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factors affecting the potential toxicity of volcanic ash

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Multidisciplinary research into volcanic ash as a respiratory health hazard arose from the eruption of Mt. St. Helens (MSH), USA in 1980 and has returned to mainstream prominance in the wake of the recent Eyjafjallajökull, Iceland eruption in 2010. Exposure to ash is known to trigger acute respiratory diseases, such as asthma and bronchitis, and has the potential to instigate chronic diseases if the particles are sufficiently fine to deposit in the alveolar region of the lungs. One suspected disease-causing mechanism arises from the existence of crystalline silica in volcanic ash, specifically as cristobalite, which is classed as a human carcinogen. Recently, we have established that the potential toxicity of volcanic ash is likely to vary depending on the type and style of eruption. Dome-forming eruptions in particular tend to generate substantial quantities of crystalline silica, which crystallises as the lava dome slowly cools. An inherent feature of these domes is their instability, resulting in collapse of the dome and generation of ultra-fine (respirable) cristobalite-rich ash.

While extensive research has focused on the biological mechanisms of silica induced diseases, fewer studies have investigated the mineralogical properties that may influence biological reactivity. The effects of structure and composition on the potential toxicity of volcanic cristobalite are ill-defined as the physiological burden has only been sufficiently studied at one location; Soufrière Hills volcano (SHV), Montserrat. Here we present results from a systematic characterisation of the mineralogical properties of cyrstalline silica from a suite of volcanic locations, with a focus on the dacitic 1980-1986 and 2004-2006 dome-forming eruptions of MSH. To further definine the disease-causing potential of ash and to elucidate the properties responsible for adverse biological responses, the abundance, purity, crystallographic form, and crystal shape of volcanic silica were determined using XRD, electron microprobe, SEM, and Raman spectroscopy. As with previous observations at SHV, the cristobalite is found within the groundmass as well as growing into vugs in dome rock, in both platy and euhedral forms. The composition is impure, containing traces of other cations such as aluminium (up to 3 wt%). The quantity of cristobalite differs between volcanic settings due to variability in activity and duration of dome growth, with MSH dome rock elevated relative to SHV (4-15 wt. % compared with 1-10 wt. %). Collating results of mineralogical data from Mt St Helens, SHV, and future results from Merapi, Unzen, and Santiaguito will provide insights into the global respiratory hazard posed by volcanic ash. As higher levels of cristobalite in respirable ash raise concerns about the onset of chronic, injurious disease following human exposure, it will be possible to recognize hazards based on existing settings; thereby significantly aiding the work of disaster managers when assessing health hazards during risk mitigation.