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Tectonic controls on porphyry copper formation in the southwest USA

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Copper is an essential metal in the clean energy technologies that will underpin the global green energy transition. With global demand set to rise by over 40% over the next two decades [1], the heat is on to discover more high-quality mineable deposits. Our dominant sources of copper are porphyry copper deposits (PCDs), which are magmatic-hydrothermal systems typically formed above subduction zones. Clustering of PCDs in space and time within magmatic arcs implies the existence of overarching tectono-magmatic controls on their formation. However, these controls must be better constrained if they are to be used to guide exploration.

In the copper-rich Laramide Porphyry Province of Arizona, PCDs are thought to have formed in a single 20 Myr period, during crustal relaxation following prolonged compression [2]. However, in the adjacent Northern Great Basin (Nevada-Utah-Idaho), a lower copper endowment and longer, episodic history of PCD formation (~170-25 Ma) suggests different tectonic controls are at play. We seek to determine the spatial-temporal links between compression, relaxation, and PCD formation in the Northern Great Basin by reconstructing the deformational and metamorphic history preserved within three exhumed metamorphic core complexes that are temporally and spatially associated with PCDs.

To constrain the timing of deformation we use *in-situ* Rb-Sr dating of syn-kinematic micas that grew during contractional and extensional deformation. Our data highlight two distinct tectonic contexts for PCD formation: (1) late syn-orogenic deposits formed during stress relaxation synchronous with peak metamorphism (~170-150 and 90-70 Ma), and (2) post-orogenic deposits formed during the early stages of crustal extension and core complex exhumation (~120-100 and 38-25 Ma).

New Lu-Hf and Sm-Nd garnet dating, combined with garnet trace element profiles and pseudosection modelling, provide more detail on how the timing and magnitudes of crustal thickening may have influenced subsequent PCD formation. A preliminary garnet Lu-Hf date from the Northern Snake Range in eastern Nevada of ~106Ma indicates burial starting earlier than has been widely recognised before, which may be connected with formation of the adjacent 120-105 Ma Ely PCD cluster.

References:

[1] IEA Report (2021), https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[2] Lamont et al. (2024), *Nature Geosciences*, doi: 10.1038/s41561-024-01575-2