Correlated Zn-Mg isotope fractionation in the Archean Fred's and Theo's flows

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Metal isotope ratio partitioning between mantle minerals become evident. However, specific effects of magmatic processes (partial melting, fractional crystallisation, metasomatism) and respective roles of T, P, fO_2 on metal isotope fractionation are still puzzling.

Zn and Mg are characterized by the same oxidation state and might occupy the same crystal site; they are potential powerful proxies to investigate the effects of mantle magmatic processes on metal isotope fractionation. The present study reports high-precision MC-ICP-MS measurements of Zn and Mg isotopic compositions on whole rocks and mineral separates from two komatiitic differenciated flows. Fred's Flow and Theo's Flow are two thick Archean flows (2.7 Ga) from the Abitibi greenstone belt (Munro Township, Canada). Fred's Flow has a komatiitic affinity, and is classified as Al-undepleted type, whereas Theo's Flow has a Fe-rich tholeiitic affinity and is classified as Al-depleted type. Their geographical relationship and ages support a common petrogenetic evolution.

The two flows show bulk Zn isotopic variations on 0.23 δ-units with average $\delta^{66}Zn_{JMC\text{-}Lyon}$ value of +0.29‰. Throughout the two stratigraphic sequences, the different lithological units display significantly distinct $\delta^{66}Zn$ values: spinifex and gabbroic units are characterized by light Zn isotopic composition ($\delta^{66}Zn_{JMC\text{-}Lyon}$ values down to +0.28±0.04‰), whilst the cumulate units show enrichments in heavy Zn isotopes ($\delta^{66}Zn_{JMC\text{-}Lyon}$ up to +0.55±0.05‰). Mineral separates show much more large Zn isotopic variations (1.6 δ-units), depending on the mineral phases. Results in bulk $\delta^{25}Mg_{DSM3}$ reproduce the same Zn isotopic profiles controlled by the lithological units, with even stronger variations. The $\delta^{25}Mg_{DSM3}$ values range from -0.48±0.06‰ (in the spinifex units) up to -0.12±0.03‰ (in the cumulate units).

Isotopic analyses of mineral separates coupled with crystallographic considerations suggest Zn and Mg isotope fractionation controlled by the inter-mineral fractionation during crystal accumulation in high T system, whose signature still remains after serpentinization.