Geophysical Research Abstracts
Vol. 13, EGU2011-2552-3, 2011
EGU General Assembly 2011

A mineralogical and toxicological assessment of the health hazard of ash from the 2010 Merapi eruption

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Mt. Merapi, Java is amongst the most active volcanoes in Indonesia and lies in one of the world's most densely populated areas, immediately north of the major city of Yogyakarta. The volcano commonly erupts viscous lava, forming an unstable dome in the crater. However, on 26 October 2010, a major explosive eruption began, with pyroclastic density currents (PDC) damaging nearby villages. Volcanic ash deposition was widespread but activity decreased around 9 November with cessation of ashfall by the end of November. With influx of ash from lahars and the history of mining of deposits in the region, it is likely that ash will continue to affect communities over the coming months to years. Following media reports of wide-spread respiratory health problems and the fact that people were returning to ash-covered homes, we launched an assessment of the risk of susceptible people developing acute and chronic respiratory diseases, such as asthma and silicosis, respectively, and associated diseases such as tuberculosis.

20 samples of fresh ash were sent to the UK and also collected by us (ash, lahar and PDC deposits) in early December 2010, when air quality assessment was also carried out. Following an existing protocol for rapid analysis of ash for health assessment, we carried out the following analyses: 1) grain size - to determine if the ash was inhalable (Malvern Mastersizer); 2) crystalline silica content (quartz and cristobalite) as silica is the primary toxic mineral in volcanic ash (XRD-PSD); 3) bulk composition – to determine variation in magma composition amongst samples (XRF); 4) particle morphology – to check for fibre-like particles (SEM/TEM); 5) surface area –closely related to toxic potential (BET); 6) leachates – to determine health-pertinent removable elements (ICP-MS); 7) surface reactivity e.g. generation of hydroxyl radicals and oxidative capacity of samples (EPR); 8) haemolysis and cytotoxicity assays – cellular bio-reactivity tests.

The ashfall from Merapi varies in the amount of respirable (< 4 μm diameter) ash (1.4 - 15.6 vol. %, typically < 10 vol. %). This range is typical of that observed in other explosive eruptions. The finest sample was erupted during the initial explosions on 26 October and its fineness may be attributable to the disruption and disintegration of an existing dome as values are in line with those seen in dome-collapse eruptions. The ash resulting from PDC, collected in people's houses, is also very fine-grained with two samples having 19 vol. % < 4 μm material. However, the sample collected from a lahar deposit (which might be mined at a later date) contained no respirable particles. The amount of crystalline silica varied considerably amongst samples. Most samples contained 3-6 wt. % cristobalite, typical of an explosive eruption at a dome-forming volcano (cristobalite is produced primarily in volcanic domes or through alteration of the edifice). Three samples contained 9-10 wt. % cristobalite, indicating that some dome or edifice material was entrained into the plume during the eruption (pure dome collapse ash might be expected to have 15-20 wt. % cristobalite). The quartz content of the ash was negligible (as magmatic quartz phenocrysts are not dominant minerals in trachy-basaltic/andesitic rocks). Other analyses are ongoing at time of writing. The results will add to our currently limited knowledge on the health impacts of ash in volcanic crises in low-income economies.