Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35358

NaCl activity in silicate melts: towards quantitative models of magmatic–hydrothermal systems

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Chlorine forms strong complexes with economically important metals (e.g., Cu, Au), markedly increasing their solubilities in Cl-rich magmatic fluids. This enables efficient metal transfer from crystallising magmas into exsolving brines and vapours, with precipitation promoted during cooling and interaction with shallower crust—processes widely invoked for magmatic–hydrothermal ore formation, including porphyry Cu systems. A key control on metal extraction and transport is fluid salinity (commonly expressed as equivalent NaCl), because NaCl-rich aqueous fluids can dissolve and carry metals at very high concentrations. Despite its importance, the thermodynamic behaviour of NaCl in silicate melts remains poorly constrained, limiting quantitative models that link melt evolution, fluid exsolution, and metal endowment. In particular, there is a persistent disconnect between experimental/thermodynamic treatments of NaCl-rich metal-transporting fluids and those of the Cl-bearing silicate melts from which these fluids separate.

To address this gap, we present a preliminary experimental study of NaCl activity in silicate melts using an approach analogous to the Ag(I)–Cl mixture employed in recent chlorine solubility experiments ([1], [2]). Our initial results demonstrate that the NaCl–NaI mixture can serve as a practical activity buffer: NaCl dissolved in basalt follows Henry's law up to X_{NaCl} (NaCl/(NaCl+NaI))≈ 0.7, defining a compositional range suitable for systematic calibration of NaCl activities in silicate melts. NaCl solubility varies systematically with melt composition: at the same X_{NaCl} in the salt, silica-rich melts dissolve less NaCl than basalts, mirroring the previously observed effect of melt composition on Cl_2 fugacity.

These findings motivate expanded experiments across melt compositions and conditions relevant to magma ascent and crystallisation, providing the thermodynamic foundation needed to couple melt Cl behaviour to saline fluid exsolution and, ultimately, to quantitative predictions of metal enrichment efficiency in ore-forming systems.

[1] Thomas, R. W. & Wood, B. J. (2021), *Geochimica et Cosmochimica Acta* 294, 28–42. https://doi.org/10.1016/j.gca.2020.11.018

[2] Rusiecka, M. K. & Wood, B. J. (2025), *Geochimica et Cosmochimica Acta* 393, 208–218. https://doi.org/10.1016/j.gca.2025.01.020

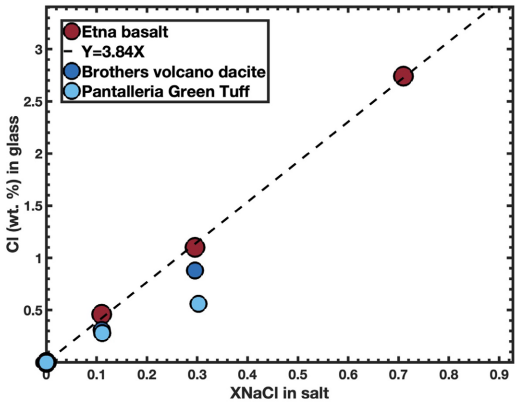

Figure 1. Mol fraction (XNaCl) in the buffer salt plotted against chlorine content (wt. % Cl) in the melt (glass after the experiment). Experiments conducted at 1.05 GPa, 1200 °C on Etna basalt, Brothers volcano dacite, Pantalleria rhyolite