A Big Data Perspective on the Behaviour of Copper in Arc Magmas

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The distribution of Cu in the Earth's crust is closely linked to the occurrence and chemistry of arc magmas [1]. There remains much debate over which magmatic parameters control upper-crustal Cu contents. Leading theories hold that the fractionation and subsequent remobilization of a sulphide-bearing cumulate play an important role in regulating Cu in arc magmas [2,3], but the exact petrologic mechanisms driving this process remain poorly constrained. To address these questions, we present a compilation of global arc magma chemistry and physics. This database was assembled using geochemical information from GeoRoc and geophysical data on subduction zones from various sources [4-6]. The database is available via open-source geospatial and programming platforms QGIS and Jupyter Notebooks. Our approach is distinct to that of than previous models [7], allowing us to seamlessly test hypotheses relating to the chemical conditions in sulphide fractionating magmas, as well as the control exerted by tectonic forcings like crust thickness and slab geometry. Our results highlight that (1) Cu is depleted more rapidly with MgO in calc-alkaline magmas (which occur in thicker crust) relative to tholeiitic magmas, due to their Fe depletion affecting phase stability. (2) Magmas showing strong garnet and amphibole signatures fractionate the most sulphide and hence have the lowest Cu concentrations (3) Fluid flux (as indicated by e.g. Ba/Nb) is not correlated with Cu contents, suggesting that the depletion history of the mantle wedge plays a major role in determining arc magma Cu enrichment. Our work highlights the power of Big Data and the value of integrating across geological datasets to understand Cubehaviour in the Earth's crust.

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