New Approaches to Constraining Cu-Co Mineralisation in the Zambian Copperbelt Using Hydrothermal Rutile and Apatite

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Despite decades of research on the Zambian Copperbelt (ZCB), the timing of mineralisation remains a contentious debate. The long-standing paradigm of multi-episodic mineralisation encompassing syndiagenetic mineralisation through to post-orogenic mineralisation (~800–500 Ma) has been challenged by a restricted 540-490 Ma synorogenic hypothesis. This is primarily based on extensive $^{187}Re/^{187}Os$ molybdenite ages across numerous ore deposits that demonstrate this late temporal affinity. However, the direct relationship between molybdenite and the timing of first copper mineralisation has been questioned. This is due to molybdenite rarely sharing contemporaneous petrographic relationships to Cu and Co sulphides. Here, we address this issue by utilising the widespread occurrence of hydrothermal accessory phases, rutile and apatite. Petrographically characterised vein and ore horizons are used to establish the paragenetic framework and relationship to ore mineral growth and then combined with in situ LA-MC-ICPMS U-Pb analyses of these accessory phases.

Our results indicate two major mineralising episodes: an older ~570-520 Ma period and a younger, previously under-represented ~490-470 Ma period. The older period is attributed to potassic brines mobilising prior to and during peak metamorphism of the Lufilian Orogeny and Hook Batholith emplacement. This event is interpreted as the first mineralising event at Mindola North. We see no clear evidence of dates exceeding 600 Ma. The younger event is interpreted as a second growth event responsible for bornite mineralisation and secondary fluid flow along pre-existing quartz-carbonate veins during post-orogenic uplift of the Lufilian Orogeny. The only previous documentation of this event is by bornite (473 ± 4 Ma) at the Kamoto Cu-Au deposit. Our results demonstrate how our understanding of the temporal evolution of Cu-Co in the ZCB can be enhanced by our approach of uniting the petrographic record with high-spatial resolution U-Pb geochronology which could be applied to other deposits within the ZCB.