

Superimposed mineralization in the Paleozoic Tuwu and Yandong porphyry copper deposits, eastern Tianshan Mountains, NW China: Evidence from geology, fluid inclusions, and geochronology

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The Tuwu (109 Mt @0.62% Cu) and Yandong (~ 300 Mt @ 0.67% Cu) copper deposits, about 6 km apart, are located in the southern part of the Dananhu-Tousuquan Island Arc belt of in the eastern Tianshan, Xinjiang, NW China. They are mainly hosted by plagiogranite porphyry and the Carboniferous Qi'eshan Group volcanic rocks, with minor mineralization in in the quartz albite porphyry at Yandong.

According to trosscutting relationships and mineral assemblages, the alteration and mineralization processes at Yandong comprise three episodes: the porphyry mineralization episode, including potassic (I), propylitic (II), early phyllic (IIIA) and late phyllic (IIIB) stages; the superimposed mineralization episode, including main- (IV) and post-mineralization(V) stages; and the supergene episode. The Cu and Mo mineralization occurred in stages III and IV, but the latter of the two was the main Cu and Mo mineralization stage. Fluid inclusions from stages I, IIIA, and IIIB yielded homogenization temperatures of 340 – 400 °C, 280 – 320 °C, and 160 – 180 °C, respectively. Homogenization temperatures from stages IV and V are mainly 300 – 340 °C and 120 – 140°C, respectively.

The Tuwu copper deposit consists of four episodes, e.g., the epidote-chlorite alteration, porphyry mineralization, superimposed mineralization, and supergene alteration episodes. Similar to Yandong, four stages are recognized in the porphyry episode, i.e., potassic (I), propylitic (II), early phyllic (IIIA) and late phyllic (IIIB), and two stage in the superimposed mineralization episode, i.e., Cu mineralization (IV) and post-mineralization (V), respectively. The Cu and Mo mineralization were mainly deposited during the porphyry episode, with minor amounts in a superimposed mineralization episode. Homogenization temperatures for stages I, II, IIIA, and IIIB vary from 420 to 480 °C, 457 to 469 °C, 300 to 360 °C, and 220 to 240 °C, respectively. In the superimposed mineralization episode, hydrothermal temperatures evolved from 360–460 °C (stage IV) to 120–180 °C (stage V).

Sericite $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the phyllically altered plagiogranite porphyry yielded plateau ages of 328.1 ± 1.4 Ma for Tuwu and 332.8 ± 3.8 Ma for Yandong, consistent with the Re-Os age (327.6 ± 2.1 Ma) of molybdenite from the porphyry mineralization episode and ore-forming plagiogranite porphyry (339 – 332 Ma). Furthermore, Re-Os dating of molybdenite from the superimposed mineralization episode, yielded an age of 324.3 ± 2.7 Ma. A similar mineral assemblage (chalcopyrite-anhydrite-calcite-chlorite) was observed in the quartz albite porphyry (323.6 ± 2.5 Ma) and the stage IV superimposed mineralization was likely associated with the quartz albite porphyry.

Consequently, we propose that at least two mineralization episodes may have occurred at Tuwu and Yandong. The porphyry mineralization (333–328 Ma), caused by the plagiogranite porphyry, contributed to the majority of the Cu-Mo resources for the Tuwu deposit, while the superimposed mineralization episode (ca. 324 Ma), related to the quartz albite porphyry, was the major Cu-Mo mineralization period for the Yandong deposit. Such superimposed mineralization style at Yandong (and minor at Tuwu) may represent a good example of the Paleozoic Cu deposits in the Central Asian Orogenic Belt.