Editorial

Volcanoes and occupational health

Volcanic eruptions are one type of natural disaster in which occupational health workers may be called on to advise either locally on disaster measures or, from a distant haven, on the health implications for expatriate communities and employees visiting or working in volcanic areas. In particular, questions may arise on the risks of inhaling volcanic ash particles, the toxic effects of ash on water and food supplies, and the hazards of volcanic gases. Before the eruption of Mount St Helens in the United States on 18 May 1980, information on such topics was scanty or anecdotal.¹ After the eruption, the covering of a large part of Washington State with a layer of fine volcanic ash up to several centimetres deep made the need for more scientific information imperative. The results of the immediate and longer term multidisciplinary health studies that followed this major eruption have now been compiled in a monograph.²

The widespread ashfall across Washington State was not remarkable for a volcano as active and as dangerous as Mount St Helens, but as its last eruption before the 1980 phase of activity had been in 1857, and as preplanning measures had not included the public health consequences of a heavy ashfall, both the population and the emergency services were taken completely by surprise. Much of central Washington state came to a halt for up to a week afterwards until rain and clean up operations had reduced the concentrations of ash in the air. Health concerns immediately arose among those living in the worst hit areas and further anxiety was engendered by the conflicting advice given by the media and medical profession. For example, some health workers and the public alike mistook the high but relatively harmless content of silicon dioxide (silica) in the silicate minerals and glass in the ash (60-65%) for the crystalline silica which would determine the potential of the ash to cause silicosis. Volcanic ash contains metallic elements as does ordinary rock but the mere mention of these constituents awoke fears of poisoning, so that blood samples from some anxious citizens were sent for analysis in a futile attempt to measure exposure.

In a chapter explaining volcanology for health professionals, in which the monitoring of a volcano's activity is interestingly compared with medical diagnosis, Newhall quotes from a Spanish landowner in the Philippines in 1814 who faced similar confused speculation: "During the two days when our atmos-

phere was filled with fine dust which the volcano of Alway hurled into the air, it was at once heard that several analyses had been done ... that some had extracted lead, some iron, and others gold; there were even some who were not sure whether they had extracted pearls or diamonds ...". Into the confusion at Mount St Helens stepped laboratory workers from the National Institute for Occupational Safety and Health (NIOSH) who rapidly determined that the crystalline silica content of the ash was 3-7% by weight, comprising about 2% quartz and 4% cristobalite. This early finding was subsequently confirmed but was initially met with disbelief in geological laboratories accustomed to performing classic mineralogical analysis. A chapter by Dollberg and his coworkers describes this controversy and the analytical problems, showing that x ray diffraction and other methods were appropriate if preceded by a digestion procedure routinely adopted by occupational health laboratories which removed the plagioclase minerals and left the crystalline silica intact. There was complete agreement from the outset on chemical testing for pH and leachable toxic elements: the ash posed little if any risk of contamination of water and food from heavy metals or fluorine, though the latter is commonly a hazard in Icelandic eruptions. The theoretical possibilities that the ash might comprise large numbers of asbestiform fibres, or had been made dangerously radioactive by radon released during the eruption, were also excluded.

The steps in formulating hypotheses for health effects arising from the inhalation of ash are discussed by Buist and her coauthors. A particular concern was that at least 90% of the ash particles in samples taken at different sites across Washington State were, by count, within the respirable range in size ($< 10 \mu\text{m}$). During and after the ashfall from the eruption on 18 May and for weeks later whenever the ash was resuspended by winds and traffic, air concentrations regularly exceeded United States ambient air quality standards for total suspended particulate matter arising from fossil fuel pollution (in the city of Yakima, for example, concentrations recorded by a standard air pollution sampler averaged $33402 \mu\text{g}/\text{m}^3$ on 18 May). Although residents heeded media warnings with many staying indoors during these periods, outdoor workers, particularly those in the police and clean up crews, were less fortunate. In addition, log-

ging and agriculture activities had to resume eventually despite a layer of ash persisting on the ground and on vegetation. Though many outdoor workers were found to experience only transient exposures higher than the NIOSH recommended limits for industrial dusts containing crystalline silica, the loggers and agricultural workers were at greater risk. The *in vitro* (tissue culture) and *in vivo* (intracheal injection and inhalation) studies performed to determine more precisely the fibrogenic potential of the ash are discussed by Martin *et al*, who show that the ash was only slightly toxic to lung cells compared with crystalline silica itself, but that it was not entirely inert. Another question was whether exposure to ash increased the risk of lung infections through impairment of bacterial and antiviral defences or cell mediated immune mechanisms: experimentally, the former at least seemed unlikely.

Attention also focused on the risk of irritation and inflammation of the respiratory tract and bronchoconstriction in individuals with hyperactive airways. Epidemiological surveillance of trends in visits to emergency rooms and admissions to hospital in the ashfall areas was established soon after the 18 May eruption, and in this and the two subsequent eruptions (25 May and 12 June) transient, modest increases in the numbers of patients attending with bronchitis and asthma were found. No increases in respiratory mortality were observed. A household survey in Yakima found that, despite the protection afforded by their homes, about a third of patients with known chronic respiratory disease developed an exacerbation of their symptoms after the ashfall, continuing in some patients for at least three months afterwards while the ash persisted in the environment. To answer questions about the long term effects, a high exposure group of loggers was identified at the invitation of a major logging company and a prospective epidemiological study was mounted first by NIOSH and was subsequently taken over by the Oregon Health Sciences University. Buist *et al* summarise the findings of their five year follow up which are reassuring, though they cannot be extrapolated to more susceptible individuals living in the community. Lung function, including a questionnaire on respiratory symptoms, was recorded annually and the main finding was that the exposed loggers experienced a short term, reversible decline in lung function and a reversible increase in symptoms, both related to exposure, indicating that the ash probably acts as a non-specific particular irritant on the respiratory tract. As expected, there were no changes in chest

radiographs, but the silicosis question cannot be answered in such a short follow up, although the risk is probably remote. Other questions that remain unanswered are whether acute or chronic exposures to ash can lead to chronic changes in lung function in susceptible people as a result of an increase in airways reactivity or, as in other industrial dusts, by contributing towards the development of chronic bronchitis.

Toxic gases such as SO₂, CO₂, and H₂S, and their aerosols, were not important at Mount St Helens except to geologists making measurements near the active crater, but they can be at other volcanoes. Although only 67 people are believed to have been killed in the massive eruption on 18 May, this figure would have been many times higher if the disaster had occurred on a typical working day instead of early on Sunday morning. The remote area around the volcano was being regularly logged and serious questions of worker safety were posed given that access had been restricted to the general public because of the threatened eruption. Some of those killed had been working when the eruption began. Most of the victims were caught in the lateral blast and pyroclastic flow (a fast travelling dense cloud of intensely hot ash and fine rock particles) which extended for as far as 27 km. The commonest cause of death found at necropsy was asphyxiation. Two loggers who had been at a spot 19 km from the crater received extensive body burns and subsequently died in hospital from adult respiratory distress syndrome thought to be due to inhaling hot ash.

The ten chapters describe these and other occupational and public health consequences of the 1980 eruptions of Mount St Helens. Explosive eruptions occur several times a year around the world, and studies in other countries are now necessary to determine how confidently we can extrapolate from these accounts to volcanoes elsewhere.

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References

- ¹ Blong RJ. *Volcanic hazards: a sourcebook on the effects of eruptions*. Sydney: Academic Press, 1984.
- ² Buist AS, Bernstein RS, eds. Human health hazards from volcanic eruptions: approach to the evaluation of a new environmental health hazard. *Am J Public Health* 1986;76(suppl):1-90.