

Copper isotope fractionation at the magnetite crisis in the Manus backarc basin

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The formation of magmatic hydrothermal ore deposits Cu is a multi-stage process that requires a number of processes to enrich Cu to economically viable proportions. Copper is a highly chalcophile element and therefore closely controlled by the concentration and speciation of sulfur. An important factor in concentrating Cu is the prevalence of oxidising conditions during magmatic differentiation that prevents fractionation of sulfides and concentrates Cu in evolved magmas. The oxidising conditions in volcanic arc magmas are therefore favourable for Cu enrichment and Cu initially behaves as an incompatible element during differentiation of arc magmas. However, the onset of magnetite fractionation in differentiated arc magmas lowers the oxygen fugacity which causes the reduction of sulfate to sulfide. Fractionation of sulfides is coupled with dramatic decreases in Cu concentrations and has hence been termed the ‘magnetite crisis’ [1,2]. However, it remains unclear whether magnetite triggered sulfide saturation contributes to the formation of porphyry Cu deposits [1,2].

Copper isotope ratios have been suggested as tracers for Cu ore forming processes [e.g. 3]. Yet, the potential for Cu isotope fractionation during initial arc magma evolution is largely unexplored. To establish a link between magma sources and porphyry Cu ores we investigate the potential for Cu isotope fractionation at the magnetite crisis. Our samples are from the Manus basin where Cu concentrations initially increase from 86 ppm at MgO = 9.2 wt.% to 276 ppm at MgO = 3.0 wt.% and then decrease to 27 ppm at the magnetite crisis [2]. Density functional theory predicts significant fractionation of Cu isotopes during transition from sulfate to sulfide [4]. Yet, our initial results suggest only minor Cu isotope variation at the magnetite crisis which we attribute to the near quantitative transition from sulfate to sulfide and incomplete removal of (Cu-)sulfides from the melt. This allows us to establish a direct link between magma source compositions and late-stage ore formation processes.

[1] Sun et al. (2004) *Nature* 431:975-978 [2] Jenner et al. (2010) *J Pet* 51:2445-2464 [3] Mathur et al. (2009) *J. Geochem. Explor.* 102:1-6 [3] Fuji et al. (2013) *GCA* 110, 29-44