Tracking sulfide fractionation in deep continental arcs: Implications for porphyry Cu deposits

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Most giant porphyry copper deposits occur in thick continental arcs where calc-alkaline igneous differentiation dominates [1]. Yet, magmas from thick continental arcs are Cu depleted (<80 ppm) [2], leading to the conundrum where the Cu in the porphyry deposits are derived from. One popular view is that the Cu is stripped into sulfide-bearing cumulates in deep continental arcs, and is subsequently extracted by remelting [2, 3]. However, sulfide crystallization processes in deep continental arcs are poorly constrained. Here we report Cu and Ag data for garnet-bearing pyroxenite cumulates from an ancient continental arc in Central Arizona [4]. Our preliminary results show that these cumulates generally have anomalously high Cu (up to 1000 ppm) and Ag (up to 110 ppb) contents, which suggests sulfide saturation during the crystallization of these deep arc cumulates [3]. It seems that both Cu and Ag contents in these cumulates first increase with decreasing Mg#, and then decline with further differentiation. Maximum Cu and Ag contents occur at Mg# of ~0.6. We provisionally think that the initial increase in Cu and Ag is due to progressive sulfide saturation driven by magma cooling and the decrease of sulfide solubility in silicate melts, which is caused by the decrease in FeO content resulting from Fe-rich garnet fractionation [5]. To explain the decline in Cu and Ag contents in the evolved cumulates, more data and probably model calculation are needed. These sulfide-bearing cumulates from deep continental arcs may be re-melted by subsequent magmas, and then the copper can be released and transported to shallower crustal levels to form porphyry Cu deposits.

References: [1] Cooke et al., 2005, Econ. Geol. 100(5) 801-818. [2] Chiaradia, 2012, Nat. Geosci. 7(1) 43-46. [3] Lee et al., 2012, Science 336 (6077) 64-68. [4] Erdman et al., 2016, Earth Planet. Sci. Lett. 439 48-57. [5] Tang et al., 2018, Science Advances, The redox “filter” beneath magmatic orogens and the formation of continental crust, in press.