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Paleo-Tethyan anoxia correlated with low porphyry Cu potential

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Porphyry Cu±Mo±Au deposits occur along the length of the Tethyside orogenic belt, from eastern Europe (e.g., Majdanpek in Serbia, ~84 Ma), through Iran (e.g., Sar Cheshmeh, ~14 Ma) and Pakistan (e.g., Reko Diq, ~12 Ma), to Tibet (e.g., Qulong, ~16 Ma; Xietongmen, ~174 Ma) and Indochina (e.g., Pulang, ~213 Ma). The majority of known deposits are Late Cretaceous to Cenozoic in age, and are associated with subduction and collisional closure of the Neo-Tethys ocean basin. In contrast, very few deposits are known to be associated with subduction and collisional obliteration of the Paleo-Tethys ocean in the Paleozoic and early Mesozoic. The oldest known deposits occur in the Triassic–Jurassic Indosinian porphyry belt of SW China, and include Pulang and the Yangla Cu skarn deposit (~233 Ma). These deposits formed is a complex environment characterized by subduction and closure of multiple small ocean basins which may not have been typical of the wider Paleo-Tethys ocean. These deposits formed after Palaeo-Tethyan anoxia had ceased.

The main Paleo-Tethys ocean basin opened between Eurasia and Gondwana in the mid-Paleozoic, and had largely closed by the Late Triassic. The paleogeography of this ocean basin in the late Paleozoic led to its almost complete isolation from the wider Panthalassa ocean, and, combined with its equatorial latitude, led to the development of anoxic conditions and the deposition of thick black shale sequences from the Late Carboniferous to Early Triassic. We suggest that subduction of this reduced oceanic crustal material would have given rise to relatively reduced arc magmas, which are inefficient at mobilizing metals from the supra-subduction zone mantle wedge into upper crustal ore-forming environments. This is because, under reducing conditions, the mantle wedge and derived magmas would be substantially sulfide-saturated, and the bulk of chalcophile and siderophile metals (Cu, Au, platinum group elements) would be retained in restite or early separating sulfide melts and minerals, leaving metal-depleted evolved magmas.

Few data exist for Paleo-Tethyan arc rocks, but a comparison of available data from the literature with much more abundant data for Neo-Tethyan rocks shows a consistent trend of lower Cu contents at a given MgO content in the Paleo-Tethyan suite, as well as lower V/Sc and Sr/Y ratios. These trace element ratios are proxies for magmatic oxidation state and water content, which are typically coupled; thus, rocks with low V/Sc and Sr/Y ratios are interpreted to be relatively reduced and/or water-poor. The available data therefore support the hypothesis that Paleo-Tethyan arc magmas were relatively reduced because they formed in response to subduction of a reduced ocean basin, and therefore contained lower Cu (and presumably other metal) concentrations compared to normal oxidized arc magmas, such as those formed during Neo-Tethyan subduction. The reduced Paleo-Tethyan magmas would therefore have had lower potential to form porphyry-type Cu deposits upon emplacement in the upper crust, consistent with the rarity of deposits of this age in the Tethyside orogenic belt.