Tectonics, climate, and copper in the Central Andes: insights from (U-Th)/He hematite geochronology

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The western margin of the Central Andes has an arid climate that is thought to have persisted since at least 15 Ma. However, the region also hosts a number of porphyry copper deposits (PCDs) with well-developed supergene enrichment blankets formed by oxidation and leaching of the primary ore by meteoric water when the climate was wetter. While some have suggested that the onset of aridity was caused by the rain shadow created by uplift of the Andes in the late Oligocene, others have proposed that the arid climate was already established by Eocene time. Determining the precise relationship between Andean uplift, aridity, and the cessation of supergene enrichment is of fundamental importance for our understanding of PCD formation and could inform future copper exploration strategies in the region.

In this study, we investigate the relationship between uplift, aridity, and copper enrichment in northern Chile by tracking the relative movement of the water table in two PCDs. Using (U-Th)/He hematite geochronology, we date the precipitation of hematite that formed by reaction of oxygenated groundwater with ferrous-bearing minerals above the redox interface at the water table. Therefore, the depth of hematite precipitation as a function of time is used to constrain the relative movement of the water table.

Hematite precipitation ages from vertical drill holes within Cerro Colorado mine range from ca. 31 to 2 Ma, and show a downward younging trend from ca. 16 Ma onwards that implies a slow and steady lowering of the water table. This drop in water table at 16 Ma was likely caused by local canyon incision in response to the onset of aridity, which is also commensurate with the cessation of supergene enrichment across northern Chile at ca. 14 Ma.

Unlike Cerro Colorado, Spence mine is not incised by a canyon, and thus may have had a more prolonged period of water table stability. Further (U-Th)/He hematite analyses will elucidate the role of uplift, aridty, and water table movement in the potential for PCD enrichment across northern Chile, and demonstrate the role of geochemistry in teasing out complex tectono-climatic processes.