Copper isotope variation during mantle magmatic migration: Insight from pyroxenites in Balmuccia peridotite massif

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Data from mantle peridotites and experimental constraints imply that sulfide melts likely enrich ^{63}Cu [1,2]. Given the predominant control of Cu by sulfides, sulfide dissolution and precipitation thus would play a key role for Cu isotope fractionation during high temperature mantle magmatic processes [1-3]. To better understand the effect of migration of sulfide-saturated basic magmas on Cu isotope in mantle rocks, we have analyzed bulk rock Cu isotopic composition of a suite of sulfide-bearing mantle pyroxenites from the Balmuccia peridotite massif (BM) in the Ivrea-Verbano Zone, Italy. These mantle pyroxenites are melt-peridotite and mineral accumulation products of sulfide-saturated basaltic melts. Mass balance indicates that sulfides host > 98 wt.% of bulk rock Cu budget of 87-484 μg/g, implying a negligible role of silicates for Cu isotope in these rocks. Overall, Balmuccia pyroxenites show significant $\delta^{65}Cu$ variations of -0.66‰ ~ 0.66‰, which cover the range reported so far for MORBs, OIBs, komatiites and fresh fertile lherzolites (BSE: 0.06‰) [1-3]. Three clinopyroxenites drilled from the same vein also show obvious differences in $\delta^{65}Cu$ from 0.12‰ to 0.41‰. The $\delta^{65}Cu$ variations in a single vein and different pyroxenites suggest strong Cu isotopic fractionation during reactive magma transport and crystallization of basaltic magmas in the mantle. Nevertheless, $\delta^{65}Cu$ does not display systematic correlations with Al_2O_3, Mg#, Cu contents and other chalcophile elements. For example, the samples with high sulfide abundance and Cu content (e.g., 484 μg/g Cu) do not necessarily show lighter $\delta^{65}Cu$ which would be expected by experimental partitioning data [1] and other studies [2, 4]. These results suggest that significant Cu isotopic fractionation does occur during high temperature magmatic processes, which strongly changes $\delta^{65}Cu$ of evolving magmas themselves and reacted peridotites and thus probably leads to heterogeneity in Cu isotopes in mantle rocks.

[1] Savage et al (2015), GPL 1, 53-64 [2] Huang et al (2017), GCA 211, 48-63 [3] Liu et al (2015), EPSL 427, 95-103 [4] Zhao et al (2017), Lithos 286-287, 206-215