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Copper isotopes track the formation and evolution of Archean TTG

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Tonalite-trodhjemite-granodiorite (TTG) rocks dominate the composition of the early continental crust, however, their petrogenesis and geodynamic environments remain debated. In the Yilgarn Craton of Western Australia, there are predominantly TTG suites and high-K rocks, which are found both within and external to greenstone belts. The high-Ca granites (including granodiorites, trondhjemites and monzogranites; 2.65Ga~2.75Ga) comprise over 40% of the total granites and are largely comparable to typical Archean TTG suites [1]. These granites primarily reflect melting of hydrated, -variably enriched and altered mafic crust (amphibolite), with some also exhibiting contributions from a LILE-enriched mantle source [2,3]. These high-Ca granites display lower Cu concentrations compared to the bulk continental crust (~27 ppm) [4]. Approximately 50% of granites have Cu concentration below 5 ppm, about 20% range from 5 ppm to 10 ppm, and roughly 10% fall between 10 ppm and 15 ppm (Total samples = 1,749). Understanding why these Cu contents are significantly lower than those observed in modern continental crust may provide insights into the formation mechanisms of Archean TTG and the geodynamic processes of the early and modern continental crust.

We analysed the Cu isotope composition of high-Ca granites and amphibolites from the Yilgarn Craton and Pilbara Craton. These granites show Cu isotope variations, with δ^{65}Cu ranging from -0.71 ‰ to +1.32 ‰, which is also markedly distinct from the bulk Earth average (δ^{65}Cu =0.07 ‰ ± 0.10 ‰) [5]. Amphibolites display heavier Cu isotope composition, with δ^{65}Cu values of ~ 0.80 ‰. We also found a positive correlation between δ^{65}Cu, Cu concentration [Cu] and Cu/Ag ratio, which might be related to Cu isotope fractionation during partial melting of their source in the presence of residual sulfides. Thes findings indicate the potential importance of sulfide stability in controlling metal budgets during the formation of early continental crust, and provide insights into the geodynamic and redox conditions of the Archean Earth.

References:

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