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Volcanic monitoring techniques applied to controlled fragmentation experiments

Ulrich Kueppers (1), Miguel Alatorre-Ibarguengoitia (1), Matthias Hort (2), Simon Kremers (1), Kristina Meier (2), Lea Scharff (2), Bettina Scheu (1), Jacopo Taddeucci (3), and Donald B. Dingwell (1)

(1) Eath & Environmental Sciences, University of Munich (LMU), Muenchen, Germany (u.kueppers@lmu.de), (2) University of Hamburg, Hamburg, Germany, (3) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy

A rapidly growing number of people is threatened by natural hazards such as volcanic eruptions, earthquakes, floods, or storms. Volcanic eruptions not only have an impact on their direct neighbourhood but may also affect aviation, infrastructure and climate, regionally as well as globally. In respect to several other natural threats, volcanoes exhibit the advantage of a usually known location of the pending threat, allowing the deployment of sophisticated monitoring networks. Such networks deliver information about volcanic systems and the correct interpretation of monitoring data is a viable key to a successful hazard mitigation strategy.

Today a large number of volcanoes is equipped with a variety of scientific instruments that help elucidate the secrets of volcanic phenomena. However, our mechanistic understanding of the processes behind recorded signals or a solid interpretation of the state of a volcano is poor. Experimental volcanology is a chief source of mechanistic understanding of volcanic systems. Here, we bring volcanic monitoring and experimental volcanology together in a campaign of well-monitored, field-based, experimental volcanology. We present results from a multi-parametric combination of well-controlled experiments and several tools commonly used for monitoring active volcanoes.

We performed rapid decompression experiments with natural rock samples from Colima volcano (Mexico) to simulate explosive volcanic eruptions. We used 2 sample varieties of approx. 25 and 35 vol.% open porosity. Sample size was 60 mm height and 25 mm and 60 mm diameter, respectively. Applied pressure ranges from 4 to 18 MPa. The pressurised volume above the samples ranges from 60 – 170 cm^3. The experiments have been thoroughly monitored with 1) Doppler-Radar, 2) High-speed and video camera, 3) acoustic and infrasonic sensors, 4) pressure transducers, and 5) electrically conducting wires to shed light on fragmentation, ejection, and ejection speed of volcanic pyroclasts. Although the involved volumes of pressurised sample and gas were small, we were able to record the experimental eruption. Thereby, we could validate in parallel the applicability of two independent methods (1 and 2) currently used to estimate the ejection velocity of erupted pyroclasts, an essential factor in ballistic hazard evaluation and eruption energy estimation. Additionally, infrasound measurements could be correlated with autoclave volume and applied pressure.

We are positive that this link of experimental volcanology and monitoring techniques will profoundly enlarge our understanding of the behaviour of active volcanoes in general. If applied to a single volcano, a more refined knowledge of the state of the art will allow an adequate hazard assessment and risk mitigation.