

Characterization of Roots Zones of Porphyry in the Grasberg Igneous Complex: Implications for Porphyry System Exploration

Utreck Frans Frisco Rumbiak^{1,2}, Putra Sadikin²

¹University Of Padjadjaran, Indonesia, Indonesia, ²Freeport Indonesia, Timika, Indonesia

The roots zones of porphyry systems are critical regions beneath mineralized centres, marked by focused fluid flow, quartz veining, and extensive wall-rock alteration. These zones play a key role in ore fluid generation and can provide indicators for previously undiscovered deposits.

This study investigates the roots zone of the Grasberg Intrusive Complex (GIC), focusing on the processes that govern mineralization and alteration. A whole-rock geochemical approach is employed, utilizing high-quality major element datasets to calculate molar element ratios—particularly K/Al, (Fe+Mg)/Al, and Na/Al. These ratios serve as proxies for the stoichiometric composition of alteration minerals and enable the delineation of hydrothermal zones. High Na/Al values are diagnostic of sodic alteration in outer propylitic zones, whereas elevated K/Al and low Na/Al values correspond to biotite-dominated potassic alteration. Intermediate values of K/Al and low Na/Al are indicative of phyllic alteration, commonly characterized by quartz-sericite-pyrite (QSP). This geochemical framework provides a systematic way of characterising hydrothermal alteration at depth.

Deep quartz veining—specifically A-, B-, C-, and D-veins—is described alongside wall-rock alteration assemblages and orebody morphologies. These features are interpreted using a comprehensive whole-rock geochemical workflow, which supports robust classification of alteration styles and paragenetic relationships. Particular attention is given to quartz Unidirectional Solidification Textures (USTs), which provide insight into rapid thermal or pressure changes during vein formation.

Preliminary results reveal widespread quartz-coarse muscovite alteration in the roots zone, offering valuable information on fluid composition and the evolution of the magmatic-hydrothermal system. The identification of muscovite-rich veins further contributes to our understanding of vein paragenesis and fluid pathways.

Overall, this research enhances the geological understanding of deep alteration processes in porphyry systems and provides practical tools for exploration, including mineralogical proxies and fluid evolution models essential for identifying fertile intrusive centres.