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Hydrothermal fluid signatures of the Yulong porphyry Cu-Mo deposit: Clues from the composition and U-Pb dating of W-bearing rutile

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Abstract

Hydrothermal rutile (TiO_2) is a widely distributed accessory mineral in hydrothermal veins or alteration assemblages of porphyry deposits and provides important information for further understanding hydrothermal fluid signatures. This study determines the geochemical composition and U-Pb dates of hydrothermal rutile from the Yulong porphyry Cu-Mo deposit in east Tibet, China. Three types of TiO_2 polymorphs have been identified based on their Raman spectroscopic, textural, and chemical characteristics. (1) Brookite and anatase pseudomorphs after titanite in a fine-grained matrix, indicating low-temperature hydrothermal fluids destabilizing primary Ti-bearing minerals during argillic alteration (type-I). (2) Elongated and prismatic rutile present in hydrothermal veins or in clusters in accompanying alteration envelope characterized by weak zoning (type-II). And (3) rutile intergrown with sulfides in hydrothermal veins, characterized by well-developed patchy and sector zoning (type-III). In contrast to the type-I and type-II TiO_2 polymorphs, tungsten is enriched in backscattered bright patches and sector zones in type-III rutile, which is due to the substitution of W^{6+} in the Ti^{4+} octahedral site. The mechanism of the enrichment of tungsten is effectively driven by the halogen-rich (F, Cl) aqueous fluids during hydrothermal mineralization. In situ U-Pb dating of the type-III rutile yields a lower intercept age of 41.8 ± 1.2 Ma, which brackets the timing of the Cu-Mo mineralization. The relationship between rutile textures and composition indicates that W-bearing rutile can serve as a recorder of hydrothermal processes in porphyry Cu deposits.

Keywords: W-bearing rutile, hydrothermal fluid signatures, U-Pb geochronology, EMPA, mineral chemistry, porphyry Cu-Mo deposits