Part Two Summary: Observing Volcanic Crises

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Numerous volcanic crises have been observed, from small and local in scale, to large regional events. Each crisis has its own contingencies, both spatially and temporally. Differing cultures, politics, economics, population sizes, scales of events, types of volcanic hazards, and geographical constraints shape the dynamics of a crisis. It is potentially only with hindsight can the variables be recognised that may have played a significant role in the success or failure of a crisis. Each event can provide valuable insights of issues to be weary of in future crisis, but equally numerous examples can help build a picture of good practices or procedures that can help foster strong links during a crisis, particularly in relation to communication between the various stakeholders.

The chapters that form Part Two of this volume illustrate some of the key issues that emerge in crises, with examples from 6 continents to illustrate the diverse and wide range of issues. These chapters demonstrate that sharing knowledge and experience is vital as long as this is done in a transparent sensitive manner, preferably prior to a crisis, and with some humility.

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Effective crisis communication is particularly challenging when dealing with caldera eruptions, especially during large phases of unrest when it is unclear as to whether an eruption is imminent. Given the infrequency of caldera eruptions, experiences remain limited, yet from recent caldera eruptions such as at Rabaul in Papua New Guinea, unrest can result in eruptive activity within very short time frames, in this case <27 h. This results in very little time to respond to a state of unrest, particularly when an eruption could be particularly powerful. The challenges that Hill et al., Chapter "Volcanic Unrest and Hazard Communication in Long Valley Caldera, California" experienced, during the 1980s unrest at Long Valley Caldera, highlight the need for effective messages that can easily be understood by the public at large. This includes open transparency, and being careful with media and public relations. The importance of good sound science is critical to building effective forecasts and also to building effective and credible working relations. Maintaining long-term relationships becomes increasingly challenging in an ever changing, globalised job market where continuity is hard to find. Hill et al. outline the 'narrow path' involved in such crises, where there is a small space between overreactions and false alarms, and conservative responses. An important lesson is that although mistakes can be costly, poor relations can be rebuilt over time.

Mt Pinatubo was an extraordinary event that balanced this 'narrow path' exceptionally well. Newhall and Solidum, Chapter "Volcanic Hazard Communication at Pinatubo from 1991 to 2015" speak of the 'pressure-cooker' that

scientist's face, the battle between the desires to continue to obtain scientific data to reduce the uncertainties, versus the pressures to communicate immediately. Indeed the immediacy of Pinatubo was key to its success; starting educational programmes early when there were still significant levels of uncertainty, employing rigorous checklists, and building in flexibility to response plans. Some of the challenges of Pinatubo were that this caldera eruption occurred following a period of long dormancy, generating scepticism. Embracing potential false alarms, reviewing the various possible scenarios, and striving for scientific coordination are clearly vital to the success of these large scale events. Indeed the recognition of trust and personal connections between the various stakeholders are sometimes more important than the warning itself. The challenges of calderas often only begin with the eruptions, but can continue with various hazards for decades after.

The 1994 eruption of Rabaul in Papua New Guinea is a positive example of an informed responsive community living around an active caldera. McKee et al., Chapter "The 1994 eruptions at Rabaul Volcano, Papua New Guinea: the roles of instrumental volcano surveillance and community awareness in preparing for the outbreak of the eruptions" outline the experiences of those living at Rabaul, many of whom have had to deal with several periods of unrest, most with only a few hours indication of an imminent eruption, across numerous vents. Whilst Papua New Guinea would benefit from the use of automated and continuous data to aid the monitoring process, with raised community awareness surrounding the volcano, crisis communication can become somewhat surplus, particularly when populations decide to self-evacuate. One of the challenges faced in Rabaul was the looting that occurred when the mass evacuation began, which also affected observatory staff. It easy to forget that observatory and civil defence personnel are also affected by looting, and civil unrest can lead to significant logistical issues for those who are trying to do their job, whilst keeping family safe.

Prolonged, low-level volcanic crises produce very different challenges to those of calderas. Popocatepetl volcano in Mexico, surrounded by over 20 million people, and persistently active over the last 20 years presents some of the most challenging conditions to effectively communicate. De la Cruz-Reyna et al., Chapter "Challenges in Responding to a Sustained, Continuing Volcanic Crisis: The Case of Popocatépetl Volcano, Mexico, 1994-Present" outlines potential solutions to maintaining a responsive community despite indifference and weariness at times among the vulnerable populations: use of social media, increasing use of web cameras and the use of their Volcano Traffic Light Alert Systems (VTLAS). The VTLAS translate the level of volcanic hazard into three alert levels for the populations, leaving no room for uncertainty about what needs to be done in response to the warning. Yet, the lessons learnt in Mexico illustrate the value of consensual approaches and deliberations between the scientists and civil protection organisations to manage the uncertainties of forecasting potential activity.

Personal connections are a recurring theme in Part 2, where at Mt Ruapehu in New Zealand, years of preparedness, communication, and building understanding through planning and simulation exercises have resulted in effective lahar management around Mt Ruapehu. Becker et al., Chapter "Organisational Response to the 2007 Ruapehu Crater Lake Dam-Break Lahar in New Zealand: Use of Communication in Creating an Effective Response" highlight the increase in communication during the crisis relative to the simulation. Despite the successful preparation, increased communication presented new challenges to the communication flows between the various stakeholders that was averted by using a diversity of communication channels. This highlights the need to have numerous channels in places, not only as a back up, but to enable multi-actor network communication and collaboration.

The Eyjafjallajökull 2010 eruption was a relatively small infrequent event that caused a significant crisis globally. The management of the crisis demonstrated that pre-eruption risk

communication is critical to building trust between emergency management officials and the general public. Bird et al., in "Crisis Coordination and Communication During the 2010 Eyjafjallajökull Eruption" outline the value of speaking with 'one voice', a challenge when many institutions work together, but in this case it was successful with clearly defined roles and responsibilities, not just within Iceland, but also across Europe. This case study highlights the need for dedicated media centers, in order to meet the enormous demands for information, particularly for such an event that causes international chaos and travel disruption.

For both frequently erupting and long-dormant volcanoes, Solana et al., Chapter "Supporting the Development of Procedures for Communications During Volcanic Emergencies: Lessons Learnt from the Canary Islands (Spain) and Etna and Stromboli (Italy)" highlight the challenges of managing these uncertain events. The inexperience of all involved (from the scientists to the public) can create significant tensions and misunderstandings that can result in poor communication, and lead to poor decision making processes. To overcome these challenges, the key is to clearly define roles and responsibilities between responding groups, along with detailing the communication protocols prior to the event. In particular the liability of scientific groups needs to be carefully outlined. To facilitate this, coordinating bodies that sit outside the scientific community are vital to generate consensus and recognise the different cultures, needs and limitations of the responding groups. Solana et al. also highlight the advantages of working with external researcher, sharing resources, and engaging the public, and outline an Italian model that encourages collaboration and camaraderie.

With over 127 active volcanoes, from the supervolcanic to the effusive style, Chapter "Integrating The Social And Physical Perspective In Mitigation Policy And Practice" by Andreastuti et al. outlines that Indonesia has much to teach us about the importance of communicating hazard information. To achieve mutual understandings across different actors and cultures informal approaches are often seen as the most effective, this is done via 'socialization' using participatory knowledge dissemination. This enables local populations to engage with, and understand the hazards and risks they face, empowering them to conduct their own assessments and make their own decisions. The strong focus on public participation helps maintain strong communication networks and lasting relationships. Whilst each volcano is different, each community around a volcano also has different features that result in different responses, that should influence the way scientists and government agencies communicate and manage volcanic crises. Where the social and physical perspectives of the volcano are integrated, meaningful communication that adapts over time is developed.

The experiences of Volcano Colima in Mexico as discussed by Cuevas-Muniz and Gavilanes Ruiz, "Social Representation of Human Resettlement Associated with Risk from Volcán de Colima, Mexico" describe the importance of the social representation of volcanic risk and how it is redefined by daily life. A key lesson learnt from these experiences is that rather than communication processes that omit the knowledge, values, and desires formed by the vulnerable populations, there is a need to find a way to improve social representation. This needs to be established within both the policy and practice of crisis communication and management, particularly when linked to the resettlement of local populations, who need a voice in the decision-making processes. The study of La Yerbauena highlights the consequences of mistrust and resentment that can result from a breakdown in this vital communication.

"If I Understand, I am Understood: Experiences of Volcanic Risk Communication in Colombia" is a poignant phrase from the work of Garcia and Mendez-Fajury that explores risk communication experiences during volcanic emergencies in Colombia. This reflective highlights the importance of a solid social science research program, to not only increase the impact of crisis communication, but also help the authorities and scientists improve their decision-making processes by understanding

the social processes involved. There has been significant focus on various education programmes to foster better understandings around the science of volcanic eruptions. Whilst the community tends to trust in the technical work of the scientific volcanic community of Colombia, further assessment of the relevance and perception of technical scientific reports by the public is required to establish how much of this information is understood and assimilated.

For island communities living in the shadows of volcanoes, there is a particularly strong influence of historical, political, cultural, social, economic, and environmental factors influencing the success and failure of volcanic risk communication. Komorowski et al., Chapter "Challenges of Volcanic Crises on Small Islands States" outline the particular intensity of politics that manifests in island communities, 'perhaps because of, rather than despite, the smallness and tightness of the communities, amongst other island characteristics'. Given the small scale and often independent communication, it is vital these local communities are engaged rather than 'consulted' so to be able to work with communities on their terms. This provides the opportunities for collaboration with communities rather than being shaped or dominated by one political party or group of actors. It is vital to be clear what is known and unknown and what can reasonably be done to fill the gaps.

Mt Cameroon volcano, Cameroon, like many volcanic regions around the world is still poorly understood. Marmol et al., Chapter "Investigating the management of geological hazards and risks in the Mt Cameroon area using Focus Group Discussions" provide valuable guidance on how to develop an effective risk management structure and generate risk reduction actions when political, social and economic conditions are challenging. Problems at Mt Cameroon range from the physical hazard aspects, to a lack of resources or capacity to monitor and mitigate against hazards and little willingness of political leaders to raise awareness and implement effective policy. To move to overcome these obstacles, Marmol et al. describe how they conducted a series of focus group discussions (FGDs) with city councillors from three municipalities around Mt Cameroon volcano, Cameroon. The authors highlight a strong need in such cases for scientists to work together with national and local authorities to translate the findings of scientific hazard and risk assessment into improved risk management practices. This chapter demonstrates that FGDs can provide an excellent framework in which to implement these aspirations through enabling interactions between all actors, with the opinion of all participants being considered at an equal level.

Whilst still focusing on Mt Cameroon volcanoe, Bang et al., "Blaming Active Volcanoes or Active Volcanic Blame? Volcanic Crisis Communication and Blame Management in the Cameroon" outlines the challenges of a 'blame' culture; they explore how blame can be managed and avoided, particularly in developing countries with frequent volcanic activity. Here, 'a paradox of frequency' can occur whereby a crisis can be blamed on either policy failure, or event failure. Blame and conflict between competing scientific groups can be highly destructive for all stakeholders and often arises due to a lack of clear and inclusive protocols. Frequency of crises can be important in shaping the behaviours of disaster managers and also of the local populations. Often Cameroon government authorities act to protect and defend their jobs rather than accepting mistakes and applying learnings. The chapter concludes by noting that it may not be the case that the frequency of events guarantees effective learning and enhanced preparedness, but that continued lack of political will and financial and human resources may hinder learning those vital lessons.