MeMoVolc workshop on the "Dynamics of volcanic explosive eruptions"

University of Geneva, Switzerland, January 29-31, 2014

Summary

Classification of volcanic explosive eruptions is crucial to our understanding of volcanic processes and associated hazards. However, all current classification schemes do not account for the whole spectrum of volcanic phenomena, fail to describe fundamental features of volcanic eruptions and are not capable of characterizing all potential eruptive intensities and styles. A new classification scheme is now required that can combine the recent progress made in physical volcanology, geophysics and volcano monitoring.

Introduction

Eruptive styles can vary significantly due to magma composition, volatile content, crystallinity, magma supply rate, conduit geometry, magma reservoir pressure and the presence of external water. The modalities and rates of syn-eruptive magma transfer from the shallow reservoir to the surface through the conduit system modulate the eruptive dynamics. Key processes and parameters that characterize explosive eruptions are only partially understood, generating confusion in the way we classify and categorize eruptions, especially for small-to-moderate-scale eruptions. Conversely, the classification of eruptive activity is generally based on a small, selected set of parameters, directly observed during eruptions or measured from their deposits that hardly represent the natural complexity of the related activity. For example, many small-to-moderate eruptions are commonly classified as violent Strombolian, Vulcanian or subPlinian (often only based on plume height or product dispersal) although being related to very different eruption dynamics. The lack of understanding of the characteristic signature of this kind of eruptions and the processes involved also leads to new attempts of describing explosive eruptions that vary from volcano to volcano, e.g. the peculiarity of lava/fire fountain at Etna with respect to the ones in Hawaii, the distinction between major and paroxysmal eruptions at Stromboli, or between different types of vulcanian activity at volcanoes dominated by silicic lava domes respect to volcanoes characterised by more mafic magmas and ash emission. This is all symptomatic of our limited current understanding of explosive volcanism, with obvious implications for the assessment of associated hazards.

Early studies of physical volcanology and proposals of classification were mainly based on visual observations of eruptive phenomena at specific volcanoes, and eventually evolved to take into account deposit features. In fact, tephra fallout deposits are traditionally the main deposits investigated to provide insights into the eruptive dynamics. However, by considering only the features of deposit dispersal, complex and unsteady source dynamics typical of small to moderate explosive eruptions cannot be fully captured, and their intensities and styles cannot be well characterized. In addition, many eruptions show hybrid features and could start with one eruptive style and terminate with a different activity, resulting in a complex stratigraphic record that is difficult to classify. Yet, other eruptions have characteristics that are gradational between the defined eruptive styles, such as Strombolian and Vulcanian, reflecting a transition in physical phenomena that are as yet imperfectly understood and quantified. Some eruptions would be better described based on the analysis of all volcanic products (e.g. volume ratio between erupted lava and tephra, or volume ratio between fallout and pyroclastic density currents deposits), and especially of the products related to those phases of the eruption marking a shift in the eruptive style.

Progress in physical volcanology, and increased capability of monitoring, measuring and modelling explosive eruptions, have highlighted how the description of eruptive behaviour should be based on the combination of deposit features, including deposit thinning, deposit grainsize, textural features, componentry, density and porosity of products (and their variation through time), together with geophysical observations of the eruption itself.

The development of a comprehensive understanding of the parameters driving explosive volcanism that can cover the whole range from weak to large explosions presents one of the main challenges of the volcanology community. A classification scheme for eruptive processes can be a useful tool to help reaching this objective. Present classification is in fact mainly based on the characteristics of tephra dispersal or on direct observations, while attention is poorly focussed on the dynamics and time-related variability of different eruptions.

A comprehensive approach to the description of explosive volcanic eruptions can only result from the combined effort of many scientists working in various sub-disciplines. A small but multidisciplinary group of the international volcanology community gathered at the University of Geneva under the sponsorship of the *MeMoVolc* Research Networking Programme of the ESF and the Earth and Environmental Section of the University of Geneva in order to: i) fill the gap between recent advances in geophysical, modelling and field strategies and current classification schemes; ii) discuss whether there is still a need for eruption classification; iii) investigate how the contributions from different sub-disciplines can be combined. Specific objectives included to: i) review new advances in our mechanistic understanding of a broad range of eruptive styles; ii) identify the critical parameters that drive and characterize explosive volcanism of different types; iii) determine the main processes that control the temporal evolution of the eruptions, and the frequently observed changes in eruptive style; iv) suggest a roadmap to produce a rational and comprehensive classification scheme.

Methodology and specific outcomes

The two and a half day workshop involved a series of keynote presentations on different aspects of eruption mechanisms and eruption classification issues (see Appendix I for the workshop program). The participants (Appendix II) were also split up into three groups for three brainstorming sessions focussed on a series of questions:

First session (Wednesday 29 January)

- Crucial parameters that drive and characterize explosive volcanism of different types, in particular the small-moderate explosions (e.g. how can we characterize unsteadiness?)
- New advances in our mechanistic understanding of these parameters and which still require investigations?

Second session (Thursday 30 January)

- Shortcomings of the way explosive eruptions are typically described and characterized
- What are the most distinctive parameters/processes that can be used to characterize/classify eruptions? And how can we measure them?

Third session (Friday 31 January)

- Modern applications and use of eruption classification (advantages and disadvantages)
- Suggestions for an alternative multidisciplinary classification scheme

Following each brainstorming session the groups reassembled for plenary discussions, and a consensus was reached by the whole group on the issues relating to each question. A Consensual Document will be soon uploaded on the meeting website (http://www.unige.ch/hazards/MeMoVolc-Workshop.html). An additional outcome of the workshop was the VHub forum open to the whole volcanological community that will provide an important opportunity to extend the effort and brainstorm forward on the topic of understanding of explosive volcanism and eruption classification: https://vhub.org/groups/eruption_dynamics.

Preliminary conclusive remarks

This workshop served to indentify open questions and research priorities that could help improve our understanding of volcanic explosive eruptions. In particular: i) We identified the main parameters and processes characterizing volcanic eruptions that include initial conditions, conduit-related magma dynamics, eruptive processes and parameters, external forces; ii) We reviewed most existing "global" classification schemes (general classification schemes that are not based on specific volcanoes) in order to identify main shortcomings and most widely-used terminology. We found that existing classification schemes fail to collate all volcanic eruptions in one simple diagrammatic form, and do not account for all volcanic behaviours and products; iii) Classification schemes need to be objective driven (e.g. scientific understanding, hazard/risk assessment, communication with public and scientific community) and simple enough to promote transfer of knowledge and scientific exchange; iv) Currently we do not have a system that can be used for all eruptions. It might be possible in the future to have a more comprehensive classification scheme, but it is more likely that it will be associated with a different way of measuring eruptions (e.g. energy balance) instead of evolving from existing schemes; v) None of the existing schemes consider the distinction between steady and unsteady processes. We identified that unsteadiness is, in fact, a key factor for describing volcanic eruptions, but also concluded that we do not yet have effective means of classifying unsteadiness itself. Future eruption classification schemes should incorporate the concept of unsteadiness; vi) Classification schemes should also describe a variety of volcanic products, such as PDCs, lava flows and gas; vii) Open questions, processes and parameters that need to be addressed and better characterised in order and to develop more comprehensive classification schemes and to progress in our understanding of volcanic eruptions include: abrupt transitions in eruption regime, conduit processes and dynamics, unsteadiness, eruption energy and energy balance.

Appendix I
Workshop Programme

MeMoVolc workshop on

"Dynamics of volcanic explosive eruptions"

University of Geneva, Switzerland, January 29-31, 2014

Organized by:

Costanza Bonadonna, University of Geneva, Switzerland; Raffello Cioni, University of Firenze, Italy; Antonio Costa, INGV, Sezione di Bologna, Italy; Tim Druitt, Université Blaise Pascal, France

Wednesday, 29 January 2014 (Room M1140, UNIMAIL)

08:30-09:00 Tim Druitt (Université Blaise Pascal, France) Introduction to the workshop

09:00-09:30 Kathy Cashman (University of Bristol, UK) Volatile controls on eruptive style

09:30-10:00 Ulli Kueppers (Ludwig-Maximilians-Universität, Germany) Fragmentation processes

10:00 – 10:30 Coffee Break

10:30-11:00 Michael Manga (University of California, USA) Microphysical processes in volcanic eruptions

11:00-11:30 Mattia de' Michieli Vitturi (INGV Pisa, Italy) Dynamics of eruptive columns and their controls

11:30-12:00 Jeremy Phillips (University of Bristol, UK) Particle transport and sedimentation

12:00-13:30 Lunch (UNIMAIL cafeteria)

13:30-15:00 *Break-out sessions*

15:00-15:30 Coffee Break

15:30-17:00 *Presentation of results from breakout sessions*

19:00-21:00 Poster session and ice breaker at UNIMAIL

Thursday, 30 January 2014 (Room M1140, UNIMAIL)

08:15-08:30 Costanza Bonadonna (University of Geneva, Switzerland) Introduction to eruption classification

08:30-09:00 Bruce Houghton (University of Hawaii, USA) Strombolian and Hawaiian eruptions and their variations

09:00-09:30 Laura Pioli (University of Geneva, Switzerland) Transient and pulsatory explosive activity

09:30-10:00 Raffaello Cioni (University of Florence, Italy) Plinian and subplinian eruptions

10:00 – 10:30 Coffee Break

10:30-11:00 Armann Hoskuldsson (University of Iceland, Iceland) Subglacial and phreatomagmatic eruptions

11:00-11:30 Gregg Valentine (University at Buffalo, USA) Eruptive activity driven by discrete subsurface explosions

11:30-12:00 Guido Giordano (University of Roma3, Italy) Caldera-forming eruptions

12:00-13:30 Lunch (UNIMAIL cafeteria)

13:30-14:00 Sebastien Valade (University of Firenze, Italy) Geophysical constraints of volcanic processes – Part 1

14:00-14:30 Matthias Hort (Universität Hamburg, Germany) Geophysical constraints of volcanic processes – Part 2

14:30-15:30 *Break-out sessions*

15:30-16:00 Coffee Break

16:00-17:00 *Presentation of results from breakout sessions*

Friday, 31 January 2014 (Room M1140, UNIMAIL)

08:30-09:30 *Break-out sessions*

09:30-10:30 *Presentation of results from breakout sessions*

10:30 – 11:00 Coffee Break

11:00-11:15 Antonio Costa (INGV Bologna, Italy) Wrap up and synthesis

11:15-12:15 *Plenary discussion: presentation of main points for the compilation of consensual document and suggestions for an alternative multidisciplinary classification scheme*

12:15-13:30 Lunch (UNIMAIL cafeteria)

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FACULTY OF SCIENCES
Department of Earth Sciences

Measuring and MOdelling of VOLCano eruption dynamics
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Appendix II
List of Participants

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