

Experimental and modeled solubilities of chlorine in aluminosilicate melts, consequences of magma evolution, and implications for exsolution of hydrous chloride melt at Mt. Somma-Vesuvius

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ABSTRACT

Solubility experiments were conducted with forty-one aluminosilicate rock compositions to determine how extensively Cl dissolves in hydrous chloride melt- ± vapor-saturated silicate melts containing low to moderate water contents at 2000 bars. Chlorine solubility in most silicate melts is dominated by the abundances of $\text{Mg} \approx \text{Ca} > \text{Fe} > \text{Na} > \text{K} > \text{network-forming Al} > \text{Li} \approx \text{Rb} \approx \text{Cs}$, but Ti, F, and P also have strong influences. The relationship of composition to Cl solubility is more complex in peraluminous and peralkaline felsic melts, because network-modifying Al, Na, and K have a greater influence than their network-forming counterparts. Also, the effects of Ca, Mg, and Al in mafic melts characterized by high $(\text{Ca} + \text{Mg} + \text{Al})/(\text{Na} + \text{K} + \text{Li})$ are much greater than their effects in silica-enriched melts.

Association coefficients that express the influence of each ion on Cl solubility were determined, and the solubility data and coefficients were employed to develop a model that predicts Cl solubility at 2000 bars for water-undersaturated melts ranging from rhyolite to basalt. The coefficients were also used to investigate the predominant chloride complexes in melt, and the bulk of the solubility data are consistent with the interaction of Cl with alkaline-earth metals that provide charge balance for network-forming Al.

The Cl solubility model is applied to Mt. Somma-Vesuvius magmas as they evolved from phonotephrite to phonolitic compositions, via fractional crystallization, to investigate the role of Cl in magmatic degassing. The results clearly demonstrate that Cl solubility was dramatically reduced by subtle changes in melt composition. Decreasing abundances of Ca, Mg, and Fe in the residual melt induced a dramatic reduction in Cl solubility that occurred simultaneously with gradual increases in the abundance of volatiles in melt due to crystallization of volatile-free minerals. The increasing abundance of volatiles and concurrent reduction in Cl solubility may have forced the exsolution of a hydrous chloride melt directly from the Cl-enriched mafic magmas. It is likely that the exsolution of hydrous chloride melt may occur in other Cl-enriched magmas, because Cl solubility depends so strongly on melt composition.