

Geochemical Signatures of Porphyry Cu Systems in Sonora, Mexico: Insights From Zircon Petrochronology

Oscar Daniel Torres-Alarcon^{1,2}, David Hernández-Urbe¹, Martín Valencia-Moreno³, Santiago Tassara⁴, Nestor Cano⁵

¹University Of Illinois - Chicago, Chicago, United States, ²Freeport McMoRan, Tucson, United States,

³Universidad Nacional Autónoma de México, Hermosillo, Mexico, ⁴Pontificia Universidad Católica de Chile, Santiago, Chile, ⁵Universidad Nacional Autónoma de México, Coyoacan, Mexico

Porphyry copper deposits (PCDs) are the primary source of copper worldwide. In Sonora, northwestern Mexico, PCDs occur within a NW–SE–trending belt that extends across the southwestern margin of North America. This study evaluates the magmatic fertility signatures of Sonoran PCDs and genetically related barren intrusions. We combine zircon U–Pb geochronology, trace-element geochemistry, and redox proxies to evaluate differences between PCD-related and barren intrusions. The U–Pb dates reveal overlapping fertile magmatic pulses from c. 80 to c. 58 Ma, with PCD-related intrusions generally coeval with or postdating barren magmas. Zircon geochemistry reveals differences between PCDs and barren intrusions. PCD-related zircons have low Ti, weak negative Eu anomalies, and steep HREE slopes consistent with a high zircon Cu fertility index ($ZCFI = 10^4 (EuN/EuN^*)/YbN + 5 Ce/\sqrt{(Ui \times Ti)}$), while barren zircons have higher Ti, stronger negative Eu anomalies, flatter HREE slopes, and hence lower ZCFI. These proxies indicate that PCD-related intrusions derived from oxidized and hydrated fertile magmas, whereas barren intrusions derived from drier and more reduced unfertile magmas. Our results indicate two pulses of PCD generation in Sonora: A first pulse that generated small PCDs (c. 80 Ma), and a second, younger event (c. 58 Ma) characterized by giant PCDs. These observations support the use of zircon geochemistry as an exploration tool to discriminate between barren and potentially mineralized intrusions.