Dynamics of explosive paroxysms at open-vent andesitic systems: High-resolution mass distribution analyses of the 2006 Tungurahua fall deposit (Ecuador)

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Abstract

Long-lasting andesitic eruptions sometimes include strong short-lived explosive events, which can pose significant hazards in populated regions. The origin and dynamics of such violent eruptions remain poorly known and may involve a combination of different factors. Tungurahua volcano, Ecuador, reawakens in 1999 and is an example of such an open-vent system that experienced a strong and deadly andesitic pyroclastic flow-forming event in August 2006. Inspection of the deposits suggested that the event could have been triggered by magma mixing (coexistence of both silicic pumices and andesitic scoria in the tephra), magma–water interaction (presence of xenolithic clasts) or deep andesitic magma reinjection (based on mineral chemistry). Here we investigate these options by performing a high-resolution mass budget analysis of the scoria fall deposit. This is achieved by analysing componentry compositions and their mass distribution pattern in the layer, which allow us to document and integrate exponential and power laws mass decay rates over wide areas. The results yield a total mass for the tephra layer of $\sim 2\times10^{10}$ kg. The pumice mass fraction is far too small (<0.4%) to account for the high explosivity of the 2006 event. Similarly, the xenoclastic mass fraction is unexpectedly small (0.2%) and suggests limited magma–water interaction. Instead, we interpret these xenoclasts as a result of upper conduit erosion at a rate of ~30 cm/h during the paroxysm. Altogether our results support an explosive event fed by a deep gas-rich andesitic reinjection, which would have incorporated a pocket of older differentiated magma and eroded the upper conduit during the sub-plinian event. The high-resolution mass-based approach reveals useful to decipher the origin of the violent 2006 paroxysm and has potential to improve magnitude determinations of ancient eruption by considering componentry mass instead of volume. It is also applicable for monitoring purposes in the context of ongoing crises at andesitic volcanoes worldwide.

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