

Geology and Mineralization of the Giant Yulong Porphyry Copper-Molybdenum Deposit, Eastern Tibetan Plateau

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The Eocene Yulong porphyry Cu-Mo deposit (4,600–~5,400 m a.s.l.) is located on the eastern margin of the Tibet plateau and formed as a result of regional transtension related to the Asian-Indian continental collision. It is China's second largest copper deposit, containing proven reserves of >6.5 Mt Cu at 0.62 wt % and >0.4 Mt Mo at 0.042 wt %. Copper-molybdenum mineralization is largely hosted in the Yulong monzogranite porphyry stock that was emplaced at 41.2 ± 0.3 Ma and intruded by several barren or weakly mineralized granite porphyry dikes. Minor copper ores occur as mineralized skarn in the contact zones between the monzogranite and Upper Triassic marine limestones. The uppermost parts of the porphyry and skarn orebodies are variably exposed and oxidized, leading to significant supergene copper enrichment. Gossans and underlying supergene zones have been partly eroded. The ore shell in the Yulong porphyry and the proximal hornfels has an asymmetric inverted cup shape in three dimensions, with the main economic ore grades in the southeastern part of the deposit extending downward to 4,000 m a.s.l. The ore shell surrounds a barren core (<0.3 wt % Cu), the top of which is about 4,400 m in elevation in the center of the porphyry stock. The high-grade Cu and Mo mineralization correlate closely above 4,300 m a.s.l., but Mo mineralization becomes more important at greater depth.

Hydrothermal alteration typical of porphyry copper systems is well developed in the deposit. Potassic alteration is expressed by K-feldspar, biotite, and quartz, with minor amounts of albite and sericite, occurring both in the monzogranite porphyry and the proximal hornfels. The potassic alteration is surrounded by a propylitic zone consisting of epidote, chlorite, albite, calcite, and pyrite that occurs as fine-grained aggregates or as veinlets in the outer margin of the deposit. The sericitic alteration overprinting potassic alteration is dominated by sericite, sulfide minerals, quartz, and minor illite and smectite, in an annular shape advanced from the top of the deposit downward along steep structures. Cu-Mo mineralization is mainly developed in the potassic alteration and, less significantly, in the sericitic alteration zone. Chalcopyrite, molybdenite, tennantite, and enargite are the predominant ore minerals.

The porphyry Cu-Mo mineralization is characterized by extreme development of a large variety of veins and veinlets. Irregular, discontinuous magnetite, biotite, and K-feldspar veins occur in lower barren core of the deposit. Barren biotite-cemented breccias and wispy biotite veinlets are distributed throughout the deposit and are cut by sulfide-bearing veins and

veinlets. Sulfide-free quartz veins contain trace diagnostic magnetite, albite, and anhydrite, which represent the earliest quartz-dominated vein seen in the deep barren porphyry. Irregular and sheeted quartz veins characterized by sugary texture occasionally coexist with thin K-feldspar halos and generally contain abundant chalcopyrite, molybdenite, and pyrite as disseminations, aggregates, or veinlets. The A2 veins comprise a complex set of crosscutting veinlets, frequently cut by biotite-bearing A3 quartz veins that are similar to the A2 veins in form and contained sulfides. A4 sulfide veins are distinguished from earlier-stage varieties by the paucity of quartz and the predominance of chalcopyrite and/or molybdenite. The later B veins fill continuous planar fractures, with parallel walls being filled by anhedral to subhedral quartz and minor K-feldspar. B veins always contain parallel lateral bands of flaky molybdenite intergrown with granular quartz and are locally filled by chalcopyrite and/or pyrite in the central voids. The pyrite-dominated D veins with feldspar-destructive alteration halos are distributed throughout the deposit and cut all early-stage veins.

The overlap of Mo and Cu grade halos and the Cu- and Mo-rich A2 to A4 and B veins suggests that Cu and Mo mineralization formed by the same ore-fluid system, rather than being driven by distinct magmatic-hydrothermal pulses. This view is confirmed by an Re-Os isochron age of 40.1 ± 1.8 Ma of molybdenite extracted from four quartz veins.