Copper isotope heterogeneity in the lithospheric mantle

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The lithospheric mantle is rarely "pristine"; instead, chemical heterogeneities on a variety of scales are inferred to be a result of multiple melt depletion, refertilisation and metasomatic events [1]. Identifying such events is critical to constraining the initial composition and evolution of this important geochemical reservoir.

Mantle sulphides are particularly susceptible to modification, significantly altering chalcophile element and isotope compositions, such as the platinum group elements and Re-Os isotopes [2]. Copper is strongly chalcophile and its isotopes are readily fractionated by secondary processes [3], making Cu a potential proxy for both sulphide alteration and fluid source. Here we present Cu isotope analyses of peridotite xenolith samples taken from Kilbourne Hole, USA, which show significant variability (δ^{65}Cu = –0.40 to +1.10‰ [4]). Such large variations are outside the "igneous" range, defined by komatiites, basalts and orogenic lherzolites (δ^{65}Cu = –0.07 to +0.16‰; [5]), and are unlikely to represent primitive mantle heterogeneity. In particular, the source of extreme heavy Cu isotope enrichment in some xenoliths can be linked to metasomatism involving a LREE-enriched fluid, possibly sourced from the subducted Farralon Plate [6].

We also see strong evidence that partial melting fractionates Cu isotopes: the isotopically lightest xenoliths (δ^{65}Cu = –0.40 to –0.20‰) are the most melt-depleted and also have the most unradiogenic ^{187}Os/^{188}Os. Thus, xenoliths in this suite with "basaltic" δ^{65}Cu imply refertilisation of the depleted material by an asthenosphere-derived melt.

Our data indicate that, in terms of Cu isotopes, the lithospheric mantle is highly heterogeneous and could be isotopically distinct from the primitive mantle.

[1] O'Reilly and Griffin (2012), in *Metasomatism and the Cheimcal Transformation of Rock*, 471-533 [2] Harvey *et al* (2011), *GCA* **75**, 5574-5596 [3] Albarede (2004), *RiMG* **55**, 409-427 [4] $\delta^{65}Cu = [(^{65}Cu/^{63}Cu_{sample})/(^{65}Cu/^{63}Cu_{SRM976}) - 1] \times 10^3$; [5] Savage *et al* (2013), *Min Mag* **77**, 2142 [6] Harvey *et al* (2012) *J.Pet* **53**, 1709-1742.