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Soluble salt concentrations in volcanic ash aggregates from subaqueous eruptions and related hazards

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Surtseyan eruptions are emergent subaqueous volcanic eruptions that can cause perturbations of air traffic as well as hazards in densely populated areas. Aggregation, an important process affecting tephra dispersal, ash budget and subsequently hazards associated with volcanic plumes, is common during Surtseyan eruptions. The seawater setting and high humidity during this type of volcanic activity might provide an important source of soluble salts which are a key factor to the stabilization, cementation and hence survival of the fragile aggregates. Understanding the role of salts on aggregate stability during Surtseyan eruptions is therefore crucial to shed light on the hazards for air traffic and populations in Surtseyan settings.

In this study, we used aqueous leaching to characterize surface salt loading of ash in aggregates generated in Surtseyan and subaerial eruptive settings. We measured the concentrations in Al, Ca, Fe, K, Mg, Mn, Si, Na, Cl and SO4. We additionally performed chemical mapping and morphological observations on these agglomerates using a Hitachi SU 5000 Scanning electron microscope (SEM) at LMU.

We observed the highest concentrations of Cl, Na, SO4, Ca, Mg and K in the aggregates formed during the 2014-2015 Surtseyan eruption of Hunga Tonga-Hunga Ha'apai volcano, Tonga. On the other hand, we found the lowest concentrations for a dry, salt-poor subaerial plume at El Salvador. Intermediate concentrations were observed in aggregates from PDCs interacting with freshwater at Tungurahua volcano (Ecuador) and PDCs entering the ocean at Montserrat. The molar concentrations between the cation-anion pairs Na-Cl and Ca-SO4 show 1:1 trends for Tonga, implying that NaCl and CaSO4 are the most ubiquitous soluble salts in the aggregates examined here, as confirmed by chemical mapping at the SEM. We additionally observed a decrease in the salt content with stratigraphy at Tonga, suggesting a reduction of the degree of magma-water interaction during progressive emergence.

These results suggest that Surtseyan eruptions involve higher rates of aggregation and increased stability of the generated aggregates compared to subaerial eruptions. This has strong implications related to tephra dispersal and related hazards for air traffic and populations in the vicinity of Surtseyan volcanoes. We generalize our results in a conceptual model linking the amount of external water and external salt source to the salt concentrations found for different eruptive settings. The presented dataset of salt concentrations can serve as a tool for ash dispersal modelling.