The Role of Crustal Anatexis in Porphyry Copper Formation During Flat-Slab Subduction: Insights from the Laramide Belt, Southwest USA

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The prevailing paradigm for the formation of porphyry copper deposits along convergent plate boundaries involves deep-crustal differentiation of metal-bearing juvenile magmas derived from the mantle wedge above a subduction zone. However, many major porphyry districts formed during periods of flat-slab subduction when the involvement of the mantle wedge would have been significantly reduced, if not absent. This leaves it unclear from where the ore-forming magmas were derived. To resolve this paradox, we investigate deep-crustal processes during the formation of the Arizona Laramide porphyry province, which formed between ~80 and 50 Ma during flat-slab subduction of the Farallon Plate beneath North America. We show that (1) Laramide-age granitoids have non-radiogenic Sr-Nd-Pb isotope signatures and (2) Proterozoic basement rocks from the Harcuvar, Harquahala, and Granite Wash Mountains in central Arizona experienced upper amphibolite-granulite facies anatexis at pressure-temperature conditions of 0.75 GPa (equivalent to a depth of ~28 km) and 750° to 780°C. U-Th-Pb monazite geochronology brackets the time of this deep crustal melting to between 73 and 60 Ma, suggesting an elevated geothermal gradient at the time of ~27.5°C/km. Crucially, this thermal climax coincided with (i) the zenith of granitic magmatism and porphyry genesis in the region (73–56 Ma) and (ii) dehydration of the shallowly-subducting Farallon slab (75–60 Ma). To explain the formation of the Laramide porphyry province, we propose that volatiles derived from the subducting slab passed straight into the lower crust, promoting anatexis of Proterozoic crustal sources without the requirement of juvenile mantle wedge-derived magmatism.