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# Oxidized primary arc magmas: Constraints from Cu/Zr systematics in global arc volcanics

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Arc volcanics are well acknowledged to be more oxidized than mid-ocean ridge basalts (MORB), but it is debated whether this is a mantle feature or a result of magmatic evolution. Copper, a sulfur-loving element, has been used to trace the behavior of redox-sensitive sulfur during mantle melting and infer similar redox states of sub-arc and sub-ridge mantle: higher oxygen fugacity in the mantle results in higher Cu contents in the primary magma. Previous studies, however, neglected elevated sulfur contents in the sub-arc mantle contributed by slab flux. The higher sulfur contents increase the portion of sulfide phases in the mantle, which increases the bulk partition coefficient of Cu during melting, resulting in lower Cu contents in primary magma at a given melting degree and $fO_2$, which therefore leads to underestimation of oxygen fugacities.

Through systematic investigation of global arc volcanic data and estimation on the sulfur contents in the sub-arc mantle, we show that Cu concentrations of arc volcanics vary systematically with crustal thickness at arcs (Fig. 1) [1], and that the Cu/Zr ratio is a sensitive indicator to identify the geochemical behaviors of Cu and S during mantle melting (Fig. 2). According to the compiled primary compositions of melt inclusions and the global sulfur emissions, we estimated the sulfur contents in sub-arc mantle to be 300 to 450 ppm. Because of higher mantle S contents, Cu systematics of arc magmas require at least one log unit higher oxygen fugacities of sub-arc than sub-ridge mantle (Fig. 2).

Low Cu contents of thick-crusted arc volcanics result from low extents of melting of sulfur-rich mantle, obviating the need for deep-crustal sulfide fractionation, with substantial implications for the origin of porphyry-Cu deposits.

Reference

[1] Zhao, Yang, Langmuir & Zhao (2022), Science Advances, in press

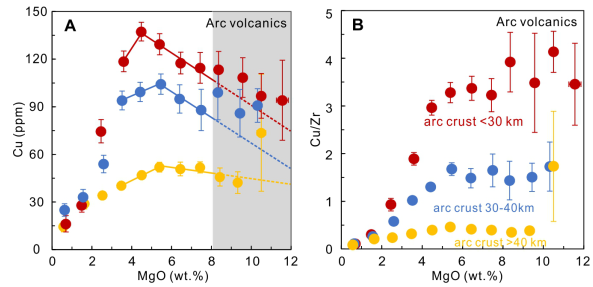

Fig. 1. Cu systematics in arc volcanics with different crustal thickness

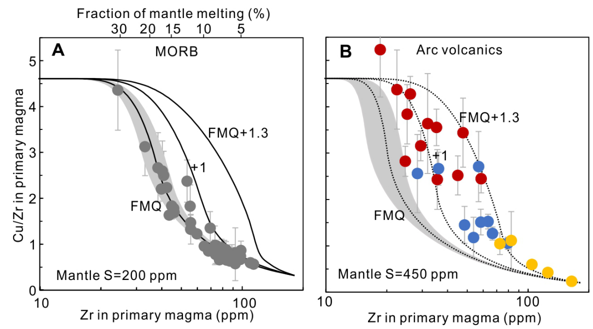

Fig. 2. Estimated sub-arc mantle oxygen fugacities