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High-Precision Zircon Geochronology and Geochemistry from the Santa Rita Porphyry Cu Deposit, NM, USA

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Porphyry deposits are major elemental anomalies in the upper crust, concentrating metals through hydrothermal magmatic systems. As a result, understanding their formation is crucial, as sourcing metal resources is increasingly important during transitions to green technology. Models for porphyry copper formation rely on factors such as crustal architecture, changes in magma genesis and the degree and lifespan of fractionation to explain their occurrence relative to barren magmatic systems. It is thus crucial to constrain the magmatic lifespan and timing of volatile release from mineralizing intrusions, as these factors may control the total metal endowment of individual deposits.

The Paleocene Santa Rita porphyry Cu deposit, located in New Mexico, USA, has been studied for decades, and serves as an archetype for porphyry Cu deposit models. Early magmatism within the volcanic-plutonic complex began with mafic to intermediate composition volcanism and intrusions, followed by mineralization associated with the intrusion of two intermediate stocks (Santa Rita and Hanover-Fierro), genetically related granodiorite porphyry dikes, and finally several hydrothermally altered rhyodacitic to rhyolitic dike swarms that postdate the main period of Cu mineralization. High-precision zircon U-Pb CA-ID-TIMS geochronology indicates that the Hanover-Fierro stock was emplaced approximately 100 kyr prior to the granodiorite porphyry dikes associated with the Santa Rita stock. The age spectra are slightly more protracted in the granodiorite dikes compared to the Hanover-Fierro stock. The post-mineralization rhyodacite to rhyolite dikes yield mostly $^{207}Pb/^{206}Pb$ ages that reflect the presence of zircon cores inherited from Proterozoic basement. The end of Cu mineralization is thus marked by a pronounced shift to more significant crustal involvement, underlining the short timeframe associated with optimal conditions for mineralization. In order to avoid zircon inheritance and best determine the timing of emplacement of the post-mineralization rhyodacite to rhyolite dikes, ongoing work includes dating a suite of small, needle-shaped zircon inclusions in quartz phenocrysts, which are morphologically distinct from the majority of the zircon separated from bulk rock. Finally, to evaluate shifts in magma genesis through time, future steps include analysis of trace element and Hf isotope compositions from all zircon dated from the deposit.