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The copper isotope composition and evolution of the continental crust as revealed by glacial diamictite composites

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Understanding how and why our continental crust has evolved through time is critical to understanding the Earth system. The formation of new continental crust at subduction zones is a defining characteristic of plate tectonics; however, the question of when modern plate tectonics became established on Earth is a vexed one.

Copper is a bioessential trace element; due to its chalcophile nature, its concentration in igneous rocks is strongly controlled by sulphide fractionation. Because of this, the subduction filter leads to andesitic upper continental crust depleted in copper relative to basalts. This depletion should result in an andesitic crust enriched in the heavy Cu isotope, as sulphides typically sequester the lighter isotope. Therefore, the Cu isotope evolution of the continental crust could indicate when arc-derived material began to dominate this reservoir.

To investigate this, we have analysed the Cu isotope composition of a suite of glacial diamictite composites whose depositional ages range from Mesoarchaean to Palaeozoic [1]. These samples have been extensively studied for a number of geochemical and isotopic proxies in order to better understand the temporal evolution of the upper continental crust (UCC); indeed, a reduction in [Cu] and Cu/Ag in these same samples between 3.0 and 2.4Ga has been used to imply that it was over this time interval that the UCC became predominantly felsic [2].

The diamictites so far analysed display a limited range of Cu isotope compositions, most of which are in error of previous estimates for the Earth's mantle [e.g. 3]. There appears to be no systematic secular change in the isotope data, nor is there an obvious relationship with [Cu] or Cu/Ag. This suggests that the UCC Cu isotope composition has remained relatively constant over much of Earth history, and that sulphide fractionation at arc settings may not have as systematic an effect on Cu isotopes as predicted.

[1] Gaschnig et al., 2016, GCA 186; [2] Chen et al., 2020, GCA 278; [3] Savage et al., 2015, GPL 1