Significance of Regolith-Landscape Evolution for Exploration of Copper Deposits, Mount Isa, Queensland, Australia

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Extensive, variable, and generally thick regolith is a major impediment to mineral exploration in regolith-dominated terrains. The landscape of the Mount Isa Inlier is a product of several sedimentation and weathering episodes. Therefore, understanding regolith and paleolandscape evolution are critical factors for geochemical exploration. The present work aims to understand the regolith formation and its significance for exploration of Cu oxide deposits in the Lady Annie, Mount Kelly, and Anthill areas, ~120 km NW of Mount Isa.

Regolith profiles were described from 55 drill holes through three traverses crossing Cu sulfide deposits to assess lateral extent and thickness of the Cu oxide halo in regolith. The ideal regolith profile was developed on calcareous and carbonaceous siltstones and sandstones of the Middle Proterozoic, lower McNamara Group. The bedrock hosts stratiform and structurally controlled copper sulfide deposits. The regolith profile consists, from base to top, of a saprock (transition zone), ferruginous saprolite (Cu-oxide zone), kaolinitic saprolite and silcrete bands (bleached zone) and terminated by a pedolith of mottled, lateritic duricrust and soil zones. The weathering profile in the modern landscape is preserved from erosion by siliceous or ferruginous duricrusts. However, in many areas the regolith profile is partially to completely eroded, exposing the underlying bedrock.

Mineralogical and chemical compositions of the regolith profile indicate that the lower ferruginous saprolite consists mainly of quartz, white mica, feldspars and goethite. Oxidation of Cu sulfides in the bedrock creates an acidic pH gradient, moving Fe, Mn, and other redox-sensitive elements such as Zn, Ni, As, and V. This acidic pH gradient is buffered by the carbonates in the bedrock, and resulted in secondary Cu carbonates in the saprock and Cu oxides in the ferruginous saprolite zone. The Cu concentrations in these two zones reach economical values (up to percentage level). Kaolinitic saprolite above these zones consists mainly of quartz and kaolinite and the enclosed silcrete bands consists mainly of quartz (>95 wt % SiO_2). The Cu concentrations in this zone are highly depleted (≤100 ppm) relative to underlying ferruginous saprolite. White mica (primarily muscovite) persists in the regolith profile even under intensive weathering as indicated by higher concentrations of K_2O, Rb, and Cs at the top of the weathering profile. Towards the upper part of the kaolinitic saprolite, mottled zone, duricrusts, and soils, secondary cavity-filling carbonates (calcite and dolomite) and sulfates (gypsum and barite) are precipitated, possibly due to the recent arid climate. This is consistent with the unexpected upward increases in CaO, MgO, Na_2O, S, Ba, and Sr.

The lateral variations along traverses indicates that the dispersion halo of the Cu oxides is thick over the sulfide mineralization with a mushroom-like shape and extends laterally for a distance of up to ~2 km, where it is overlain by thick, bleached saprolite. Soil, lateritic duricrust and mottled zone are also anomalous in Cu and other trace elements, and thus can be used as sampling media but require interpretation of soil origin (in situ vs. transported) and an awareness of anomaly dilution by recent calcification and gypsification.