

Propylitic Alteration and Metal Mobility in Porphyry Systems: A Case Study of the Northparkes Porphyry Cu-Au Deposits, NSW, Australia

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Propylitic alteration is typically the most ubiquitous and laterally extensive alteration facies in porphyry ore systems. With exploration increasingly focused on searching under cover, it may be the only visible sign of hydrothermal activity. Consequently, knowledge of propylitic assemblages and how they form is crucial to effective exploration in these domains. Despite this, propylitic alteration is relatively poorly understood, with deposit models generally assuming an isochemical process driven principally by heated meteoric water. We present a detailed study of the Northparkes porphyry cluster to test this paradigm and establish whether systematic changes in whole-rock and alteration mineral chemistry that could assist with exploration targeting are developed.

Northparkes, located in central NSW, consists of several small alkalic Cu-Au porphyry bodies, host to both high-grade and subeconomic mineralization. These multiphase quartz monzonite intrusions are particularly narrow (~200–300-m diameter) but highly elongate (>1.4 km vertically), emplaced within and above a larger monzonite pluton. The Late Ordovician to Early Silurian intrusive system forms part of the Macquarie arc, which at Northparkes has been overprinted by deformation associated with the Lachlan fold belt. Field observations show each porphyry is surrounded by a small-scale alteration halo, with progression from an inner potassic alteration, characterized by K-feldspar + biotite, through a magnetite + biotite halo, passing outward to a widespread propylitic epidote + chlorite zone. Each intrusive center therefore appears to have focused a discrete hydrothermal system that affected the appearance and mineralogy both of earlier intrusions and country rocks as a function of their spatial position and lithology.

The flux of metals (e.g., Cu, Au, Zn, Mn, Pb, V, Co) and ore-related elements (e.g., As, S, K, Ca, Sr) passing through the principal alteration zones was quantified using bulk-rock geochemistry and chemical mass transfer analysis. The mineralogical residence of these elements was also mapped throughout the propylitic zone, with an extensive epidote and chlorite LA-ICP-MS mineral chemistry dataset. Results show propylitic alteration is not isochemical, with marked gains and losses of a wide range of major, minor, and trace elements across the alteration facies. Elements lost from the potassic zone are typically gained in the propylitic zone (e.g., Ca, Fe, and Co), and extensive outward dispersion of other elements is observed. This is reflected either as a decreasing outward concentration (e.g., Cu, Si, Ti, and S) or in a halo of higher values (e.g., Zn and Mn). Similar trends exist, but often with a greater magnitude of variation, in the chemistry of epidote and chlorite from the innermost to outermost propylitic zone.

Such distribution patterns for metals and ore-related elements, in particular their residence within propylitic alteration minerals, indicate a close link in space and time between intense propylitic alteration and ore formation. We contend that propylitic alteration is generated principally by lateral and upward infiltration of magmatic fluids into the host rock sequence. For exploration, it is clear that examining propylitic mineral chemistry and recording details such as mineral assemblages, alteration intensity, and texture are critical to improving success.