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Volatile trace element emissions from magmatic degassing and lava-water interaction during the 2021 Cumbre Vieja eruption, La Palma

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Volcanoes emit large quantities of volatile trace elements to the atmosphere and surface environment, particularly during prolonged fissure eruptions. Many volatile trace elements are also classified as environmental pollutants and therefore emissions can impact on health and agricultural practices within local communities. Explosive lava fountaining during the 2021 Cumbre Vieja eruption, La Palma, generated energetic eruption plumes accompanied by sustained effusive activity (Fig.1). The first lava flows reached the ocean on 29 September producing a secondary plume fuelled by thermohydraulic interaction between lava and seawater; high lava fluxes into relatively shallow water quickly built an extensive lava delta.

We sampled the trace element and acid gas emissions (S, Cl) from explosive lava fountaining, non-explosive lava effusion, degassing lava flows (~3 km from source) and the ocean-entry using filter packs and cascade impactors (ground-based and aerial). S/Cl molar ratios vary between different degassing sources, from 34 in the explosive fountaining plume, to 2–4 in the non-explosive effusive plume, to 0.3–0.9 at the ocean-entry. The ocean-entry plume is rich in Cl, as expected from vaporisation of seawater, and also contains a greater % of S and Cl as particulate aerosols (versus gaseous) compared to high-temperature vent emissions. We find that S/Cl in the ocean entry plume increases over several days, reflecting a decreasing contribution from lava-seawater interaction relative to degassing lava flows in the cooling lava delta. This result suggests that thickening of the delta prevailed over lateral expansion and self-limited seawater interaction, consistent with visual observations. This situation contrasts with the ocean-entry established during the 2018 KÄ«lauea eruption, Hawai'i, where lava-seawater interaction was fed predominately by lava tubes into deep water, thus sustaining a much higher interaction efficiency. We will present trace element signatures for all degassing sources and test the hypothesis that differences in the outgassed trace element assemblage between magmatic degassing and lava-water interaction are speciation-controlled and predominately reflect the relative affinity of each element for sulfide versus chloride ligands. We will discuss the implications of these data for understanding trace element volatility in alkaline ocean island basaltic magmas and for hazard assessment during future eruptions.