



Quantifying HCl and SO₂ adsorption by tephra in volcanic eruptions

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Tephra-gas interaction in eruption plumes leads to scavenging of volatiles (SO₂, HCl, HF) and forms soluble salts and aqueous acids on tephra surfaces. The presence of these compounds may induce a number of environmental effects upon tephra emission and deposition. These may range from acid damage to vegetation surfaces, to the release of key nutrients or toxic metals into lake or surface ocean waters. It has also been suggested that alterations to tephra surface chemistry imparted by volatile scavenging may contribute to in-plume particle aggregation, so influencing tephra dispersal and fallout. Gaining further insight into the possible effects associated with, or indirectly resulting from, gas-tephra interaction necessitates a renewed mechanistic investigation of the latter. Such an undertaking must expand upon the three stage, 'solid aerosol adhesion / volatile adsorption / acid condensation' scavenging model proposed by Oskarsson in 1980. We present the results of SO₂ and HCl uptake experiments on tephrite, phonolite, dacite and rhyolite glass powders conducted over a range of in-plume temperatures (100-800°C). Using a suite of analytical techniques, we identified coupled adsorption-diffusion mechanisms driving the scavenging of SO₂ and HCl. These volatiles reacted with Ca- and Na-bearing surface sites to form CaSO₄, Na₂SO₄ and NaCl deposits; uptake is thought to be sustained respectively by near-surface co-diffusion of O²⁻ with Ca²⁺ or Na⁺, and interdiffusion between H⁺ and Na⁺. The scavenging of SO₂ and HCl was also subject to complex thermal, temporal and compositional controls which were strongly influenced by the chemical composition of the glass. By reference to our experimental findings and to current plume evolution and conduit flow models, we are able to estimate the potential for SO₂ and HCl uptake by direct adsorption onto tephra particles within the eruption plume. Our findings therefore highlight those eruptive environments where in-plume gas adsorption may significantly alter tephra surface chemistry, and in doing so, may dictate the intensity of any induced chemical effects in the plume or in receiving environments.