Cu-isotope evidence for subduction modification of lithospheric mantle

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Ultramafic xenoliths and megacrysts entrained in Quaternary basalts from the Geronimo Volcanic Field of SE Arizona indicate that the lithospheric mantle is heterogeneous in terms of its Cu-isotope composition. The petrology and geochemistry of the xenoliths provide insights into the source of the Cu in melts that interacted with and metasomatized the mantle beneath the Basin and Range of the western US.

The xenoliths include both Type I (Cr- & Mg-rich) lherzolites and Type II (Al- & Ti-rich) pyroxenites and wehrlites (± amphibole). Type II lithologies are interpreted as the crystallization products of basaltic magmas within the lithospheric mantle. Estimates of the Mg numbers for these basalts, based on MgO/FeO of xenolith olivines, indicate they were moderately evolved (i.e. Mg # = 38 – 52). Although Sr- and Nd-isotope compositions are consistent with an asthenospheric origin (~0.7029 & ~0.5130, respectively), H-isotope data provide evidence for involvement of a subduction component. Metasomatic amphiboles in Type II xenoliths have δD values ranging from -82 to -23‰, with amphibole megacrysts having heavier δD on average (-49‰, n=7) than amphiboles separated from Type II clinopyroxenites (-69‰, n=7). The low δD values are characteristic of normal mantle (~-80‰), but the higher δD values are consistent with metasomatism by fluids released from subducted oceanic crust.

Whole rock Cu isotope compositions of the Type II xenoliths range from +0.14 to +1.44‰, which is considerably heavier than asthenospheric mantle (i.e. *ca.* 0‰ ± 0.2‰). Metasomatized Type I xenoliths also range to heavier values (up to +1.12‰). Readily leachable Cu in the xenoliths, assumed to be hosted in sulfides, exhibits an even wider range of $\delta^{65}Cu$ values -0.78 to +3.88‰, indicating considerable isotopic heterogeneity within individual samples. Host basalts are isotopically light (-0.23‰ to -1.30‰) compared with most of the entrained xenoliths, so interaction with the host basalt is not responsible for the compositional variation recorded by the xenoliths. The mechanism(s) responsible for the Cu isotope heterogeneity may involve a combination of processes (e.g. kinetic effects, redox reactions, chromatographic effects), but metasomatism by fluids derived from recycled crustal materials is believed to predominate, consistent with the H-isotope data.