Alteration Geothermometry and Exploration Implications of the Gajah Tidur Porphyry System, One of Two Systems that Formed the Supergiant Grasberg Cu-Au-(Mo) Deposit

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Based on geochronological data and field relationships, researchers have recently proposed that the Grasberg Cu-Au-(Mo) deposit comprises two overlapping porphyry Cu systems, the deeper and older (~3.4 Ma) Gajah Tidur (GT) Cu-Mo-(Au) system and the shallower and younger (~3.1 Ma) Main Grasberg (MG) Cu-Au system. Dating of abundant hydrothermal muscovite and subordinate biotite in this study supports the age relationships between the two porphyry systems and indicates that alteration and associated Cu-Mo-(Au) mineralization beneath the now mined-out Grasberg open pit is mainly associated with the GT porphyry system. As well as a ~1-km difference in emplacement depth compared to MG, a different metal signature (Cu-Mo-(Au) vs. Cu-Au), and distinct parent intrusion geometry, Cu mineralization in GT is mainly associated with a lower-temperature alteration assemblage. Sulfur isotope temperatures from sulfate-sulfide pairs show that initial GT magmatic-hydrothermal fluids formed K-feldspar-biotite alteration at temperatures up to 590°C. Cooling of this fluid from ~460° to ~370°C resulted in white mica-dominated alteration associated with anhydrite, chlorite, chalcopyrite, and pyrite. Further cooling (340°–280°C), outward from the core of the hydrothermal system, is characterized by a muscovite-quartz ± pyrophyllite assemblage associated with covellite-pyrite mineralization. While Cu mineralization in the GT porphyry system is largely associated with white mica assemblages (muscovite-anhydrite-chlorite and muscovite-quartz ± pyrophyllite), high-grade Cu and Au mineralization in the MG system is chiefly associated with a K-feldspar-biotite-magnetite assemblage formed at higher temperature than the GT K-feldspar-biotite alteration. The overlapping GT and MG porphyry systems formed the supergiant Grasberg Cu-Au-(Mo) porphyry deposit, within which GT contributed an estimated 30% for Cu, 10% for Au, and 75% for Mo. The existence of two closely spaced, well-mineralized porphyry systems where the older system was emplaced at a greater depth than the younger one is an unusual occurrence that has significant exploration implications.