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Block-and-ash flow dynamics and hazards at Merapi volcano (Java, Indonesia): a ground penetrating radar approach

R. Gertisser, N. Cassidy, L. Nuzzo, S. Charbonnier, and K. Preece
Earth Sciences and Geography, Keele University, Keele, ST5 5BG, United Kingdom (r.gertisser@esci.keele.ac.uk)

Merapi, a composite volcano in Central Java, is best known for its nearly persistent volcanic activity characterized by the extrusion of viscous lava domes and collapse of these domes to produce block-and-ash flows (BAFs). BAFs generally follow narrow valleys resulting in distally extensive, yet spatially confined, deposits having significant depths, even at large distances from the source. As observed during the most recent eruptive episode of Merapi in 2006, these flows can also separate from the main channels and spill over the valley sides to create relatively thin overbank flows that extend across and cause widespread devastation in interfluve (non-valley) regions on the volcano's flanks. These areas often contain the highest population densities as they are considered safe from the effects of flash flooding, lahars and all but the most extreme eruptions. As such, predicting the occurrence, nature, extent and location of BAFs and related overbank flows is vital for accurate and realistic assessments of their volcanic hazard and risk potential.

In August 2008, a four-week field programme of ground penetrating radar (GPR) data collection was carried out on the 2006 deposits aiming to improve traditional models of BAF transport and deposition. By their very nature, these models often rely on observational and interpretational evidence alone, which can be complicated by a combination of poor exposure, rapid lateral facies variations and unknown palaeo-topography. Our GPR survey focused on the large-scale (deposit) and small-scale (intra-deposit) structures of the valley-filling BAF deposits in the Gendol river valley as well as the overbank deposits on either side of the main valley. Diffraction hyperbolae in the GPR sections from large, decimetre- to metre-sized blocks within the deposits and distinct, coherent and traceable reflections, related to changes in matrix grain size or distinct blocky horizons, can be related to observable features in exposed deposit sections. These allow larger scale variations in grain size and deposit thickness as well as flow unit boundaries to be traced and mapped at a metre scale over areas where exposure is limited or absent.

Given the unpredictable behaviour and potential for loss of life and property of BAFs, not only at this volcano but also at similar locations around the world, it is essential to improve models of the transport and emplacement dynamics associated with BAF deposits. With an unrivaled ability to non-invasively image the architectural complexity of BAF deposits, GPR is a useful, non-invasive tool for developing such enhanced models.