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Abrupt Switch in Magmatic Plumbing to Tap Porphyry Copper-Fertile Magmas

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Porphyry-type Cu deposits are amongst the most intensively studied ore systems (Richards, 2018) and will play a major role in the shift towards a green economy. They form from large, long-lived, multicomponent magmatic complexes, mostly in subduction-related settings (e.g.,Seedorff et al., 2005; Sillitoe, 2010; Wilkinson, 2013). Due to limited or patchy exposure of their 3D architecture (Seedorff et al., 2008), it is often difficult to determine when and why a relatively small number of systems, and more specifically certain batches of magma within them, produce deposits. We address this from field, mineralogical, geochemical (whole-rock and zircon), and geochronological (zircon U-Pb CA-ID-TIMS and molybdenite Re-Os) studies of the unique, comparatively complete ~8-km-deep cross section through the archetypal Yerington porphyry system, Nevada (Dilles, 1987).

We show that long-lived (>1.5 m.y.), relatively shallow (~1-8 km; Dilles, 1987) emplacement of the premineralisation McLeod Hill quartz monzodiorite and Bear quartz monzonite plutons, from a mid-crustal source (~15-20 km depth), rapidly switched (over ~100 k.y.) to slightly deeper intrusion (~4-8 km; Dilles, 1987) of more evolved magmas from a lower crustal source (~20-40 km depth) to form the Luhr Hill granite. Inward crystallisation of the latter produced Cu- and volatile-rich magmas, which were emplaced upwards as multiple generations of aplite dikes. These acted as crystal mush conduits (Carter et al., 2021) for exsolving magmatic-hydrothermal fluids from large volumes of underlying magma, over a period of up to ~1.1 m.y., to form the four known porphyry Cu deposits within the apices of the Luhr Hill granite. This framework, where porphyry deposit formation relied on a rapid switch in magma source and evolution to more copper-fertile compositions and the focussing of fluids through crystal mush dikes (Carter et al., 2021), offers new constraints for exploration models.

References

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