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Stable Cr isotope characteristics of the subcontinental mantle: a case study from Étang de Lherz (France)

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Approaches to constrain the d53Cr the bulk silicate earth (BSE) based on komatiite or peridotite investigations [1-4] yield values similar to -0.12±0.06 ‰ [1] being indistinguishable of the average composition for ordinary and carbonaceous chondrites [5, 6]. MORB, however, show distinctly lighter Cr isotope signatures around -0.24 ‰ [7,8] evidencing resolvable stable Cr isotope fractionation within Earth's high-temperature reservoirs. This consistently light isotope value of MORB can, however, not be explained by pure peridotite melting or crystal fractionation and is mostly considered as evidence for small-scale mantle heterogeneities as for example the presence of pyroxenite during melting [7].

To gain further insight to Cr isotope fractionation processes within magmatic reservoirs we investigated ultramafic mantle rocks from the Étang de Lherz (France). This mantle body consists of harzburgites and lherzolites with small intercalated websteritic bands [9]. The relation of harzburgites and lherzolites is interpreted as melt-rock interaction based on REE systematics [9]. Recently, harzburgites were interpreted as predominantly pristine melting residues [10]. Both studies interpret lherzolites as a result of refertilisation of harzburgite with upwelling N-MORB like partial melts represented by the websterites [10]. Obtained bulk rock d53Cr signatures for harzburgite are ca. 0.25‰ heavier compared to BSE whereas lherzolite values span the range of BSE to MORB type Cr isotope signatures. Thus, both observed signatures would fit simple melt depletion-refertilisation processes. Websterites, however, show d53Cr values as light as -1.6‰ being significantly different to MORB Cr isotope signatures despite showing typical N-MORB like REE pattern. This large isotopic difference of more than one per mille is taken as evidence that at least some Cr follows kinetic and not equilibrium isotope fractionation.

[1] Wagner et al 2021 Chemical Geology 576:120121 [2] Jerram et al 2020 Chemical Geology 551: 119761 [3] Xia et al 2017 EPSL 464:103-115 [4] Sossi et al 2018 PNAS 115: 10920-10925[5] Schoenberg et al 2016 GCA 183:14-30 [6] Bonnand et al 2016 EPSL 435: 14-21 [7] Wagner et al 2023 GCA 353: 76-91 [8] Ma et al 2022 GCA 327:79-95 [9] Le Roux et al 2007 EPSL 259: 599-612 [10] Wang & Liu 2024 EPSL 640: 118793