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## 2014 Oxford Volcano Seismology Discussion Workshop Report

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## **Workshop Report: Oxford volcano seismology discussion, August 2014**

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### **Workshop details**

This report presents the outcomes of a volcano seismology discussion workshop held in Oxford, United Kingdom on the 5th August 2014. The goals of this workshop were to identify some key challenges in volcano seismology; to have a community discussion of the big questions in our field, and develop ideas about the ways forward towards addressing these questions. There were 20 participants at the workshop from the UK, USA and Europe (see Appendix for participant list), and there was some cross-attendance between this workshop and a similar discussion workshop held in April 2014 before the SSA meeting in Anchorage, Alaska.

### **Workshop summary**

Volcano seismology is a crucial part of any volcano-monitoring effort and accurate forecasting of volcanic activity relies heavily on observed seismicity. In this workshop we identified the main obstacles to improving our understanding of the processes involved in generating observed geophysical signals. The discussion acknowledged that many scientific questions arise from our incomplete understanding of the generation and temporal evolution of volcanic seismicity. Additional challenges arise from the difficulties of quantitatively comparing activity from one volcano to another; and indeed, whether or not it is scientifically valid to do so. There was general consensus that a lack of standardisation of the types of analysis done with volcano seismic data, the lack of preservation of important metadata and the inconsistencies of terminology used by volcano seismologists all currently limit our ability to compare signals across volcanoes. There was agreement that addressing these issues would allow a move towards a unified understanding of seismicity generated at volcanoes, and would improve both our fundamental understanding of volcanic processes and our ability to forecast eruptions. However, it was also recognised that volcano seismology alone cannot answer all these questions and integration of all types of volcano-monitoring data (e.g. to include gas emissions and deformation) must be used to build as complete a picture as possible of subsurface processes at volcanoes.

## Discussion on challenges in volcano seismology

Workshop participants initially identified three topics to motivate further detailed discussion:

1. How best to extract meaning from seismic signals.
2. How best to integrate multiple datasets (including seismicity) to understand all states of volcanic activity through space and time.
3. How best to use and share both data and data processing algorithms.

From discussion of these topics the workshop participants identified more specific outstanding questions and challenges that fall broadly into two categories, although some overlap naturally occurs. Firstly, 'scientific questions', and secondly, 'technical challenges' associated with addressing those scientific questions.

### *Scientific questions*

1. Is it possible to compare processes occurring at different volcanoes, or should all volcanoes be treated as unique?
2. Given an incomplete understanding of the subsurface structure and heterogeneity of the volcanic edifice what can be said about the contribution of source vs. path to the observed seismicity at volcanoes? What effects do fluids have on seismicity, both on the source and on the path?
3. Are current classification schemes meaningful? Current classification is often linked to interpretation, but is this valid given the uncertainty in source processes and incomplete knowledge of the subsurface structure?
4. Are the characteristics of volcano-seismic unrest that do not culminate in eruption different to seismic activity preceding volcanic eruption, and if so how can those signals be differentiated?

### *Technical challenges*

1. What is the best procedure for basic analysis of volcano seismic data and to what extent can standardisation between observatories, researchers etc. be established? The workshop participants seemed to form a general consensus that at least some degree of standardisation was desirable in order to facilitate direct comparison between signals observed at different volcanoes.
2. Similarly, can a suitable code-sharing platform be developed? The workshop participants were positive about the progress made by individual researchers and observatories developing their own data processing tools, but felt that a centralised platform for this code to be

shared throughout the volcano seismology community was highly desirable in order to facilitate future progress.

3. Given the time constraints for many researchers how can sharing of derived data be encouraged and standardised? Raw data and metadata can be stored and efficiently shared through the IRIS data management centre. WOVodat has the potential to be a common platform for hosting and sharing derived data, but is still in development and not yet fully operational.
4. Are research scientists working on the right techniques and tools to fulfil the needs of observatories? What barriers are there to the uptake of techniques by observatories? How useful are complex techniques to an observatory and how can they be used to best effect?
5. What are the scientific criteria for targeting fieldwork sites and justifying target volcanoes for future study?

### **Recommendations and actions**

There was a consensus that some of the scientific questions and technical challenges identified are intrinsically linked and need to be addressed in parallel; while some other scientific questions can only be addressed by solving the technical challenges first. The workshop participants discussed several combined solutions.

1. The validity of comparing activity across different volcanoes could be addressed by systematically assembling and analysing multi-disciplinary data from multiple volcanoes. Workshop suggestions included:
  - Development of 'best-practice' guidelines for a standard routine for processing volcano seismic data that would facilitate comparison of data between volcanoes.
  - Automated standardised online processing of raw data as it is uploaded to data portals, such as IRIS.
  - A fully operational and fully populated platform like WOVodat would be a useful tool for comparing multi-disciplinary data between different volcanoes. Encouraging data submission through a top-down funding approach may be a way to ensure WOVodat is populated with data from as many volcanoes as possible.
  - Legacy data is an important resource for understanding comparative volcanic behaviour, but due to time and funding constraints is often underutilised. Funding agencies are attracted by exciting new blue skies research, but the volcano seismology community has highlighted (and should continue to highlight) the need to encourage funding for better management of existing networks and better mining of existing data.

2. Our fundamental understanding of volcanic processes would be improved by a better understanding of the subsurface structure, both spatially and temporally. Workshop suggestions included:
  - Investing in dense large N array campaigns, such as a transportable volcano array, would improve 3D velocity models and improve detailed models of subsurface heterogeneities. Similarly, standardisation of the types of analysis of subsurface structure (e.g. tomography, anisotropy) would further the understanding of the subsurface.
  - Investing in long-term projects would improve understanding of the temporal evolution of volcanic systems and potentially enable recording of entire eruptive cycles.
  - Incorporating multi-disciplinary data, both ground-based and remote sensing data, would improve testable models of volcanic behaviour.
  
3. Knowledge exchange between researchers and observatories, between academia and industry, and between individual researchers, can lead to new discoveries and new approaches in methodologies. Workshop suggestions included:
  - Improved dialogue between researchers and observatories would lead to better collaboration and better integration of research outputs into operational tools. Performing a survey to establish the current level of interaction between observatories and researchers, and to determine future needs for observatories, was suggested as a first step towards achieving this.
  - The hydrocarbon and geothermal industries have well-established methodologies and good understanding of fluid movement processes (e.g. fracking). Improved dialogue with industry could lead to advances in models of volcanic behaviour.
  - Bootcamp style workshops were suggested to promote development of code and exchange of knowledge between researchers, observatories and industry.
  - A platform for code sharing and collaborative code development would enable researchers to see what code already exists and build on existing code. Encouraging creation of a volcano seismology toolbox section on VHub would facilitate such code sharing and development.
  - Continue dialogue between researchers and encourage targeted workshops that bring together specialists from all disciplines.

## Appendix: Participant List

<b>Name</b>	<b>Affiliation</b>
Baird, Alan	University of Bristol, UK
Bell, Andrew	University of Edinburgh, UK
Biggs, Juliet	University of Bristol, UK
De Angelis, Silvio	University of Liverpool, UK
Greenfield, Tim	University of Cambridge, UK
Hammond, James	Imperial College London, UK
Hawthorne, David	SEIS-UK, University of Leicester, UK
Hunt, Jonathan	University of Oxford, UK
Johnson, Jessica	University of Bristol, UK
Karl, Sandra	University of Leeds, UK
Lamb, Oliver	University of Liverpool, UK
Lesage, Philippe	Universite de Savoie, France
Luckett, Richard	British Geological Survey, UK
Mather, Tamsin	University of Oxford, UK
Pyle, David	University of Oxford, UK
Rodgers, Mel	University of Oxford, UK
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