to be cancelled and cost the airline industry £130 million per day (International Air Transport Association estimate).
- Volcanic particles in ash clouds can have adverse effects on human health and may cause severe damage to aircraft (Mackie et al. 2016).
- Previous studies of volcanic particle morphology have mostly used 2D imaging techniques and little is known about their appearance in 3D.
- In order to improve understanding of the damage caused by volcanic particles we have previously developed methodology to examine their appearance in 3D using confocal microscopy (Wertheim et al. 2017).
- The aim of this study was to compare natural volcanic ash fragments with experimentally-vesiculated volcanic glass.



Olympus LEXT confocal microscope.



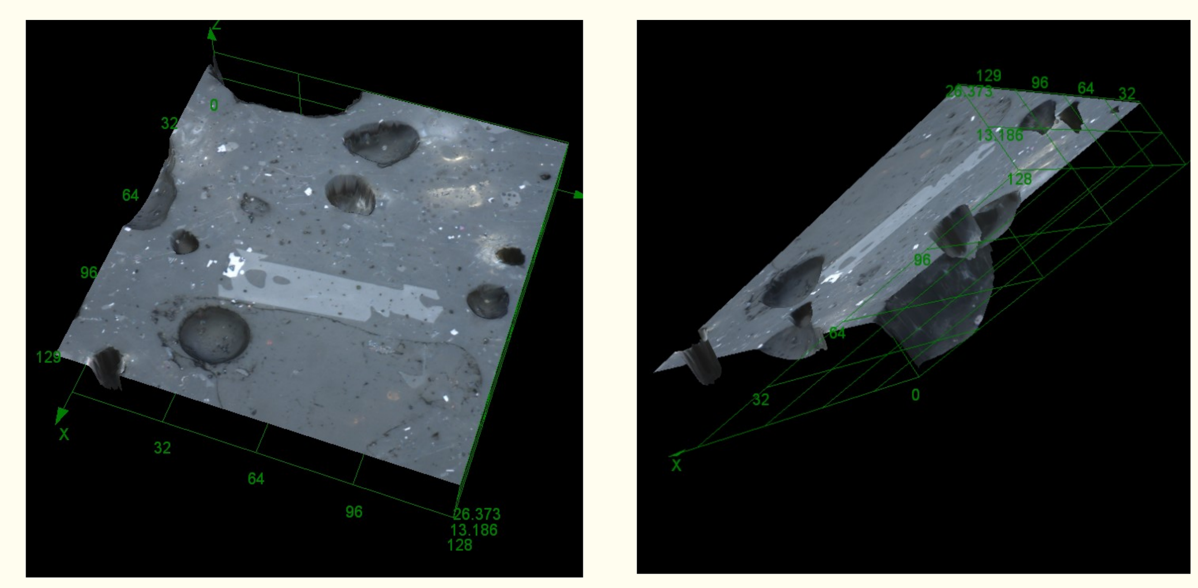
Example of views of strew slide from Eyjafjallajökull sample 256x256x47μm (x50 objective).

Materials and Methods

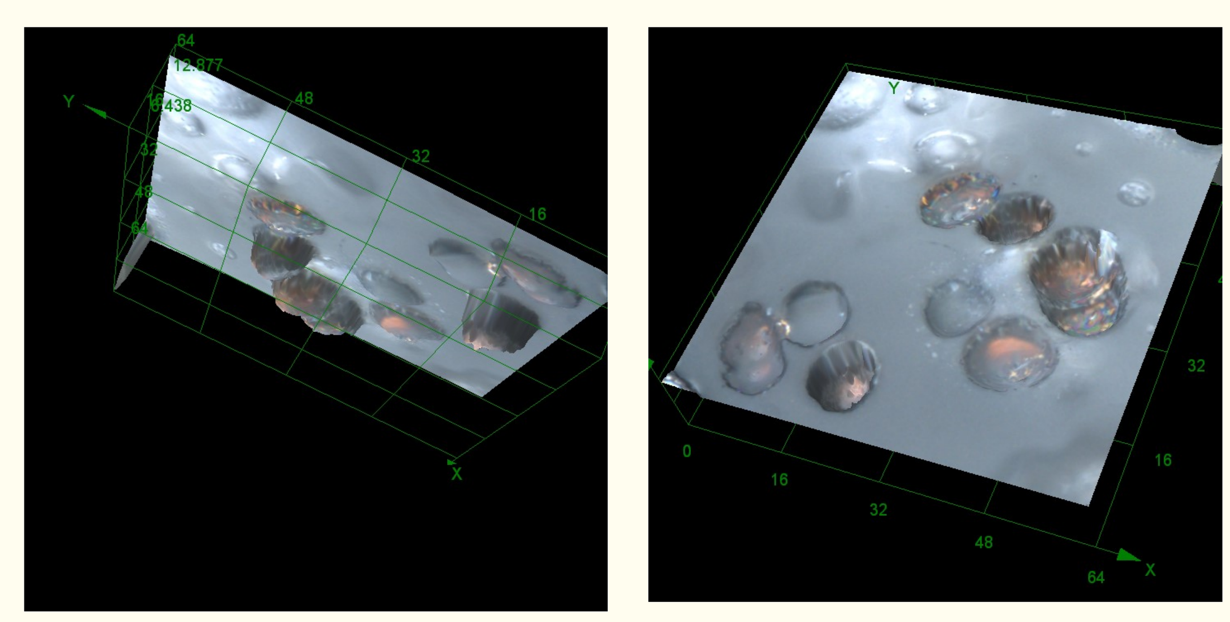
- 2 sets of volcanic particle samples from the Eyjafjallajökull eruptions and one set from the Grimsvötn event.
- Eyjafjallajökull samples contain basaltic, intermediate and silicic fragments.
- Grimsvötn (2011) eruptions contained basaltic material.
- Samples were sieved and washed with propan-2-ol in an ultrasonic bath. The solution was poured on filter paper. Using a strew slide approach particles were distributed on double sided tape fixed to glass microscope slides.
- Two samples of artificially produced rhyolitic volcanic glass. These samples were designed to represent pre-eruptive magmatic conditions within the crust.
- The artificial volcanic glass chips and additional the natural material samples were embedded in epoxy resin (Specifix-20) and ground down to expose a continuous flat surface with exposed vesicles. Thus thick sections of volcanic material were also prepared.
- Forty-two bubbles were imaged in fine mode setting using the LEXT microscope's x50 or x100 lenses. The numerical aperture of the lenses is 0.95.
- The microscopy procedure for the strew slides was to focus just below the level of the mounting tape with the upper level being set just above the maximum detected height on laser imaging.
- Linear measurements were made using the proprietary software for the LEXT microscope.
- Confocal microscopy was used to acquire intensity images, colour height data and combinations of height, intensity and optical data in order to study the morphology of fragments of various sizes.

Results

- Smaller fragments were often angular, elongate and bladed forms.
- Larger ash particles again demonstrated sharp angles, with the overall form being angular to sub-angular.
- Some fragments were close to spherical in shape and were consistent in their form with the existence of broken bubbles or vesicles.
- The rock thick section method allowed imaging bubbles that intersected the cut surface of the sample. Internal bubble structures were also observed.



Example of views of thick section from Eyjafjallajökull sample 128x128x26μm (x100 objective).



Example of views bubbles in artificial volcanic glass sample 64x64x13μm (x100 objective).

Discussion

Volcanic glass can give insights into magma flow behaviour, eruption characteristics, deposition at the surface and cooling (Cassidy et al. 2018, Saxby et al. 2018, Wertheim et al. 2017).

Our study has shown that 3D confocal microscope imaging of volcanic glass particles from two Icelandic volcanoes together with experimentally vesiculated volcanic glass can help understand the morphology of volcanic dust fragments including investigating bubble structure; the true colour 3D images help in further assessing the imaging data. The image features seen include bubble structure, fracture patterns, shape morphology and characteristics of grains.

Simulated fragments and bubbles compare well with real material from the Icelandic events, with similar overall bubble sizes. 3D laser confocal microscopy imaging of volcanic glass fragments helps in examining the structure of volcanic particles and hence has the potential of leading to improved understanding of their potential impact.

References

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