AASHCOM - a new approach for the automated quantification of the different components in volcanic ash based on single SEM/EDX particle analysis coupled with statistical data treatment

Why is the quantitative study of ash of importance?

Volcanic ash consists of several components (e.g. crystals, pyroclasts formed from older or recent magma, lithoclasts from the volcanic conduit and basement) in various proportions. The relative amount of these components can deliver crucial information on several complex processes occurring within the volcanic system and in the interface between the eruptive surface and the atmosphere, which determine the evolution of the activity of the volcano. Some of the questions that can be addressed when studying the componentry of ash are (1) the estimation of the depth of magma fragmentation, (2) the tracking of new magma batches, (3) the degree of recycling processes, during specific ash events, (4) compositional variations of the erupted magma in time and (5) understanding the impact of volcanic ash on human health and agriculture. All these aspects can enormously help us to understand the actual behavior of the volcano, and thus, achieve a better forecasting of future eruptions.

Description of the new approach

Based on automated single particle SEM/EDX analysis the morphology and chemical composition of thousands of particles can be determined within few hours. In this way, the different components (e.g. loose crystals, lithoclasts and pyroclasts) making the ash, are quantitatively characterized. Subsequently, the obtained discriminative parameters (i.e. elemental composition, aspect ratio, circularity, etc.) are used to calculate the relative proportions of single components. In addition, fractal dimensions for particle outlines can be calculated and used as a complementary discriminative tool (e.g. Rausch et al., 2015). In the past, the classification of the different morpho-chemical groups was done manually. The large amount of data obtained from single particle SEM/EDX analysis makes the manual treatment of the data very laborious, which is the reason why this very promising tool has not been exploited in the field of volcanology and other fields that could actually greatly profit from it, so far.
To overcome this issue, Particle Vision GmbH developed in collaboration with the Institute of Data Analysis and Process Design (IDP) at the Zürich University of Applied Sciences (ZHAW) and the University of Fribourg, a particle-classifier software, which cluster the particles with common morpho-chemical characteristics together based on a statistical approach. Clusters that have eventually not yet been integrated in the software will be constantly updated as new chemical classes will be analysed. The software is being developed in the frame of a Swiss CTI (Commission for Technology and Innovation) project.
Here, we present a first but already extremely useful prototype, which represents an intermediate product of the final ash componentry tool. It already allows an arbitrary number of particles to be efficiently analysed and grouped in chemical classes.
The software is able to process a SEM/EDX data set in few seconds delivering a large package of comprehensive graphs (e.g. heatmaps, ternary diagrams, etc.). In the heatmaps (Fig. 1), the results are sorted after grain size (increasing from left to right) or heavy elements and the elemental composition of each single particle is shown in the vertical orientation (one column corresponds to one particle).

In the second and final stage of the project the software will deliver the relative proportions (Fig. 2) of the different chemical classes (Figs. 2, 3) based on statistical cluster analysis. These results are automatically given in number concentrations but mass concentrations can easily be calculated as well. This could be relevant for the estimation of erupted magma mass and volume.

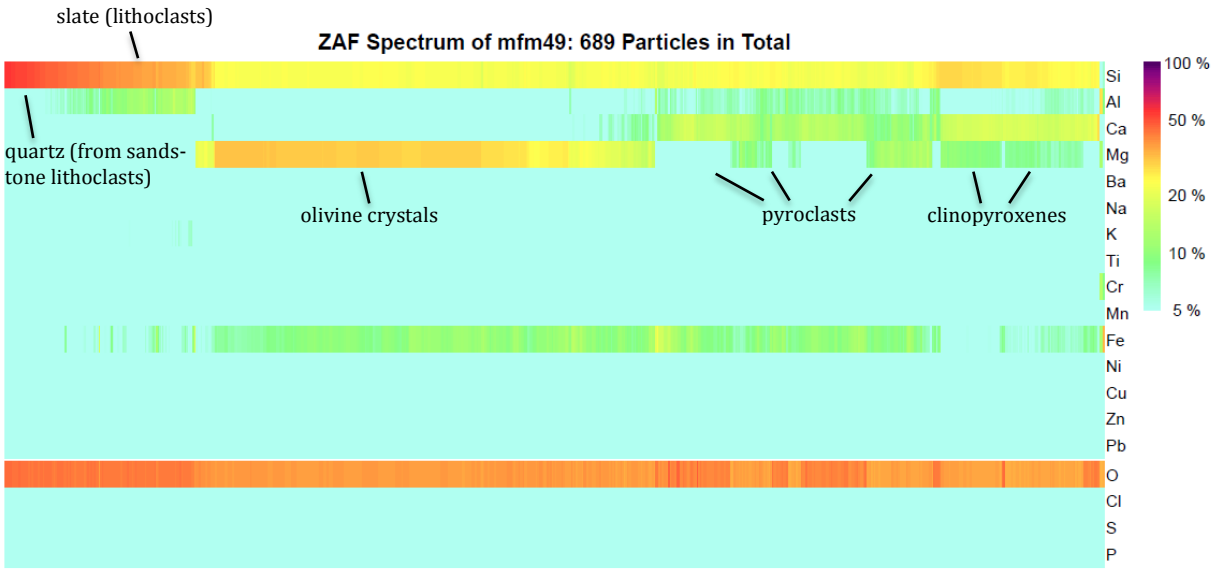

Fig. 1: overview of the SEM/EDX results of a volcanic ash sample (689 particles analysed) sorted after the elemental composition. Each column shows the composition of one single particle.

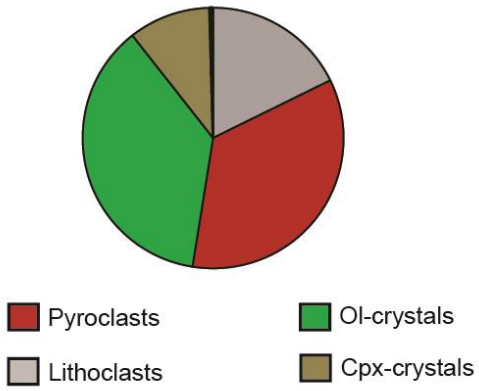

Fig. 2: Pie chart showing the relative proportion of the different components (pyroclasts: 35 %, lithoclasts: 18%, olivine (ol) crystals: 37 % and clinopyroxene (cpx) crystals: 10 %. Percentages are given in particle number %.

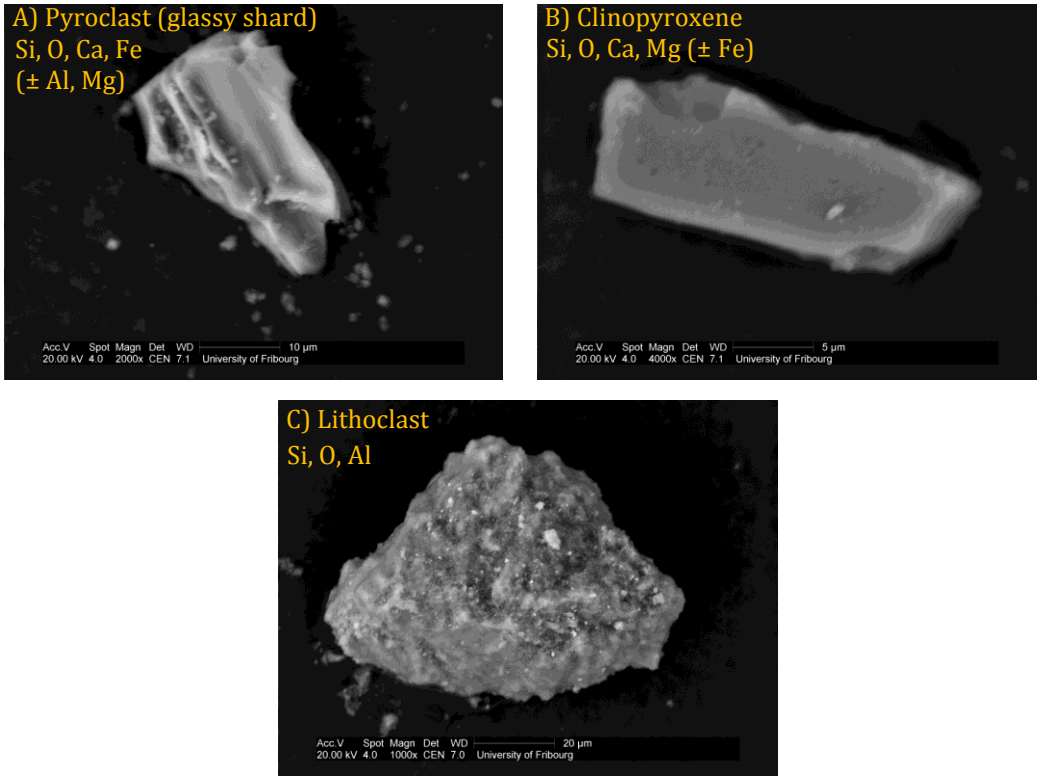

Fig. 3: Backscattered images of A) a vesicular glassy pyroclast, B) a clinopyroxene crystal and C) a lithoclast

Use of AASHCOM

At the beginning, the functions of the ash componentry tool (AASHCOM) will be offer as a service of Particle Vision GmbH. The evaluation of the first data set is offered as a courtesy of Particle Vision GmbH. After an initiation period there will be access to the software on a web platform, at which different type of inscriptions will be available.

Data input requirements

To guaranty a high-quality outcome of the results delivered by the ash componentry tool the SEM/EDX analyses have to be performed following specified standards given by Particle Vision GmbH (**SOP**: http://www.particle-vision.ch/index.php/en/products/particle-classifier). SEM/EDX data obtained with different microscope settings can be eventually evaluated with the ash componentry tool. In that case, cannot Particle Vision, however, guaranty the quality of the results.

Implications

This tool facilitates enormously data treatment of extensive and complex automated single particle SEM/EDX analysis and will accelerate the processing of a large number of samples/analyses.
Automated single particle SEM/EDX analysis for morpho-chemical characterization of volcanic deposits combined with the use of the ash componentry tool AASHCOM could represent a big step forward in the area of ash monitoring since it enables the rapid quantification of ash during the activity of a certain volcano. Volcanos present commonly precursors at least months to weeks if not years prior to an eruption. By monitoring the morpho-chemical variations of the eruptive products with time, important changes in the style of activity can be identified practically in real time. Hence, this tool could be useful for monitoring purposes of active volcanoes worldwide.

Contact:

Dr. Juanita Rausch
Phone: +41 76 513 70 30
Skype: juanitarauschpv
Email: juanita.rausch@particle-vision.ch

info@particle-vision.ch
www.particle-vision.ch