Global Volcanic Hazards and Risk

Approximately 800 million people live within 100 km of active volcanoes worldwide, and with ever-growing populations, the likelihood of volcanic emergencies is increasing. Volcanic eruptions can cause extreme societal and economic disruption through loss of life and livelihoods, and damage to critical infrastructure.

Originally prepared for the United Nations Office for Disaster Risk Reduction, this is the first comprehensive assessment of global volcanic hazard and risk, drawing on a wide range of international expertise. It presents the state of the art in our understanding of global volcanic activity, as well as a thorough introduction to volcanology, accessible to a broad audience. It also looks at our assessment and management capabilities, and considers the preparedness of the global scientific community and government agencies to manage volcanic hazards and risk.

Volcanic hazard profiles and local case studies are provided online for all countries with active volcanoes, with invaluable information on volcanic hazard and risk at the local, national and global scale. Particular attention is paid to volcanic ash, the most frequent and wide-ranging volcanic hazard. The first global ash fall hazard map is presented along with a discussion of the characteristics and impacts associated with volcanic ash fall.

Of interest to all those concerned with reducing the impact of natural hazards and disaster risk reduction, including government officials, the private sector, students, researchers and professional scientists, this book is a key resource for the disaster risk reduction community and for those interested in volcanology and natural hazards. A non-technical summary report is also included for policy makers and general interest readers. This title is also available as Open Access via www.cambridge.org/volcano.

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* The contributors to this report are listed separately within Appendix B.
† See www.cambridge.org/volcano for Appendix B which comprises a short discussion of the global distribution of volcanic hazard and risk and individual profiles of volcanism for all countries and regions with volcanic activity within the last 10,000 years.

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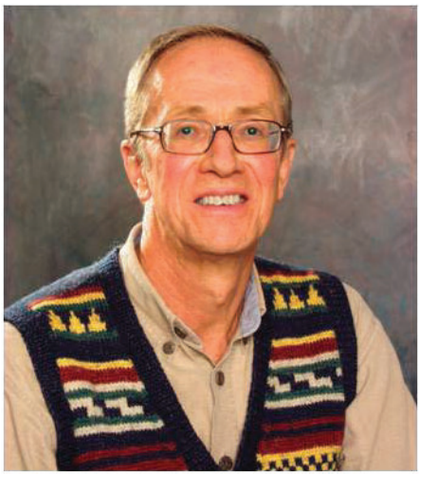
Foreword



Ray Cas
President, International Association for Volcanology and Chemistry of the Earth's Interior (IAVCEI)
October 2014.

This contribution from the Global Volcano Model Network (GVM) and the International Association for Volcanology and Chemistry of the Earth's Interior (IAVCEI), on the status of global volcanic hazards and risk assessment capability for the United Nations Office for Disaster Reduction (UNISDR) Global Assessment Report for Risk Reduction 2015 (GAR15 Report) is an extremely timely and important reminder that there is still a huge amount of work to be done. GVM is a collaborative international initiative, involving multiple research and government institutions, in collaboration with IAVCEI, and has as its mandate *"to create a sustainable, accessible information platform on volcanic hazard and risk"*. This task would be difficult for any learned association or institution by itself, and has required funding and logistic support from multiple international sources.

Over 130 scientists from 86 institutions in nearly 50 countries worldwide have contributed to this work, representing a remarkable collaborative effort of the volcanological community. The World Organisation of Volcano Observatories (WOVO) is a key Commission of IAVCEI and has contributed to profiles of volcanism for the 95 countries or territories with active volcanoes.

This book provides a state-of-the-art assessment of the preparedness of the global scientific community and government agencies to manage volcano hazards and risks globally. It demonstrates alarmingly that adequate information to make informed hazard and threat assessment exists for only 328 (about 20%) of the Earth's 1,551 "active" volcanoes that are known to have erupted during the Holocene (<10,000 years). The situation is even more concerning when considering that there are many dormant volcanoes that have not erupted in the Holocene, but could still erupt.

This situation clearly indicates that much more needs to be done by governments worldwide to improve both the monitoring capabilities for all the known active volcanoes, and as importantly, undertake detailed investigations of the geological histories of all known active and dormant volcanoes.

Monitoring provides only a modern snapshot of the level of activity or unrest of volcanoes, which is crucial to assessing if volcanic eruption is imminent. Seismic and geodetic networks are core to such monitoring, as is gas sampling and analysis. Development of modern airborne and ground-based remote sensing technologies and data sets are now also enhancing our abilities to assess unrest at volcanoes.

However, even if an eruption is imminent, without a database on the eruption history, the frequency and magnitude of eruptions, and the previous eruption styles of a volcano, trying to predict the most likely hazards and their magnitude, becomes poorly constrained guesswork. *Understanding the geological history of volcanoes is one of the most important tools in modern*

volcano hazard and risk assessment. Understanding the previous behaviour of a volcano requires a programme of careful geological mapping, providing data on the dispersal patterns and stratigraphic occurrence of the spectrum of deposit types and their magnitude. Together with knowledge of the geochemistry and geochemical evolution, and a well-constrained geochronological framework of events, factually-based hazard and risk assessment is only then possible.

Sadly it seems that such basic and essential geological knowledge is lacking for almost 80% of the world's active volcanoes! Is this a function of inadequate funding, or an assumption that geological and stratigraphic fieldwork is old fashioned and no longer relevant, or both? This requires urgent attention.

Undertaking geological mapping of volcanoes need no longer be tedious and require covering every square metre of a volcano. Modern remote sensing databases such as Aster, radiometrics, aeromagnetics, LiDAR, etc, offer fast, smart ways of producing first-order maps of volcanoes, that can then be ground-truthed in strategic areas to confirm apparent stratigraphic superposition relationships, evaluate deposit types, collect samples for geochemistry and geochronology, and efficiently produce an assessment of the geological history, eruption styles, deposit types, eruption magnitudes, hazards and risks.

Having compiled a geological database through collaboration with the Smithsonian Institute's Global Volcano Program (GVP), GVM has introduced a Volcano Hazard Index (VHI) for each volcano for which there is an adequate geological record. This important new innovation begins to provide an overview of the range of possible hazards for a particular volcano, the likelihood of specific hazards occurring, and their magnitude, based on the previous history of the volcano. I am pleased to note that just this year to emphasise the importance of understanding the geology of volcanoes, Secretary-General of IAVCEI, Joan Marti, organised an international workshop on the theme of "The geology of volcanoes" on the volcanic island of Madeira. A proposal to form a new IAVCEI Research Commission on this theme is now being prepared.

In addition, measures of the populace exposed to volcanic hazards are introduced to better understand the volcanic threat. A significant statistic of the report is that 800 million people live within 100 km of active volcanoes, 226 live million within 30 km and 29 million live within 10 km. This again highlights the importance of developing a better understanding of volcanic hazards and their impact.

The report also briefly addresses the potential economic impacts of volcanic events, which as global populations increase are just likely to rise. The 2010 Eyjafjallajökull eruption in Iceland was a startling wake-up call on this.

In summary, the GAR15 Report on Global Volcanic Hazards and Risks is a stark reminder that there is still a huge amount of work to be done in understanding the hazards and risks of the world's volcanoes. Major investments are required not only in acquiring and deploying more monitoring equipment on more volcanoes, but also for undertaking ongoing geological mapping and fieldwork to improve understanding of hazards and risks on all active volcanoes.

On behalf of IAVCEI, I congratulate GVM and everyone who has contributed to the GAR15 Report, most of whom are members of IAVCEI. The GAR15 Report will provide UNISDR, governments, IAVCEI and its members with much to consider.

Preface

Volcanic hazards and risk have not been considered in previous global assessments by UNISDR as part of the biennial reports on disaster risk reduction. This book developed as a consequence of Global Volcano Model (GVM) being invited to make such an assessment by UNISDR for its 2015 report. GVM worked in close collaboration with the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) to contribute four background papers for the 2015 Global Assessment Report (GAR15) of UNISDR. These background papers contain a lot more information than could be included in GAR15 and can be construed as the evidence on which UN ISDR have been able to include volcanic risk into their report. Although the background papers were placed on the UNISDR website they would have become part of the ephemeral grey literature that increasingly pervades scientific publication. Thus the decision was made to publish the reports together as an open access e-book with the support of UNISDR.

The book represents the efforts of the global volcanological community to provide a synthesis of what we understand about volcanoes, volcanic hazards and the attendant risks. The book owes its existence to the efforts of many scientists from many countries. There are over 130 authors from 47 countries. Members of the World Organisation of Volcano Observatories (WOVO) have been immensely helpful and collaborative in providing information for the country profiles and making sure that the facts are correct. Outside of those who have directly contributed are many thousands of scientists throughout the world who have provided the data and scientific analysis within the peer-reviewed literature to contribute to the collective knowledge, which we have tried to synthesise. There will be shortcomings and omissions in any endeavour of this kind. GVM and IAVCEI have the ambition to carry out future global analyses to reflect advances in knowledge and to address shortcomings and omissions in this inaugural attempt at a global synthesis.

The book is organised and presented in a rather unconventional way, reflecting that it represents four different background papers for the GAR15. Each background paper has a different and complementary purpose and may also attract different readers. We decided not to change the reports in any significant way apart from some minor re-formatting and cross-referencing. The reader will likely notice some repetition between the main chapters, which reflects the logic of the reporting to UNISDR. Chapter 1 is a summary of our findings and key issues designed for a non-technical readership. We hope that a wide range of people within the disaster risk reduction community will find this chapter accessible. Our findings are evidence-based and draw from the scientific literature as well as some new analysis. We also utilise case studies to illustrate the issues or provide a more detailed analysis of certain key topics. Thus Chapter 2 is essentially a much longer version of Chapter 1 containing much more technical detail and the evidence base on which Chapter 1 draws, including references to the peer-reviewed scientific literature and authoritative sources. This chapter is written more for a technical audience or for those who want to understand the science and evidence in more detail. We do not though assume any expertise in geoscience disciplines so the chapter is reaching out to a wide technical audience within the disaster risk reduction (DRR) and natural hazards communities. Chapter 3 is a more specialist study of volcanic ash fall hazard based on the work of the GVM ash hazard task force. Ash hazard has risen to prominence in recent years due to the impacts on aviation and is the volcanic hazard where probabilistic methods have advanced the most. There are 23 case studies, each of which constitutes a short chapter. Brief synopses of these short case studies are included in Chapter 1 for the non-technical readership, with three

supplementary short case studies. These case studies were chosen to illustrate the wide range of scientific and risk management issues related to volcanoes. Finally there is supplementary material, which consists of profiles of each of the 95 countries and territories with active volcanoes. Most of these profiles were written in collaboration with members of the World Organisation of Volcano Observatories (WOVO). The intention is to update these profiles as new information becomes available and it is anticipated that these updates will be a collaboration between GVM and WOVO members.

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