

Quality Criteria? Evaluating Porphyry Cu Prospectivity Data Layers Using Southwestern USA Porphyry Cu Deposits

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Understanding the distribution of domestic critical mineral deposits is a key goal for the U.S. Geological Survey. Prospectivity mapping relies on available datasets and known deposit characteristics to predict the potential for undiscovered deposits. While many deposit formation models are built on fine-scale details, such as atomic-scale species complexation or mineral-scale redox transitions, prospectivity mapping requires deposit-to-regional level datasets comparable at the national scale. To evaluate how various datasets may reflect deposit occurrence and endowment, we studied the Chino, Morenci, Hannover-Fierro, and Tyrone porphyry Cu deposits in Arizona and New Mexico. These deposits range from 4.8-33.9 Mt Cu, were emplaced in a variable host rock lithologies, and include porphyry and skarn mineralization.

Geochemical indices reflective of deep crustal, hydrous magmatic evolution, such as whole-rock Sr/Y, La/Lu and Eu/Eu*, are ubiquitous in the region. However, they are not necessarily indicative of mineralizing magmatism, non-mineralizing rocks also commonly have similar compositions. Duration of magmatic assembly correlates with total ore endowment for high-precision geochronology datasets. This suggests it could be a powerful prospectivity tool, however such data are currently sparse and low-precision data can lead to spurious interpretations. Regional-scale geophysical data offers relatively continuous observations over large areas, making them ideal for prospectivity mapping, though with certain limitations. Processed multispectral images from ASTER scenes effectively highlight hydrothermal alteration across all four porphyry systems. However, weathered basin-fill and dense vegetation can complicate data interpretation. Airborne magnetic data typically show low magnetization over the porphyry systems, but magnetite-rich skarn deposits may present local magnetic highs. Radiometric data reveal increased potassium concentrations, particularly in regions with mined material that may be obscuring the signal from the host rock. Together, these data suggest that detailed quantitative criteria are needed to accurately predict critical mineral resources, and that it is necessary to combine datasets to prevent false positives.