Volcano vs. environment: Where, when and why does ash aggregate?

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Volcanic ash is generated during explosive eruptions through an array of different processes; it can be produced in large quantities and can, in some circumstances, have the potential for far-reaching impacts beyond the flanks of the volcano. Aggregation of ash particles can significantly impact the dispersal within the atmosphere, and its subsequent deposition into terrestrial or aquatic environments.

However, our understanding of the complex interplay of the boundary conditions which permit aggregation to occur remain incomplete. Tungurahua volcano, Ecuador, has generated a series of pyroclastic density currents (PDC) in August 2006 during a series of dry, Vulcanian explosions that travelled down the western and northern flanks of the volcano. In some locations, the related PDC deposits temporarily dammed the Chambo river, and the residual heat within those deposits produced vigorous steam plumes. During several field campaigns (2009- 2015), we mapped, sampled, and analysed the related deposits. At the base of the Rea ravine, PDC deposits today are approx. 10 m thick, mainly comprised of massiveash-lapilli tuffs. In the top 10-15 cm, we observed abundant ash aggregates up to eight millimetres in diameter within a poorly sorted, ash-depleted lapilli tuff, primarily comprised of rounded pumiceous and scoriaceous clasts of similar size. This peculiar stratigraphic layer is capped by a thin fall unit of coarse ash that we also find elsewhereat the top of the August 2006 deposits, proving the deposits' primary nature.

Leaching experiments have shown that these aggregates contain several hundred ppm of soluble sulphate and chloride salts. Analysis of water samples of the Chambo river doesn't show any significant pattern that could explain this pattern. Recent laboratory experiments (Mueller et al. 2016) have shown that aggregate cementation is enhanced by crystal growth from phases dissolved in water upon evaporation as it enhances the probability of accretionary lapilli preservation. In the case of Tungurahua, we suggest that steam pluming from the dammed Chambo river, coupled with soluble salts emplaced by gas-ash interactions between ejection and deposition, provided a unique opportunity for the formation of accretionary lapilli with sufficient mechanical strength to survive deposition, accounting for their presence in a deposit otherwise absent of such aggregates. Textural analysis of these aggregates did not reveal features unique to this genesis. This scenario provides an important reminder of the role played by external environmental triggers in shaping the properties volcanic ash deposits.