Zn isotope fractionation in Archean komatiites and associated lava-flows

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Komatiites are volcanic ultramafic rocks with high MgO content (>18Wt.%), which make up the first few blocks of the Archean crust and are indicative of the earliest stages of the Earth mantle dynamics.

The present study reports high-precision MC-ICP-MS measurements of Zn isotopic compositions in whole rocks and mineral separates from Fred's Flow and Theo's Flow, two thick Archean differenciated flows (2.7 Ga) located in 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 an Fe-rich tholeiitic affinity and is classified as Al-depleted type. Their geographical relationship as well as their complementary geochemical compositions suggest that they are genetically related. Characterizing fractionation processes of their Zn isotope compositions would provide constraints on diffusion transport, crystallisation processes, and melting conditions involved in the komatiites petrogenesis.

Small but significant shift in δ^{66}Zn values for whole rocks is systematically observed between Fred's flow (mean δ^{66}Zn = +0.30±0.04‰ (2SD)) and Theo's flow profiles (mean δ^{66}Zn = +0.39±0.03‰). For each flow, the Zn isotopic profile is relatively monotonous, except for the gabbroic units with slightly lower δ^{66}Zn (down to +0.28±0.04‰) and the basal ultrabasic units where enrichments in heavy Zn isotopes are clearly obvious (δ^{66}Zn up to +0.55±0.05‰).

Zn isotopic compositions in mineral separates vary on a large range of 1.6 δ-unit, and their relative modal contributions can explain the whole rock isotopic trends. As a whole, mineral separates reproduce the same isotopic shift between the two flows, as previously shown by the bulk rocks, suggesting a fractionation control by the crystallisation/melting conditions. Individually, chromites show especially strong enrichments in light Zn isotopes, relative to the silicates. Olivine, clinopyroxene and plagioclase exhibit generally smaller isotopic fractionation with respect to each other, but are characterized by contrasted δ^{66}Zn values suggesting correlation with the polymerization degree. No relationship has been observed between the Zn isotope fractionation and (light) alteration degree of the lava flow or mineral.

Further analyses are needed to discriminate secondary Zn mobilization, crystallisation or cooling rate effects, and establish interesting comparison with Mg and Fe isotopic results reported by Dauphas et al. (2010) on Alexo komatiites.

[1] Dauphas et al. (2010) *Geochimica et Cosmochimica Acta* **74**, 3274-3291.

Ni partitioning between olivine and high-MgO silicate melts: Implications for Ni contents of forsteritic phenocrysts in basalts

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There has been considerable interest in the presence in basalts of forsteritic olivine (*ol*) phenocrysts with elevated NiO contents (i.e., up to 0.5-0.6 wt. % NiO, substantially higher than in normal peridotitic *ol*, [typically 0.35-0.40 wt. % NiO]). It is difficult to produce such high NiO contents in peridotitic *ol* via simple melting processes; so assuming that *ol* phenocrysts that crystallize at low P mimic the compositions of *ol* in deeper residual magmatic sources, the existence of phenocrysts with such elevated NiO contents would require that *ol* in these sources contain comparably elevated NiO contents. This has led to several hypotheses to explain NiO-rich *ol* in mantle sources of basalts (e.g., contamination of the lower mantle by the core; metasomatism of normal mantle by silica-rich melts of eclogite). If, however, the partition coefficient of NiO between *ol* and melt (D_{Ni}) depends strongly on T and/or P, *ol* phenocrysts that crystallize at lower P's and T's than those at which their host magmas last equilibrated with mantle need not mimic the compositions of *ol* in their residual sources. This would provide an explanation for NiO-rich *ol* phenocrysts that does not require NiO-enriched mantle *ol*.

We measured D_{Ni} between *ol* and picritic liquid at 0.001-30 kbar; by adjusting the T at each P, we kept liquid MgO contents similar (~17-18 wt. %) for all experiments. This experimental feature was critical because D_{Ni} is a strong function of liquid MgO content; so by keeping the MgO content essentially constant, we isolated the dependence of D_{Ni} on P and T from its dependence on MgO. D_{Ni} in our experiments decreases from 5.0 to 3.8 (by wt.) as T increases from 1400 to 1550°C. Our results are well described by a simple Ni-Mg exchange equilibrium assuming (1) ideal models for the liquid and *ol* and (2) the standard state ΔV and ΔC_P of the reaction are zero. Previous measurements of D_{Ni} are scattered, but the same model can describe simultaneously our isochemical results and the literature data in which T and MgO (and P) vary considerably.

Using our model, we calculated the NiO contents of Hawaiian *ol* phenocrysts that would crystallize at 1 kbar from primary magma separated from its residue at ~35 kbar. If the T difference between the residue and the conditions of phenocryst crystallization is ~150°C and the NiO content of residual *ol* is 0.37±0.02 wt. %, the calculated NiO content of *ol* phenocrysts is 0.47±0.025 wt. %. This is not as high as the highest NiO contents of Fo-rich Hawaiian phenocrysts, but it matches most of the data (0.44±0.07 wt. % NiO; 2σ). This simple calculation demonstrates that the effect of T on D_{Ni} can explain much of the range in NiO contents of Hawaiian *ol* phenocrysts without invoking processes that enrich mantle *ol* in Ni. Although such Ni-enrichment processes may operate, their contributions to basalt genesis need not be as large as suggested by models that do not consider the effects of T differences between source regions and the environments of phenocryst formation. A similar calculation reproduces the moderate enrichment in NiO in komatiitic *ol* assuming komatiitic magmas are dry, deep, and hot melts of the upper mantle.