

Formation of giant copper deposits driven by rapid uplift and sudden depressurization

**RUI WANG^{1,*}, CHENHAO LUO^{1,*}, YINGCAI SUN¹, SHAOCHEN WU¹, XIAO-PING XIA^{2,†},
XIAOLIN WANG^{3,‡}, AND WENJIE XIA¹**

¹State Key Laboratory of Geological Processes and Mineral Resources, Frontiers Science Center for Deep-time Digital Earth, Institute of Earth Sciences, China University of Geosciences, Beijing 100083, China

²Hubei Key Laboratory of Petroleum Geochemistry and Environment, College of Resources and Environment, Yangtze University, Wuhan 430100, China

³State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering, Nanjing University, Nanjing, Jiangsu 210023, China

ABSTRACT

Porphyry Cu deposits in collisional orogens are new targets for modern mineral exploration. A series of post-collisional (Miocene; 22–12 Ma) porphyry copper deposits with Cu reserves over 45 Mt have been discovered in the Gangdese magmatic belt, southern Tibet. These magmas were derived from the partial melting of sulfide-bearing Tibetan juvenile lower crust and were well primed for porphyry Cu deposits, having high oxidation states and being rich in volatiles such as water, S, and Cl. However, only some plutons ended up with economic ore concentrations. We measured the igneous zircon water contents of ore-related and barren high Sr/Y magmas in the Gangdese belt, southern Tibet, and found that magmas that produce giant porphyry Cu deposits have lower zircon water contents than barren and small-deposit related magmas. Combined with previous studies of fluid inclusions, magmatic breccias, apatite geochemistry, and thermal histories, which demonstrated higher initial water content in causative porphyries such as the giant deposits of Qulong and Jiamia, we believe that the lower zircon water content may be attributed to these magmas experiencing faster cooling and sudden depressurization of a large, primed, volatile-saturated or supersaturated mid-to-upper crustal magma chamber, which led to rapid and voluminous volatile exsolution and fluid discharge. These processes caused intense hydrothermal alteration and large ore deposition. In contrast, magmas that experienced slow cooling and deep emplacement would undergo steady-state degassing and weak alteration. The variable intrusive and thermal histories across the Gangdese intrusions reflect the interplay between surface and lithospheric dynamics within the Himalaya-Tibet orogen. Our findings suggest that the differences in zircon water content reflect the emplacement rate and depth of each granitic body and, therefore, may serve as an indicator for tectonics and the potential for mineralization.

Keywords: Giant copper deposits, post-collisional setting, zircon water content, rapid uplift, fluid discharge, volatile exsolution