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Cl and HCl solubility in silicate melts

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Chlorine is a key volatile in magmatic and volcanic systems, being a major consumer of atmospheric ozone and an important ligand for metal transport. Here we report 1200 °C experiments at 0.5–1.63 GPa on hydrous andesite, dacite and rhyolite containing up to 8–9 wt.% H_2O. Runs were equilibrated with Ag–AgI–AgCl buffers to impose fCl_2 and with graphite-saturated C–O–H fluids to maintain fO_2 near the CCO buffer. Measured Cl contents of quenched glasses define chloride capacities (C_{Cl}) which we combined with existing anhydrous datasets.

LASSO regression on the combined database yields an updated chloride-capacity parameterisation that performs better for evolved, silica- and alkali-rich compositions. Across the full range to 8–9 wt.% H_2O, an explicit $HO_{0.5}$ term remains statistically insignificant, indicating that H_2O affects C_{Cl} mainly through ideal dilution of network-forming and network-modifying cations rather than via a strong, specific control on Cl dissolution. Refitting the full dataset with updated P–T constraints gives (1)

where P is in GPa, T is in K, and Xi are single-cation mole fractions.

We then coupled the revised C_{Cl} model to H_2–H_2O–HCl equilibria and a C–H–O–S–Cl fluid-speciation code to obtain a compact expression for HCl fugacity as a function of melt composition, temperature, pressure and fH_2O , without requiring independent constraints on fCl_2, and fO_2 (2)

Applied to published natural melt inclusions, the approach predicts very low fCl_2 (~10^{-10}–10^{-6} bar) but much higher fHCl (~10^{-1}–10^{2} bar) at near-surface conditions, consistent with HCl being an important component of many volcanic gases. Our approach also reproduces SO_2/HCl for the 2002–2003 Mt. Etna eruption and anticipates pronounced decompression-driven changes in SO_2/HCl and S/Cl arising from contrasting pressure dependences of sulphur and chlorine capacities. This new framework links petrological records (melt inclusions, matrix glasses) to magmatic-gas HCl, enabling improved interpretation of excess degassing, plumbing-system behaviour and volcanic halogen fluxes. Finally, HSC Chemistry calculations of high-temperature air–gas mixing at the vent quantify the generation of reactive, ozone-destroying ClO from HCl during initial plume formation.

$$log C_{Cl} = 1.15 + \frac{4359X_{Ca} - 3055X_{Si} + 2059X_{Fe} - 3875X_{K} + 163X_{Mg} - 514P}{T} \quad (1)$$

$$f_{HCl} = K_{HCl} \times \frac{f_{H_2O}^{0.5}}{K_{H_2O}^{0.5}} \times \frac{Cl\ (wt.\%)}{C_{Cl}} \quad (2)$$