## Alteration-mineralization and Whole Rock Geochemistry at the Deep Mill Level Zone (DMLZ) Ertsberg District, Papua

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The Ertsberg-Grasberg district hosts the world's largest Cu-Au (-Mo) skarn system. The mineralization is related to the Pliocene Ertsberg- and Grasberg intrusive complexes, which intruded the Jurassic-Cretaceous Kembelangan Group siliciclastics and Cenozoic New Guinea Limestone Group.

The Ertsberg granitoids have medium $SiO_2$ and high $Al_2O_3$ contents, and consist mainly of (quartz-) monzonite and minor (monzo)diorite. Least-altered samples have upper crust-normalized enrichments in certain large ion lithophile elements (LILEs, e.g., U and K) and depletions in all high field strength elements (HFSEs, e.g., Ti, Y, and Yb). The samples are fresh to moderately-altered, featured by garnet-diopside skarn and/or porphyry-style (potassic, propylitic, phyllic) alterations and anhydrite replacement. Elemental mass balance calculation indicates that the porphyry-style alteration zones are featured by feldspar destruction and the accompanying alkali depletions, although the loss of K– Rb (in potassic and phyllic zones) and Ca-Ba-Sr (in propylitic zone) are balanced by their respective capturing in secondary K-feldspar-mica and actinolite-epidote-anhydrite. Decarbonation of the dolomitic wallrocks likely released Mg-Ca-Sr, which facilitated the subsequent forsterite-diopside exoskarn and anhydrite alteration. The enrichments of various ore-related target/pathfinder elements in these altered samples are consistent with their mineralized nature, e.g., Fe– Mn (magnetite), Cu-Fe-Bi-Se-Te (bornite), Mo-Re (molybdenite), Au-Ag-As-Bi-Te (auriferous pyrite/arsenopyrite), Zn-Fe-Mn-Sn-In (sphalerite), and Pb- Ag-Bi (galena).

Ores at Ertsberg are mainly skarn-hosted, whose formation comprises five stages: (I) prograde skarn; (II) retrograde alteration; (III) massive anhydrite replacement; (IV) late hydrothermal veining; (V) supergene alteration. Massive magnetite and main Cu– Au mineralization occurred in Stage II and III, respectively, although minor Cu mineralization persisted to Stage IV.