Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.28211

Calcium Isotopes as a tracer for high-temperature processes: recent advances in mantle and magmatic geochemistry

JINTING KANG

University of Science and Technology of China

Calcium isotopes have emerged as a powerful geochemical tool to investigate high-temperature magmatic processes in Earth and planetary bodies. Recent advancements in analytical precision and experimental constraints have significantly enhanced our understanding of (1) the Ca isotope compositions of mantle reservoirs, (2) inter-mineral fractionation factors among key mineral phases, and (3) fractionation mechanisms during magmatic processes.

Previous studies have revealed that the Earth's fertile mantle exhibits a homogeneous $\delta^{44/40}$Ca value of ~0.94‰ (relative to NIST SRM 915a). Oceanic crust, typified by mid-ocean ridge basalts (MORBs), and continental crust, characterized by granitic rocks, both exhibit lighter $\delta^{44/40}$Ca values compared to the fertile mantle. This contrast highlights the utility of Ca isotopes in tracing mantle-crust interactions. Theoretical calculations demonstrate that equilibrium Ca isotope fractionations between mantle minerals (e.g., clinopyroxene, garnet, and melt) are controlled by several factors including temperature, pressure and composition. Partial melting, melt percolation, and magma ocean crystallization of planetary bodies may induce large Ca isotope fractionations, particularly during kinetic diffusion or rapid cooling.

These advances position calcium isotopes as a critical tracer for resolving open questions in mantle dynamics, crust-mantle recycling, and planetary-scale differentiation processes. Future integration with multi-isotope systems (e.g., Mg, Fe) and high-pressure experimental studies will further refine its application in high-temperature geochemistry.