Cities on Volcanoes 9
November 20-25, 2016
Puerto Varas, Chile
'Understanding volcanoes and society: the key for risk mitigation'

Investigating topographic effects on block-and-ash flow dynamics and hazards

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Keywords: block-and-ash flows, geomorphology, channel capacity, overbank flows

Block-and-ash flows (BAFs) are small-volume pyroclastic flows generated by lava dome (or lava flow front) collapse and are problematic as it is difficult to predict the scale, duration, periodicity and spatial distribution of their flows. They possess a sensitive dependence on local slope and surface roughness, and the effects of this dependence become more important as the current approaches the deposition phase. Despite this known physical link between flow behavior and topographic parameters, rheological laws used in standard numerical models of BAFs are limited to bulk mobility, providing a poor approximation to real flow behavior. Their unpredictable character makes BAFs a high threat to surrounding populations at active volcanoes, specifically when involving the breakout of valley-confined BAFs into unconfined overbank flows, spilling out of the principal valley paths. This phenomenon has been observed and described in the past at Merapi (Indonesia) and Soufriere Hills (Montserrat) volcanoes where the sudden reduction in channel capacity, and/or the presence of break-in-slope and high channel sinuosity, were correlated with the generation of deadly overbank flows. Detailed investigations of the recent BAF events in July 2015 at Volcán de Colima (Mexico), through field, laboratory, GIS and remote sensing studies, emphasize the key effects of major geometric changes in the affected valleys in controlling the generation and emplacement of overbank flows. The rapid infilling and erosion of pyroclastic material by the successive emplacement of a series of BAF pulses in the Montegrande ravine resulted in sudden changes in valley morphology, which precipitated the generation of over-spilling BAFs. These findings aim to: (1) define new empirical relationships between the processes that control the emplacement and deposition of BAFs and their potential for overspill/avulsion and local geomorphic parameters; (2) invert key flow parameters at critical locations comprising the source database needed for enhancing and calibrating standard PDC-hazard models.