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Tectonic Triggers for Porphyry Copper Mineralization: The Central Andean Case

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Recent contributions that genetically group porphyry copper deposits (PCDs) according to tectonic setting have shown that fluid-rich magmas with elevated metal-carrying capacity may form during or subsequent to collisional orogenesis; this includes late-stage delamination of newly formed crustal roots, or postorogenic extensional collapse. Examples of PCDs formed in this kind of setting are those associated with Tethys closure, such as those of the Balkans or Kerman belt in Iran, which are associated with head-on continental collisions. Other examples (Papua New Guinea, southern Mongolia) involved convergence between intraoceanic arcs and continental blocks. In contrast, there is no evidence of accretion in the Andes for at least the last 250 m.y., suggesting that PCD formation there occurred in a regime of more "normal" subduction.

However, in both the Andes and Tethyan realm, PCD-related intrusive rocks share the same distinctive petrographic and geochemical features: oxidized, hornblende-rich "adakitic" rocks with high Sr/Y and La/Yb ratios, derived from water-rich magmas—these cannot be considered normal subduction products. Some authors have linked the occurrence of giant PCDs in the Andes to the subduction of sea-floor bathymetric highs (e.g., Juan Fernandez and Nazca ridges) or, more recently, to the subduction of serpentinized and hydrated transform fault zones. However, these assumptions are not consistent with the geographic distribution and age of PCDs that formed at 61 to 52 Ma and 43 to 33 Ma in southern Peru and northern Chile, and 14 to 5 Ma in central Chile. These events match the ages of major regional deformation events that correlate with readjustments in the global plate system. This relationship is especially straightforward for the Eocene-early Oligocene PCDs of northern Chile and southern Peru that were formed during the Incaic orogeny. Here differential tectonic shortening of several hundreds of km led to the formation of the Bolivian orocline, accompanied by tectonic uplift and concomitant crustal thickening, slab flattening, arc migration, and increased subduction erosion.

On a global scale, the Incaic episode appears to have resulted from acceleration of the absolute westward motion of South America due to the reorganization of global plates caused by the final ("hard") collision of India and Eurasia at ca. 45 to 40 Ma (followed by the syn- to postcollisional formation of the 41–32 Ma Yulong PCDs, just after the Andean Incaic PCD event). Similarly, in the case of central Chile during the late Miocene-Pliocene, formation of the giant PCDs at Los Pelambres and El Teniente followed the compressive collapse of the volcanotectonic Abanico Basin of Oligocene-Miocene age due to another burst of westward motion by South America; this increased mechanical plate coupling, crustal thickening, and shallowing of the subducting Nazca slab. Thus, formation of giant PCDs appears to be triggered by global tectonic processes, the effects of which are partly synchronous in both the Tethyan and Andean domains. In this regard, and as one example, the genesis of the Andean Incaic PCDs could be seen as a far-field effect of the initial stages of Himalayan orogenesis.