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In-plume gas scavenging: Insights into gas adsorption, ash-surface chemistry and the role of water

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In-plume gas scavenging-processes are well known to occur in large volcanic eruptions, where, over the range of plume conditions (temperature and gas composition) and physicochemical ash-surface properties, volcanic gases (mainly SO_2, HCl, and HF) can be sequestrated by the occurrence (alone or combined) of three processes: (1) salt deposition, (2) adsorption, or (3) acidic liquid condensation on the ash-surface. Several studies have sought to constrain the diffusion-driven mechanisms through which scavenging occurs, the optimal temperatures for efficient scavenging, and the likely reaction products formed. Here we bolster these datasets with new high-resolution experimental work.

Our current project additionally seeks to identify the role of water vapour in gas scavenging processes using a time- and temperature- series of experiments with well-characterized ash samples, for which, particle size distribution, surface area, and bulk chemistry were constrained. These samples will be exposed to various hydrous and anhydrous gas atmospheres with proportions of some plume-relevant gas mixtures (SO_2, SO_2-H_2O) at high temperatures (200 to 800 °C) for various time series (1 to 60 min.) in the Advanced Ash-Gas Reactor (AGAR) available at the LMU chemistry laboratory.

Post-experimental samples are analyzed by standard leachate techniques. We show that a diffusion-controlled sequestration mechanism will be strongly temperature dependent proportional to the diffusivity of the mobile species. In complex mixtures of gases, which could result in the diffusion of more than a single species, it remains to be tested whether simple diffusion models can yield average sequestration volumes. This will be tested explicitly using simple diffusion time scaling laws. Future work should target the additional combined effects of HCl, SO_2 and H_2O in more realistic complex volcanic atmospheres.