

Chlorine isotope fractionation in ore-forming systems and its implication for polymetallogenic processes.

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Chlorine isotope fractionation in ore-forming systems and its implication for polymetallogenic processes

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Chloride is one of the most significant anions in ore-forming hydrothermal fluids, and chlorine isotopes are potentially sensitive tracers of the origin and evolution of ore-forming fluids. However, it is still underutilized due to a lack of knowledge on chlorine isotope fractionation during ore-forming processes, particularly at high temperatures. Many metal cations can form a series of complexes with chloride ions in fluids, and their coordination patterns show a diversity of changes at high temperature^[1]. Using first-principles density functional theory, this work calculates chlorine isotope fractionation in variable ore-forming processes. All metal-Cl complexes in hydrothermal fluids are enriched in $\delta^{37}\text{Cl}$ compared to chloride ions. Among evaporites, the enrichment of the heavy Cl isotopes decreases in the sequence of halite > carnallite > aqueous chloride > kainite > sylvite > bischofite, which is consistent with the experimental phenomenon that progressive precipitation of halite from brine lowers the $\delta^{37}\text{Cl}$ value of the residual fluid until the formation of K-Mg chlorides during continuous brine evaporation in sedimentary basin environments.

In volcanic-hydrothermal system, there are two distinct chlorine isotope fractionation patterns when volatilization of HCl is controlled by equilibrium or diffusion processes. In low-temperature ore deposits formed from single-phase fluids, $\delta^{37}\text{Cl}$ in fluid inclusions indicates the sources $\delta^{37}\text{Cl}$ of hydrothermal fluids, particularly if they are of seawater or basin brine origin. In high-temperature ore deposits, Cl is partitioned between vapor and salt-rich liquid phases of magmatic origin. The wide $\delta^{37}\text{Cl}$ variation sensitively reflects the multiple processes along metals transport and deposition (e.g., vapor-liquid phase separation, sericitic alteration etc.).

[1] Seward, T.M., A.E. Williams-Jones, and A.A. Migdisov, 13.2 - The Chemistry of Metal Transport and Deposition by Ore-