

Oyu Tolgoi, Mongolia: Siluro-Devonian Porphyry Cu-Au-(Mo) and High-Sulfidation Cu Mineralization with a Cretaceous Chalcocite Blanket

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Abstract

The Oyu Tolgoi porphyry Cu-Au-(Mo) deposit is located in the Gobi Desert of southern Mongolia. The deposit consists of three main mineralized zones (North, Central, and South Oyu), interpreted to constitute at least two separate porphyry copper centers. Oyu Tolgoi is associated with a series of small, structurally controlled stocks and dikes of monzonitic and dioritic composition, which intrude a sequence of Siluro-Devonian volcanic and sedimentary rocks. Country rocks consist of pillow basalt and basaltic andesite interbedded with fine-grained clastic sedimentary horizons. The sequence is interpreted to have formed in a subaqueous island-arc volcanic environment, which formed part of the extensive Paleozoic Tuva Mongol arc. These island-arc rocks are covered by Carboniferous terrigenous sequences and are intruded by Carboniferous syenite and granite and Permian alkaline granite. Much of the area is covered by poorly consolidated Cretaceous sedimentary sequences.

Central Oyu consists of a multiple-phase hydrothermal breccia crosscutting an altered fine-grained feldspar porphyry containing porphyry-type alteration and mineralization. The breccia underwent texture-destructive advanced argillic alteration characterized by several associations of quartz, alunite, dickite, pyrophyllite, sericite, and zunyite plus lesser svanbergite and fluorite. These associations overprint earlier formed K silicate and quartz-sericite-illite assemblages. Copper mineralization at Central Oyu is present in a supergene chalcocite blanket that formed at the expense of a pyrite-rich, hypogene chalcocite-covellite-tennantite (arsenosulvanite, sulvanite, chalcopyrite, bornite) sulfide suite that accompanied the advanced argillic alteration event.

At South Oyu, a feldspar-hornblende porphyry of monzonitic composition intrudes a sequence of fine-grained andesite and basaltic andesite. Hypogene copper-gold mineralization occurs as early magnetite-rich, pyrite-poor quartz-chalcopyrite-bornite stockworks and sheeted veinlets. Hydrothermal alteration is composed of biotite and K feldspar with apatite and minor albite. Magnetite averages 7 to 10 vol percent, and copper and gold grades vary sympathetically. These early assemblages are overprinted by a sericite-chlorite event with ore-grade copper and erratic gold and molybdenum values and also by structurally controlled, pyrite-rich advanced argillic alteration.

K-Ar ages show that the hypogene copper-gold mineralization at South Oyu is latest Silurian-earliest Devonian (411 ± 3 Ma) and that the entire district was intruded by postmineralization syenite during the Carboniferous (307 ± 4 Ma). The supergene chalcocite blanket at Central Oyu formed in the Early Cretaceous-earliest Late Cretaceous, based on ages for supergene alunite of 117 ± 1 and 93 ± 1 Ma, which makes Central Oyu one of the oldest preserved chalcocite blankets in the world. Chalcocite blanket preservation was favored by climatic desiccation into the Late Cretaceous and the Tertiary.

It is inferred that significant regional uplift took place at the Silurian-Devonian boundary. This synmineralization uplift and erosion may have been in part responsible for the telescoping of the hydrothermal systems at Oyu Tolgoi, including the superposition of epithermal-style associations over higher temperature, deeper seated assemblages typical of the porphyry environment.