

# 16. Historical Analysis and Volcanic Disaster-Risk Reduction

Science does what it must; humans comprehend what they can.

J. Byrne (2012)

## Patterns in the Historical Record

Documented histories are complex time series, punctuated by major events that commonly define turning points. This history of volcanic eruptions and disaster management is no different. Historical trends also have impetus and trajectories, which define future challenges and even, on the basis of lessons learnt from history, ways to deal with them.

Slicing seamless narratives into time sectors hardly acknowledges the continuities of histories and the long-lived interdependencies of the many factors defining them, but here there is value in drawing together some key threads, first, in recognising five periods or phases which, spliced end-to-end, define a framework of recorded volcanic crises and disasters in Near Oceania.

The first, longest, and least complete phase is the 330 years between 1545, when Spanish voyagers probably noticed volcanoes in Near Oceania, through to about 1875, when Europeans began to settle permanently in volcanically active areas, most notably in St Georges Channel and in the Rabaul area. This phase encompasses the European Scientific Revolution, the Enlightenment of the 'long eighteenth century', and the Industrial Revolution. Near Oceania was still remote to Europeans and few written records of extended observations of volcanoes or their eruptive activity were produced. One notable exception is the account left by William Dampier of his voyage through the islands north and north-east of New Guinea Island in 1700 AD. An especially large volcanic eruption at Long Island during this phase created a 'time of darkness' across much of mainland New Guinea, the memory of which is still retained in traditional stories, but the eruption was not recorded in written history by actual eyewitnesses.

German, British and Australian colonialism dominated the second phase between 1876 and 1941. Colonial headquarters were established by the Germans at Rabaul in 1910 on the foreshores of Simpson Harbour in Blanche Bay, where damaging eruptions at both Vulcan and Tavurvur had taken place at Rabaul in 1878. These eruptions did not present a particular concern for the German, or later, Australian authorities, bearing in mind their common recognition of

the considerable economic advantages of the superb natural harbour formed by the sea-breached calderas of Blanche Bay. A repeat of the 'double eruption' phenomena at Tavurvur and Vulcan in 1937, however, changed the attitudes of the Australian authorities to the dangers of volcanic eruptions when about 500 people were killed and ash fell heavily on Rabaul, causing little damage but leading to temporary evacuation of the town. The future of Rabaul as a government administrative centre was reviewed after this unexpected eruption. Volcanologist C.E. Stehn wrote that a transfer to a safer place was unnecessary if a well-equipped volcanological observatory were established in order to provide science-based warnings of eruptions. In sharp contrast, and in the same report, however, W.G. Woolnough stated the opposite — that, bearing in mind the uncertainties involved in eruption prediction '... the provision of elaborate warning systems should not be entertained.'<sup>1</sup> Stehn's view prevailed, however, and a volcanological observatory became operational in 1940, thus marking the start of an expectation or even promise of early warnings for eruptions at Rabaul. The 'promise' arguably represents the most important scientific turning point in this volcanological history and one that would be tested in future years, particularly in 1983–1985 and 1994.

The next ten years of the third phase, from 1942 to 1951 inclusive, were dramatic both volcanologically and in terms of world events. Australian operations at the new volcanological observatory were interrupted by the Second World War when, following earlier military actions against China and the United States, the Japanese invaded Rabaul in January 1942. The Japanese military established a volcanological observatory at Sulphur Creek to assist its naval operations in Rabaul Harbour. The building was destroyed by Allied bombing, however, and not until 1950 did Australia restart volcanological operations at Rabaul by appointing Australian volcanologist G.A.M. 'Tony' Taylor to the task of running the re-established facility on Observatory Ridge. Taylor soon became heavily involved in investigative work at Lamington volcano, Papua, following the large explosive eruption there in January 1951 when almost 3,000 people were killed. This is still the largest known death toll from the impact of a natural geological hazard recorded anywhere in Near Oceania. The Lamington tragedy secured the future of the volcanological observatory at Rabaul as a required service that, from this time on, covered active volcanism throughout the whole of the then Territory of Papua and New Guinea — a task much larger than the one defined for Rabaul volcano alone.

More than 30 years of the fourth phase between 1952 and 1985 represent a period of general growth for the observatory at Rabaul, especially with regard to the installation and operation of improved instrumental systems for volcano monitoring at Rabaul itself. Observatories with instrumental cellars were also

---

1 Stehn & Woolnough (1937), p. 157.

constructed at both Manam and Esa'ala in 1964, and were part of a local-observer network that also included Ulawun and Langila volcanoes. Authorities in the 1950s continued to be influenced by the Lamington disaster. They initiated or supported evacuations at Long Island in 1953, Bam in 1954, and Manam in 1957, and a government-supported evacuation also took place at Esa'ala in 1969. Papua New Guinea became an independent nation in 1975 and the Solomon Islands in 1978, thus taking over the responsibility for volcano monitoring from Australia and Britain, respectively. A major seismo-deformational crisis at Rabaul in 1983–1985 led to forecasts of an imminent eruption from intra-caldera vents, but none had taken place by the end of the crisis period.

Reduced general concern for the situation at Rabaul during the first eight years of the final period from 1986 to the present day, translated into a decline in instrumental monitoring capacity for the national volcanological service of Papua New Guinea centred on the Rabaul Volcanological Observatory (RVO). Adequate early warnings were not issued in the hours preceding the disastrous eruptions at Tavurvur and Vulcan, Rabaul, in September 1994, and evacuations there were initiated largely by the affected communities themselves. The governments of Australia and the United States after 1994–1995 began providing support to the Government of Papua New Guinea for the strengthening of the RVO through a series of international development-assistance projects.

\*

Four volcanoes in New Oceania have been the most dangerous since the mid-1870s, based on the historical evidence of dated volcanic disasters. All of them are in Papua New Guinea: Rabaul in 1878, 1937 and 1994; Ritter in 1888; Lamington in 1951; and Manam on several occasions, but especially in 2004–2005. Other historically or potentially active volcanoes have caused justifiable concern for the safety and livelihoods of local communities. These include Karkar, Pago, Ulawun and, to a lesser but still significant extent, Kadovar, Bam, Long, Langila, Garbuna, Sulu Range, Tuluman, Bagana, Kavachi, Simbo, Goropu, Victory, Koranga and the volcanoes of the Dawson Strait area.

The precise number of active or potentially active volcanoes in New Oceania is unknown, and the total of 57 subaerial volcanoes mentioned at the beginning of this book and listed in the Smithsonian Institution database — whether the 'Holocene' attribution is certain or just possible — includes probable examples of volcanoes that will never be in eruption again. Nevertheless, many eruptive centres in Near Oceania are a threat, not only from the general type of eruptions seen at the historically active volcanoes of the region but also from larger-scale eruptions that have not been observed and recorded. Savo in the Solomon Islands, Bamus and Makalaia-Dakataua in New Britain, and Victory in Oro Province are just four examples of 'sleepers' volcanoes. All four are capable of

producing eruptions larger than when each was last active in the nineteenth century. Geothermally active Yelia, in the highlands of mainland New Guinea, is an example of a type of 'sleeper' volcano that has not been active historically, but which may well break out in eruption again. Furthermore, the stories of a 'time of darkness' in the highlands of mainland New Guinea, caused by a VEI (volcanic explosivity index) 6 eruption at Long Island, apparently during the mid-seventeenth century, are a reminder that the mild eruptions witnessed historically at Long are not representative of much larger possible eruptions from such caldera-related volcanoes. Other, similar, caldera systems include Rabaul-Tavui, Lolobau, Galloseulo-Hargy, Pago-Witori, Makalaia-Dakataua, Garove, Unea, Umboi, Karkar and Loloru. Then there are high coastal volcanoes such as Ulawun, Bamus, Manam and Victory, which could produce major gravitational collapses and widespread tsunamis in the future, or else calderas, together with large accompanying eruptions.

Following, then, is an important conclusion. The many eruptions recorded since the mid-1870s in Near Oceania are all small — that is, VEIs of no more than 4 — compared to some recorded geologically but of a scale not yet witnessed in recent times. The threat from these much larger eruptions in the future is real. Furthermore, volcanic risk in Near Oceania is higher today than at any time since people first entered the region more than 40,000 years ago because of the much larger, sedentary populations, and the permanent agricultural lands and built environments on which they depend.

Another striking feature of the historical record is the eruption 'time clusters' of 1951–1957, 1972–1975, and 2002–2006. There are also hints of clusters in 1875 to 1878 and 1884 to 1899, but these are less clear and conceivably both could represent two parts of one longer period of enhanced eruptive activity. The starts and ends of all of these periods are not well defined, and there exists the possibility that these are simply statistical anomalies, rather than the clusters having any real geophysical significance. Nevertheless, volcanologists who were involved in the assessment of the 1951–1957 and 1972–1975 eruption time clusters proposed that these periods may have begun as a result of preceding tectonic-earthquake activity or 'regional geophysical unrest'. Furthermore, the remarkable earthquake sequence in the northern Solomon Sea in 2000 conceivably could have triggered the eruption cluster of 2002–2006. Perhaps the most practical lesson to be learnt from these eruption clusters is that they require extra work from volcanologists and that consideration should be given to requests for external, temporary assistance to offset the excessive workloads at these times.<sup>2</sup>

---

2 There is an intriguing corollary to these comments on eruption time clusters, which can be made with reference to the example of one particular volcano. Ulawun produced severe eruptions, first in January 1970 after a long period of relatively minor activity, and again in September 2000. Adding both of these

## Evacuations, Early Warnings and False Alarms

This history contains 13 documented examples of at-risk communities evacuating either before or after the initial outbreak of a nearby volcanic eruption or because of the immediate threat of one. All 13 examples date from 1937. Evacuations of people from active volcanic areas undoubtedly took place before 1937 — for example, at Victory in the 1880s — but little if anything is known about them. Furthermore, 1937 is the year when a new, more scientific and instrumental approach to monitoring volcanoes was adopted in the hope of providing early warnings of eruptions. Each of the 13 documented examples has its own unique combination of factors, but the examples as a whole can be used to assess the degree of success of authorities, including volcanologists, in declaring evacuations that saved lives.

**Table 9. Thirteen Evacuations in Papua New Guinea**

Group A	Group B	Group C
Rabaul 1937	Esa'ala 1969	Long 1953
Goropu 1943	Rabaul 1984	Bam 1954
Lamington 1951	Rabaul 1994	Manam 1957
Pago 2002	Sulu Range 2006	Ulawun 2000
Manam 2004		

Nine of the 13 documented examples, shown loosely as Groups A and B in the table, are cases where evacuations took place without them first being declared by authorities, whether they were assisted by volcanologists or not. Group A evacuations are instances where the actual outbreak of an unexpected volcanic eruption triggered the movement of people away from a volcano to places of greater safety, in most cases immediately. Authorities in all five cases played no part in disaster-mitigation efforts before the outbreak of eruptions, but inevitably took a lead in post-disaster relief and recovery work amongst the displaced communities. The Lamington eruption of 21 January 1951 is a

---

eruptions to the respective eruption time clusters that followed them soon after in 1972–1975 and 2002–2006 respectively, expands each of the clusters by two years to 1970–1975 and 2000–2006, in which case Ulawun was the first of the volcanoes of each cluster to begin eruptive activity. Note, however, that both the January 1970 and September 2000 eruptions at Ulawun *preceded* the respective series of tectonic earthquakes that have been proposed as ‘triggers’ for the two eruption time clusters. Thus, either the timings of these two particular Ulawun eruptions are coincidental — that is, they are not linked at all to the time clusters and are therefore irrelevant to them — or else both eruptions are a hint that, in some cases, eruptions of a cluster can precede large tectonic-earthquake series. In other words, the eruptions and tectonic earthquakes are both simply expressions of the same period of ‘regional geophysical unrest’, irrespective of which comes first. Furthermore, some eruptions at Ulawun perhaps can be regarded as precursor volcanic signals for subsequent major, tectonic earthquake series. This last conclusion, given on the basis of current but limited evidence, is speculative, but the idea could be tested by future eruption/earthquake events.

standout example in this group of five. The deadly eruption there developed so quickly and savagely that few people within the devastated area could escape, although some apprehensive villagers did manage to self-evacuate before the catastrophe on that Sunday morning. The number of dead, almost 3,000, greatly exceeded the number of survivors who were from the destroyed settlements, who happened to be away from home at the time of the catastrophe, and who, with others from villages outside of the devastated area, moved further away to areas of refuge.

The phase of eruptions that started at Manam on 24 October 2004, also classified in Group A, eventually led in late November and December of that year to a slow evacuation from the island to care centres on the mainland. Limited data from a single seismograph at the makeshift observatory at Warisi on Manam in 2004–2005 was used by RVO to assess the general seismic condition of the volcano. The extent to which these data and the reports provided by RVO from Rabaul were strongly influential in authorities arranging for the eventual evacuation of the islanders is unclear, however, given the low-level nature of the available scientific information and the unreliability of the communication links between Rabaul and decision-makers in Madang and Port Moresby. The initial eruption of 24 October 2004 and the major eruption of 27–28 January 2005 were both unexpected.

The four examples in Group B are examples of at-risk communities evacuating because they were themselves sufficiently concerned about warning signs of an imminent eruption that they were not prepared to wait for authorities to announce an evacuation. Government authorities in these cases soon gave their support in one way or another to these ‘self-evacuating’ communities, even though Rabaul in 1994 is the only one of the four where an eruption actually broke out soon after the evacuation. The other three were in effect volcanic ‘false alarms’.

The remaining four examples shown in Group C are of evacuations taking place as the result of early warnings and declarations being made by authorities with or without the recommendations of volcanologists. Evacuation at Long was undertaken without any prior input from volcanologists, whereas the successful evacuation of Manam Island in 1957 was a case where Taylor’s recommendation to the authorities was based in large part on his forecast of major eruptions at Manam being expected at times of strong earth tides and after general tectonic unrest in the region, and based only to a limited extent, if any, on instrumental results.

Perhaps the most telling of the three Group C examples during the 1950s was the tragic case of Bam Island in 1954 when volcanologists recommended the permanent evacuation of the island because of the perceived high risk from

future major eruptions. The Bam islanders were taken to care centres on the mainland in November 1954, and 24 of them died there, apparently mainly through disease. Mild explosive eruptions had been taking place from the summit crater of Bam, but no one in authority seems to have considered seriously the self-sufficiency of the Bams themselves in coping with the dangers of these eruptions.

The three volcanic alarms raised by the authorities and volcanologists in the 1950s were almost certainly an overreaction influenced by the shadow of the Lamington tragedy in 1951, and by the fear of similar tragedies taking place at Long, Bam and Manam, for which the authorities and volcanologists might be held responsible. Lamington itself was also a case where more lives might have been saved had the opinions of two Europeans in authority not been heeded by so many local people. There is, therefore, in all three cases a strong element of misplaced colonial paternalism — that white men had a greater understanding of such things compared to people in traditional societies. This seems to have been a common misperception at that time, and not just in Near Oceania, although later European research into natural disasters, social structures, and change in traditional communities soon demonstrated otherwise.<sup>3</sup>

Ulawun in 2000 is only one example in the total of 13 where instrumental results were important in providing timely early warnings of an impending volcanic eruption, thus contributing significantly to decisions being made regarding evacuation. Seismic activity recorded at Ulawun in September 2000 was used by RVO as justification for recommending an immediate evacuation. The final recommendation had to be made promptly by RVO and directly to the affected communities as the final seismic build-up took place rapidly over only a few hours, including during the hours of darkness immediately after sunset. Evacuations began on the night of 28–29 September, only a few hours before Ulawun broke out into full eruption. Other, equally important factors, however, that contributed to this success were: (1) a highly capable local volcano observer at Ulamona Mission and Sawmill, Martina Taumosi, with whom RVO volcanologists in Rabaul discussed by radio the instrumental results being received by her at Ulamona; (2) the high level of hazard awareness in the local community caused by an RVO-led awareness campaign that was undertaken only three weeks previously; (3) people in the community seeing the beginning of the eruption and so being motivated to evacuate promptly; and, (4) the willingness of local businesses to quickly provide road transport. Thus, instrumental early warning was not the only factor in ensuring a successful evacuation. The short-lived eruption at Ulawun in 2000 did not have any disastrous impacts, other than destruction of some gardens, but this does not mean that the evacuation was unnecessary. On the contrary, powerful eruptions like those in 2000 could

---

<sup>3</sup> See, for example, Torry (1978).

easily be the trigger for future large-scale cone collapse on Ulawun, as well as even larger and more disastrous eruptions and possible tsunami impact over a wide area of the Bismarck Sea.

There are numerous examples in Near Oceania, including some not mentioned in this history, of what may loosely be called volcanic ‘false alarms’ — that is, cases where early warning signs on active volcanoes were *not* followed by damaging volcanic eruptions. Some ‘early warning’ signs on volcanoes have nothing to do with an impending eruption. Water vapour trails streaming off the summits of high conical volcanoes can be misinterpreted by aircraft pilots and others as being plumes of volcanic origin, whereas in fact they are a meteorological effect of strong upper winds on normal weather clouds. Landslides on volcanoes may be the result of heavy rainfall, or shaking from distant tectonic earthquakes, or both, and have no connection with the movements of magma beneath a volcano. Changes in the extent and behaviour of geothermal areas on volcanoes can be part of the normal evolution of shallow geothermal systems as hot geothermal fluids and mineralisation excavate new channels, rather than being indicative of emplacement and impending eruption of magma. One example of this is the local reports in February 1984 of the increased activity in the thermal areas bordering Dawson Strait area, Milne Bay Province, including coral-reef die off at Dobu Island. Intense swarms of felt, local earthquakes in volcanic areas may also cause concern, but these may not be of volcanic origin and will not necessarily signify subsequent eruptions.

The ‘false alarm’ at Sulu Range in 2006 can be highlighted because the scientific evidence pointed strongly to intrusion of magma beneath the volcanic area. People evacuated because of the threat of an eruption, but none has taken place — at least to date. Magmatic intrusion without eruption, such as at Sulu, can indeed be regarded as a *volcanic* false alarm, but there is a need for at-risk communities and supporting authorities to accept that such ‘intrusive’ events are not unusual beneath volcanoes and that they will not necessarily lead to a volcanic eruption. Another case in this context is Kadovar in 1976, when a newly enlarged thermal area gave cause for concern. Did this represent normal, non-threatening, geothermal activity finding a new way to the surface, or was it triggered by a magmatic intrusion beneath the volcano? The answer remains unknown.

Two unusual examples of false alarms are at Koranga volcano in 1967, when volcanic-like events in the crater probably represented the burning of reactive iron-pyrites exposed to the atmosphere; and, at Simbo volcano in 1993, when threatening black emission clouds turned out to be combustible sulphur set alight by a bushfire that had been apparently lit by tourists. Plans for evacuations were made in both of these instances, but the plans did not need to be implemented at the time. A false alarm at Lamington volcano in 2002 was

caused by escalating rumours following reports of smoke and noises from the volcano, and people becoming dizzy and dogs fainting in the summit area, none of which could be confirmed by later investigations. Rumours can be founded on inconsequential or poorly understood phenomena, but may gain in strength unnecessarily through the powerful and rapid transmission of events by word of mouth. There is also the example of the 1983–1985 seismo-deformational crisis at Rabaul being recognised by some people for several years afterwards as a ‘false alarm’, whereas it can now be regarded as the precursor to damaging eruptions ten years later in 1994. The alarm in this case proved not to be ‘false’.

This brief review of evacuations and false alarms since 1937 can be concluded by making two remarks. First, the management of events suspected by volcanologists to be of little consequence and which are expected to lead to false alarms, or just minor benign eruptions, is just as important as managing the lead-up to volcanic eruptions and disasters considered by volcanologists to be more likely and of larger impact. Both are times when open dialogue with affected communities is equally essential. Second, the self-sufficiency and resilience of at-risk communities on volcanoes in Near Oceania are important factors to identify in asking the question: what are the best approaches and methodologies that should be adopted for reducing volcanic risk in such areas? Strong, reactive communities in one sense challenge authorities to do better in deciding when to declare official evacuations, including the volcanologists who monitor volcanoes instrumentally and who aim to provide the best possible scientific advice to authorities. Strong communities will not necessarily wait for official advice from volcanologists who, understandably, may be cautious and restrained in issuing an alert. Rather, communities may respond spontaneously, promptly and confidently when the conditions warrant such action. The evacuations at Rabaul in September 1994 are an excellent example of this where people from Matupit Island said that their old people, who in 1937 had experienced the precursory signs of the eruptions 57 years earlier, urged the community to leave — and the community did so in timely fashion.

## Artefacts and Oral Traditions

Adequate volcanic-disaster information from the historical record of observations in New Oceania covers less than 150 years, but are there other potential sources of information on volcanic disasters and on the ways that people have dealt with the threat of volcanic hazards and coped with their impacts? One such source is traditional archaeology, coupled with studies of historical ecology and changes in vegetation and foods that supported people. A strong partnership between archaeology and volcanology has existed ever since the nineteenth century excavations at Pompeii of the volcanic disaster in 79 AD.

This collaboration has included even the debated role of volcanic eruptions as the cause of the demise of some ancient civilisations. One well-known example is the caldera-forming, possibly VEI 7 eruption at Thera Island, Greece, in about 1610 BC, which resulted in the destruction of the Bronze Age city of Akrotiri on present-day Santorini and, conjecturally, determined the eventual end by volcanic-tsunami impact of the Minoan culture on Crete. Another example is the proposed elimination of some early Mayan cities, in about 450 AD, by a VEI 6+ eruption at Ilopango volcano, El Salvador.<sup>4</sup>

The principal benefits for archaeologists working in volcanic areas are the widespread sequences of airfall tephra that can be dated by geochronological methods. The broad areal extents of the tephra represent individual time horizons for spatial correlation and comparisons of contemporaneous cultural artefacts, as well as of edible plant remains such as nuts and coconut shells, together with peat, pollen, phytoliths and starch grains. The tephra may build up long-duration sequences at any one site of archaeological and palaeo-environmental interest, although the number of such sites that can be studied across any one time horizon may, for different reasons, be limited. This applies to the results of the extensive archaeological work on Willaumez Peninsula in West New Britain Province, where the evidence has been used in discussions of whether the volcanic eruptions are the cause of subsequent cultural change, and thus possibly even to adaptations to the ongoing threat of volcanic hazards. These discussions, however, are fraught with uncertainty, especially where the physical evidence consists mainly of obsidian tools and chips, and where the important discussions on risk and strategy amongst the affected peoples themselves remain archaeologically invisible. Furthermore, the relative dating of and connections between events commonly remains controversial and inconclusive in the absence of precise geochronological data. Which came first, volcanic eruption or social change? And, if definitely the former, is that necessarily conclusive that cultural adaptation to the volcanic threat necessarily followed the eruption?

What people on Willaumez Peninsula thought and how they made decisions about volcanic threats and evacuation are not recorded archaeologically. Neither are their deductions about volcanic early warning signs nor how they coped with false alarms. There is, consequently, a temptation to apply conclusions from present-day viewpoints or through application of results from pre-history studies in other parts of the world. Syncretism and imaginative interpretation of minimal evidence, however, must be and have been guarded against. There are, after all, no known equivalents of Pompeii in Near Oceania, or reported evidence yet for people being killed by the VEI 5–6 eruptions at Witori and Dakataua

---

<sup>4</sup> The radiocarbon ages and VEI values quoted here for Santorini and Ilopango are from Siebert et al. (2010). See also Harris (2000).

— for example, tephra-buried human bones or destroyed settlements of any significant size or number. The only certainty is the rapid burial of landscapes and therefore habitable surfaces by airfall tephra and pyroclastic flows, and the new surfaces so formed remaining uninhabitable for people, presumably until gardens could be re-established, or forest and reefs returned to provide their required food resources. Nevertheless, there is some appeal in the general conclusion that the people on Willaumez Peninsula who were affected by the Witori-Dakataua eruptions may well have been resilient in facing the effects of volcanic eruptions, bearing in mind that they probably had a low dependency on built environments, a high degree of mobility including movements by both land and sea, a minimal reliance on intensive agriculture and domesticated food stuffs, and presumably low population densities.<sup>5</sup> Risk, therefore, was probably much lower compared to that for the more populous and sedentary communities of present-day West New Britain Province.

Navigating the written records for this narrative has involved, as in many other historical efforts, the search for the Holy Grail of factual objectivity. All historical narratives, however, are shaped by the many tellers, writers, listeners and readers of real events and so, inevitably, are subjective, although verification can be used more favourably to check factual veracity in the histories of more modern times. Oral histories are arguably no different and so, in the absence of written records, are potentially useful sources of facts, or of what originally may have been facts.<sup>6</sup> Myths and legends are an integral part of all histories, including scientific ones, and they have coloured the histories of volcanic eruptions and disasters over the millennia. But can oral traditions carrying points of volcanological interest such as eruptions, disasters, and coping strategies, be used in isolation as scientifically valuable testimonies for past events? Interrogation of volcano-related stories transmitted through oral traditions has been another popular, multidisciplinary, research activity in recent years yet, like its partner field of volcanic archaeology, the results are generally characterised by uncertainty if not inconclusiveness.<sup>7</sup> Nevertheless, some verification is possible where the stories are consistent with local volcanic geology and where they overlap with eras of written histories, and where both the written and orally transmitted histories are consistent with each other.

Pre-industrial societies in Near Oceania are known through their stories, and in European anthropological accounts of them, to have accepted the existence and

---

5 Highly mobile communities may be the norm for many societies in circum-Pacific regions before European contact. Sheets (2007), for example, described examples from eruption-affected parts of Central America, which are similar in this respect to the societies inferred for the Willaumez Peninsula area.

6 See, for example, the general review and discussion on oral history and oral traditions by Neumann (1992) in his book on the Tolai people of Rabaul.

7 See, for example, recent compilations of conference papers on volcanic oral traditions edited by Grattan & Torrence (2007) and Cashman & Giordano (2008). These compilations include specific papers on oral traditions in volcanic areas of the south-west Pacific by Cronin & Cashman (2007) and Cashman & Cronin (2008).

recognised the importance of spirit worlds involving deities, ancestors, totems, as well as fiends who exist alongside humans in the physical universe. Powerful spirit figures in volcanic areas were feared, or at least recognised as requiring respect or some sort of propitiation through ritual and ceremony. The many features of the volcanic landscape at Rabaul are an example where different kinds of spirits or *kaia* inhabit different landscape features and where the word 'kaia' itself in Tolai society was in some instances synonymous with active volcanoes. Tolai oral tradition includes the story of the eruption at Sulphur Creek in about 1850, which is told allegorically and dramatically as a fight between a large crab and a snake from the spirit world.

The names of some spirits in parts of Near Oceania are those of active volcanoes themselves. Ulawun and neighboring Bamus are examples, both deriving from the story of the 'smoking' Ulawun who is also known as the Father. The spirit Ulawun is said to have introduced tobacco to the local Nakanai people. He married a Nakanai woman, and Bamus is one of their sons — hence 'South Son' as a synonym for Bamus. In addition, Karkar volcano is named after a founding ancestor who is now present in the spirit world. The summit caldera area of Karkar, including Kanagioi peak, is where people live after death, together with deities and ancestors, as well as being the site of the Christian 'heaven' and a place where 'cargo' is manufactured. Perhaps the most dramatic volcano-related personality in Near Oceania is Zaria, the terrifying female spirit who lives in the active crater of Manam Island and who features in stories of the origin of fire and whose unfortunate husband is seen frozen in geological form as Yabu Rock on the south-western side of the island. The crags at the summit of Lamington volcano in Oro Province also held geo-legendary significance for the local Orokaiva who regarded the summit as the centre of their universe. The ancestor Sumbiri was the first Orokaivan to die. He became a spirit master, living inside the mountain along with those Orokaivan people who died after him.

All of these stories — at Ulawun, Bamus, Karkar, Manam and Lamington — refer to the summits or active craters of high volcanic mountains inhabited by personalities from the spirit world, but avoided by humans. Non-settlement by people of these volcanically dangerous summit areas is a sensible precaution, of course, and the stories do raise the possibility that the existence of the spirits worked as a good reason for people to stay away. The spirits in practice may, therefore, have been effective in reducing volcanic risk.

People living on or near three other volcanoes in Near Oceania have stories relating to eruptions that were not witnessed by Europeans, but which, to differing degrees, are potentially valuable as sources of volcanological information. The villagers of Savo Island in the Solomon Islands have a rich oral history of large prehistoric eruptions for the volcano that today is regarded, on the basis of its volcanic geology and historical activity, to be still dangerous. Strong oral

traditions also underpin the existence of Yomba volcano, south-east of Long Island, where Hankow Reef now exists, and whose strange disappearance — according to some of the stories — is said to have been catastrophic. Hankow Reef may well be built on a volcanic foundation, but side-scan surveying of the surrounding sea floor has not revealed any further evidence relating to the past geological history of this legendary volcanic island. The third example is the comprehensive collection of stories collected from mainland New Guinea, and from the highlands region in particular, of the ash falls that produced the Tibito and Olgaboli tephtras exposed, for example, at the Kuk archaeological site. The younger Tibito Tephra appears to correlate with the Matapun Beds on Long Island, which were deposited at about the time of the latest, caldera-forming, VEI 6 eruption at Long. The oral traditions in the Huli area of the highlands concerning Tibito Tephra include the well-documented and ash-fall-related phenomena of *mbingi*, which includes the preparations that must be made traditionally for similar events in the future — an example of prehistoric disaster mitigation.

All three of these examples of volcanic oral tradition have ongoing issues concerning the accurate dating of the events or observations being reported, and relating their timing to the modern calendar. Some attention has been given to this challenge by counting the number of reporting generations, of a particular length, back to the time of the original event in a narrative of oral history. Such counting is difficult because the narratives cannot be regarded necessarily as being chronologically precise. Generations may be omitted or added for reasons related to, for example, claims on land, or tribal competition for political and social dominance, or simply by human error. The narratives also cannot be regarded as being designed and promulgated primarily for the transmission of precise historical facts, but rather may have cultural, even artistic and poetic value that has been used for ritual or performance purposes. Furthermore, verification of the claimed generational sequences from more than one authoritative source may be impossible to obtain. Radiocarbon dating of materials hosted by tephtras or their palaeosols may help in some cases, but accurate correlation of isotopic values for very young materials to just a few years on the modern calendar is still difficult, despite modern advances in radiocarbon dating. Large, global, volcanic events can be dated on an annual basis from suitable ice-core and tree-ring records. Identifying the source volcano, however, involves a process of eliminating other volcanoes and eruptions, which depends on having good radiocarbon dates in the first place.

## International Disaster-Risk Reduction

More important than interpretations from archaeology and the oral traditions of former times are the present-day risk perceptions of communities in volcanically active Papua New Guinea and the Solomon Islands. Contemporary risk perceptions cannot be assumed to be those of yesterday. Oral traditions can and should be studied, but modern at-risk communities in Near Oceania now live in a different world, one that is globalised, technologically linked, and governed largely by the forces of secular rationalism rather than by traditional belief systems. The modern world's strengths and opportunities need to be used in the ongoing work of volcanic disaster risk reduction. This world is, however, a global network of interaction and competition, a hierarchical patchwork of national sovereignties in which global wealth and human capacity are unevenly and unfairly distributed. Global climate change, population growth, stresses on essential resources, losses of biodiversity, and the threats of nuclear catastrophe between warring nations, are dominant global threats and risks, rather than volcanic ones.

Financial support for international disaster management efforts is directed largely towards relief and recovery following major disasters, such as the 2004 Indian Ocean tsunami, the 2010 Haiti earthquake, and the 2011 Honshu earthquake and related tsunami and Fukushima nuclear-power disaster. These disaster responses represent episodes of altruistic, humanitarian and material outpouring, which is assisted by the voluntary financial contributions made by concerned citizens from many countries. The needs of the affected countries are promoted dramatically by global media outlets through news stories and high-impact film footage and social media. Funding for disaster recovery may also, in some instances, lead to economic and social benefits that did not exist in the affected country before the disaster. There are also many political and diplomatic rewards and advantages to be gained on the international stage by countries who respond generously and effectively at such times of tragedy. In contrast, however, funding for disaster risk reduction — that is, the mitigation or prevention of and preparation for disasters — tends to be less forthcoming, despite work by the United Nations through its International Strategy for Disaster Reduction, or the World Bank through its Global Facility for Disaster Risk Reduction. Furthermore, successful application of disaster risk reduction efforts does not make for exciting stories and thus it receives little attention from the world media. Disaster risk reduction today is, nevertheless, a well-known theme in the international field of disaster management. It even has its own acronym, DRR, which has become part of disaster management language of government policy-making and academic research.

There are many ways in which DRR can be achieved nationally and locally. Hazard and risk-assessment and mapping are essential as ways of identifying community vulnerabilities, and a clear determination of community risk perceptions is fundamental. Hazard awareness-raising in communities is important, including through education and formal inclusion in school curricula. Legislation to prevent development in areas vulnerable to natural hazards can be productive but difficult to impose. Effective building codes ensuring the construction of safe housing during, say, earthquake-induced ground shaking is another way to achieve DRR, if the resources are available to build safer buildings. Scientists, engineers, technicians and town planners also can consider DRR issues when designing the placement and construction of roads and bearing in mind evacuation routes to predetermined refuges, as well as early warning systems and critical infrastructure such as hospitals, power plants, airports and harbours. The rapid transmission of hazard alerts is critical and ideally must include partnerships with the news media. At-risk communities can practice prescribed evacuations.

DRR is also an element of international development assistance for countries, such as Papua New Guinea. Natural hazard risk reduction concepts are included in the development assistance policies of many national and international donor agencies. Development assistance is well known as an effective instrument of political influence, but in some countries, international disaster management can be a crowded 'market place', requiring recipients of such assistance to manage the diplomatic complexities of implementation that are caused by the attention of multiple, possibly competing donors. Some donor agencies are more concerned than others about the effectiveness of their investments and whether resulting improvements are sustainable once the assistance ends.

This, then, is the general context for the more specific issues of volcanic risk reduction in Near Oceania, including what role volcanological observatories should play.

## **Observatories and Volcanic Disaster-Risk Reduction**

The European concept of the 'volcanological observatory' was imported to the New Oceania region from the Netherlands Indies in 1937, during Australian colonial times, and the first 'volcanological observatories' — built in Italy in the second half of the nineteenth century — were based on the model of astronomical observatories equipped with telescopes for observation and study of the planets and stars. Telescopes were, and still are, used for such direct 'observing' purposes in many volcanological observatories, which may be situated on isolated,

underpopulated parts of mountains providing good visibility of summit areas and active craters. This physical isolation of observatories, however, commonly gives rise to perceptions of a monastic culture of volcanologists who focus on narrow scientific endeavours that are separate from the needs of the real world. Furthermore, the observatory culture has developed its own set of customs, mores, and traditions that have been built up over many decades in different parts of the world.

Volcanological services in Third World countries, such as those of the Circum-Pacific region, are run largely by governments, which means that volcanologists and technicians are public servants who are accountable to the government in power. Furthermore, national volcanological services commonly operate from a single headquarters, which may be identified as the country's volcanological centre or 'observatory'. There is a high public expectation that such taxpayer supported volcanological centres will be successful in providing a national eruption early warning service based on the data recorded from instruments installed on threatening volcanoes. Evacuations can be recommended, thus reducing the risk of potentially damaging effects on society. An ideal situation is where such instrumentation on any one active volcano is permanent and can be operated 24 hours a day, seven days a week. This may not be possible, however, if there are many dangerous volcanoes scattered throughout the country and national funding support is inadequate for capital and maintenance costs for instrumentation at all of them. Theft, vandalism, scavenging, and the climatic deterioration of equipment deployed in isolated areas, as well as the destruction of instruments by volcanic eruptions, are additional problems. Indeed the question should be asked: Is the instrument-based volcanological observatory 'model' still relevant to the challenges of volcanic DRR work in modern and independent countries, such as Papua New Guinea? The question is important in recalling that only once during the last 75 years has instrumental data been significant in declaring the need for evacuation anywhere in Near Oceania — at Ulawun in 2000. Alternative strategies may be needed in order to reduce volcanic risk, especially during times of crisis.

Interpreting the results of instrumental monitoring on volcanoes is not straightforward, whether in a wealthy or less privileged country. This is because ground shaking measured by seismographs, or temperatures measured in thermal areas, or ground deformation measured by tiltmeters, GPS equipment, and so forth, are surface phenomena. They are related, but only indirectly, to the activity of deep-seated magma bodies, the important and primary characteristics of which — such as gas content, viscosity, temperature, pressure, and volume of magma likely to be erupted — cannot be measured by these secondary 'surface'

techniques. Neither can the robustness of blocked eruption conduits nor the strength of the crustal rocks that confine the pre-eruption magma reservoir, be measured by these methods.

Both Papua New Guinea and the Solomon Islands are young, sovereign, nation states which, like other volcanically active countries in the Circum-Pacific and in the Third World in general, occupy challenging places in a rapidly changing world. Thousands of people in Near Oceania live on or near volcanoes, many of which are capable of producing scales of eruption far greater than any recorded there in historical time. The Solomon Islands and Papua New Guinea, however, have contrasting opportunities and challenges in the field of volcanic DRR. Only seven of the 57 Holocene volcanoes of Near Oceania are in the Solomon Islands chain, and only Kavachi has been repeatedly active historically, so far without significant hazard impact. Historically active Savo, on the other hand, being so close to the capital Honiara, is a constant and visible reminder of future threats from this potentially dangerous volcano. There is no national volcanological service in the Solomon Islands, as there is in Papua New Guinea, and all matters pertaining to geological hazards are covered by a small number of general geoscientific staff in the Ministry of Mines, Energy and Rural Electrification in Honiara.

The population of the Solomons is probably around only 550,000, spread mostly amongst the small islands of the western Solomon Islands chain. Neighbouring Papua New Guinea, in contrast, has a population approaching seven million, and has an abundance of natural resources including minerals and natural gas — particularly on New Guinea Island which is by far the largest land mass in Near Oceania. Papua New Guinea, therefore, has considerable wealth potential, which if realised, could be invested in the strengthening of public service agencies, such as the national volcanological service. RVO in principle, therefore, could become self-sufficient in the years ahead, and ideally may not require international development assistance for undertaking its work.<sup>8</sup>

Determining the type and extent of instrumental monitoring on the many active volcanoes of Near Oceania thus remains a difficult challenge. The posed question then reduces to one of cost-benefit: Are instrumental systems on active volcanoes the best and most cost effective way of reducing volcanic risk through early warning of eruptions?

---

<sup>8</sup> There is value in this context of Papua New Guinea and the Solomon Islands joining with Vanuatu in supporting the creation of a Melanesian Volcanological Network, and collaborating in the exchange and sharing of the volcanological resources in each of the three countries. A proposal for such a network was completed in 2008 by the Applied Geoscience Commission SOPAC, which is now a division within the Secretariat of the Pacific Community, SPC. The proposal has yet to attract financial support.

## Strengthening At-Risk Communities in Near Oceania

A striking conclusion from the analysis of evacuations in Near Oceania since 1937 is that communities at risk from volcanic eruptions in Papua New Guinea are commonly self-reliant when decisions have to be made about their own safety and the need for possible evacuations. Such community decisions typically can be made promptly, responses can be rapid, and the evacuating communities can be remarkably mobile, as long as authorities do not interfere negatively with the spontaneity of the process, as in the case of Lamington in 1951. ‘Spontaneous’ evacuations such as these can, in many circumstances, be a more effective way of volcanic-threat avoidance, compared with waiting for instrument-based early warnings of eruptions from cautious, distant authorities. Well-informed, resilient, and self-sufficient communities may be the first to recognise the earliest signs of volcano change, meaning that professional volcanological assistance can be requested. Volcanologists can then respond rapidly and deploy mobile arrays of instruments, if necessary, for further assessment of the potential threat. This may be a more practical option for countries such as Papua New Guinea where funding support may not exist for expensive, permanent, and sustainable instrumental networks on volcanoes.

A critical success factor for any national volcanological observatory is the way in which it collects, compiles, stores and analyses information about the nation’s volcanoes. Making observations of eruptions and collecting instrumental data are important, but there is also a fundamental requirement to ensure that the different types of scientific information obtained by one generation of volcanologists are made available as a legacy for the next. This is where compiling data, writing reports, building bibliographic reference collections, managing geographic information systems, and using national spatial-data infrastructures are crucial, not just for coping with contemporary volcanic crises, but for future ones too. Knowledge is, indeed, crucial and much still needs to be learnt about the dangerous volcanoes of Near Oceania — their geological histories, scales of past eruptions, internal structure, and how threatening magmas come to be emplaced and then evolve beneath the volcano. Additional investment in investigative field surveys and related research must continue, leading to a greater understanding of how threatening volcanoes ‘work’.

These themes as a whole give rise to the requirement for an even stronger program of building volcanically resilient at-risk communities in which instrumental monitoring plays a more balanced, cost-effective, and sustainable part. A government volcanological agency such as RVO is required to advise provincial authorities and its host department in Port Moresby regarding volcano status, eruption alerts, and evacuation recommendations, as it has done

since its establishment in 1940, but public awareness campaigns are now at the core of RVO's work. Papua New Guinean staff from RVO make repeated visits to volcanically at-risk communities, giving presentations at open meetings, answering questions, and using audio-visual equipment. They visit schools and, in East New Britain, encourage visitors to observatory headquarters in Rabaul to see the volcano-monitoring instrumentation in operation, where necessary providing transport from outlying areas.<sup>9</sup> Volcanology is an international science that progresses resolutely on many fronts and 'does what it must', but there are no reasons why at-risk communities in Near Oceania cannot continue to increase their resilience by taking greater advantage of the transferable knowledge that the science provides.



**Figure 130. RVO officer Jonathan Kuduon, on the left, addresses school children and other villagers during a volcano-awareness campaign at Bokure village on Manam volcano in 2000.**

Source: D. Okole. Rabaul Volcanological Observatory.

<sup>9</sup> A different approach is the Participatory Rural Appraisal or PRA methodology used at a workshop on Savo Island in 1999. The PRA methodology was developed overseas and the main drivers for the workshop were three volcanologists from New Zealand and Australia 'who tried to combine the roles of facilitators and educators, and to involve the input of all stakeholders (from community to national government) in the process of volcanic risk management' (Cronin et al. 2004b, p. 105; see also Petterson et al. 2008). The same methodology was used on Ambae Island, Vanuatu, where a special attempt was made to incorporate traditional knowledge of eruptions with scientific concepts (Cronin et al. 2004a).

## References

- Byrne, J., 2012. 'Noted', *The Monthly*, February, p. 64.
- Cashman, K.V. & S.J. Cronin, 2008. 'Welcoming a Monster to the World: Myths, Oral Tradition, and Modern Societal Response to Disasters', in K.V. Cashman & G. Giordano (eds), 'Volcanoes and Human History', *Journal of Volcanology and Geothermal Research*, 176, no. 3 (special edn), pp. 407–418.
- Cashman, K.V. & G. Giordano (eds), 2008. 'Volcanoes and Human History', *Journal of Volcanology and Geothermal Resources*, 176, no. 3 (special edn), pp. 325–437.
- Cronin, S.J. & K.V. Cashman, 2007. 'Volcanic Oral Traditions in Hazard Assessment and Mitigation', in J. Grattan & R. Torrence (eds), *Living Under the Shadow: Cultural Impacts of Volcanic Eruptions*. Left Coast Press, Walnut Creek, California, pp. 175–202.
- Cronin, S.J., D.R. Gaylord, D. Charley, B.V. Alloway, S. Wallez & J.W. Esau, 2004a. 'Participatory Methods of Incorporating Scientific and Traditional Knowledge for Volcanic Hazard Management on Ambae Island, Vanuatu', *Bulletin of Volcanology*, 66, pp. 652–68.
- Cronin, S.J., M.G. Petterson, P.W. Taylor & R. Biliki, 2004b. 'Maximising Multi-stakeholder Participation in Government and Community Volcanic Hazard Management Programs; A Case Study from Savo, Solomon Islands', *Natural Hazards*, 33, pp. 105–36.
- Grattan, J. & R. Torrence (eds), 2007. *Living Under the Shadow: The Cultural Impacts of Volcanic Eruptions*. Left Coast Press, Walnut Creek, California.
- Harris, S.L., 2000. 'Archaeology and Volcanism', in H. Sigurdsson (ed.), *Encyclopedia of Volcanoes*. Academic Press, San Diego, pp. 1301–314.
- Neumann, K., 1992. *Not the Way It Really Was: Constructing the Tolai Past*. University of Hawaii Press, Honolulu.
- Petterson, M.G., D. Tolai, S.J. Cronin & R. Addison, 2008. 'Communicating Geosciences to Indigenous People: Examples from the Solomon Islands', in D.G.E. Liverman, C.P.G. Pereira & B. Marker (eds), *Communicating Environmental Geoscience*. Geological Society, London, Special Publications, 305, pp. 141–61.
- Sheets, P., 2007. 'People and Volcanoes in the Zapotitan Valley, El Salvador', in J. Grattan & R. Torrence (eds), *Living Under the Shadow: Cultural Impacts of Volcanic Eruptions*. Left Coast Press, Walnut Creek, California, pp. 67–89.

- Siebert, L., T. Simkin & P. Kimberley, 2010. *Volcanoes of the World*. 3rd edn. Smithsonian Institution, Washington D.C., University of California, Berkeley.
- Stehn, Ch.E. & W.G. Woolnough, 1937. 'Report on Vulcanological and Seismological Investigations at Rabaul', *Commonwealth of Australia Parliamentary Paper 84 of 1937*, pp. 149–58.
- Torry, W.I., 1978. 'Natural Disasters, Social Structure and Change in Traditional Societies', *Journal of Asian and African Studies*, 13, pp. 167–83.