

Zinc behavior during mantle melting: a reappraisal of natural and experimental observations

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Mantle stable isotope heterogeneities resulting from high-temperature processes have been reported for a growing number of elements. Among them, Zn is of great interest due to its single valence state (Zn^{2+}) in compounds or complex ions which makes it insensitive to redox conditions. Zn isotopic compositions ($\delta^{66}Zn$, relative to JMC-Lyon) in igneous rocks vary up to $\sim 0.3\%$ from ultramafic rocks ($\delta^{66}Zn = +0.10$ to $+0.30\%$) [1,2,3] to isotopically heavier mantle-derived melts ($\delta^{66}Zn = +0.25$ to $+0.40\%$) [2,4,5,6]. Yet, there is a major controversy about the behaviour of Zn and its isotopes during mantle partial melting: some authors suggest that high degrees of melt extraction may fractionate Zn isotopes up to $\sim 0.15\%$ [1,2] while others find no resolvable Zn isotope variations ($< 0.015\%$) in melting residues [3].

Considering a bulk partition coefficient close to unity ($D^{mantle-melt} \sim 1$) and focusing on the role of pressure during partial melting (e.g. spinel vs garnet stability field), previous modeling studies have failed in reproducing Zn concentrations and Zn isotope compositions in both mantle peridotites and mantle-derived basalts [1,2,3]. Here, we explore the role of temperature on Zn behavior during mantle melting.

Through (1) a comprehensive review of Zn elemental and isotopic compositions in mantle-related rocks and (2) an exhaustive compilation of relevant experimental works, we show strong evidences of a thermal control on Zn partitioning at melting conditions. Results are incorporated into a mantle melting model which successfully reproduces Zn concentrations and isotopic compositions in basaltic and ultramafic rocks. Major implications for Zn elemental and isotopic heterogeneities in the Earth's mantle and new potential applications of Zn isotopes as tracers of source lithology are further discussed.

[1] Doucet *et al.* (2016) *EPSL* 451, 232-240. [2] Wang *et al.* (2017) *GCA* 198, 151-167. [3] Sossi *et al.* (2018) *Chemical Geology* 477, 73-84. [4] Ben Othman *et al.* (2003) *EGS-AGU-EUG Joint Assembly*. [5] Chen *et al.* (2013) *EPSL* 369, 34-42. [6] Herzog *et al.* (2009) *GCA* 73, 5884-5904.