# Geology, Mineralization, and Fluid Inclusion Constraints on the Genesis of the Zhibula Cu Skarn Deposit, Gangdese Belt, Tibet

Jing Xu,[1*] Youye Zheng,[1,2] and Xiang Sun[2]

[1]Faculty of Earth Resources, China University of Geosciences, Wuhan 430074, PRC
[2]School of Earth Science and Resources, China University of Geosciences, Beijing 100083, PRC

E-mail, xujing3800@126.com

The Zhibula Cu skarn deposit contains 0.32 Mt Cu metal with an average grade of 1.64%, and is located in the Gangdese metallogenic belt of southern Tibet. The skarn is a typical metasomatic skarn related to interaction of magmatic-hydrothermal fluid and calcareous host rock. The present study aims to constrain the ore-forming processes based on detailed field work, petrology, and geochemistry. Major stratiform skarn orebodies occur at the contact between tuff and marble of the Lower Jurassic Yeba Formation. Alteration zones generally grade from a fresh tuff to a garnet-bearing tuff, to a garnet pyroxene skarn, and finally to a wollastonite marble. Minor endoskarn alteration and zonation are also observed in the causative intrusion, which grades from a fresh granodiorite into a weakly chlorite bearing granodiorite, to a green diopside-bearing granodiorite, to a dark red-brown, garnet-bearing granodiorite. Prograde minerals, identified by electron probe microanalysis include andradite of various colors (e.g., red, green, and yellow) and green diopside. Retrograde metamorphic alteration overprints the prograde skarn, and is mainly composed of epidote, quartz, and chlorite. Ore minerals consist of chalcopyrite and bornite, followed by magnetite, molybdenite, pyrite, pyrrhotite, galena, and sphalerite.

Both granodiorite and monzogranite have been mapped near the deposit. They have similar zircon U-Pb SIMS ages (16.9–17.0 Ma) and are coeval with a molybdenite Re-Os age (16.9 ± 0.64 Ma), interpreted as the age of mineralization. Geochemically, these intrusive rocks exhibit an I-type calc-alkaline granitoid signature. Zircon isotopic compositions of εHf(t) (+4.5 to +8.8) and $\delta^{18}O$ (+6.0 to +6.6‰) indicate both lithologies share a similar magmatic origin. We interpret the origin of these intrusions to be related to partial melting of thickened juvenile lower crust, triggered by upwelling of asthenosphere which was induced by the convective removal of the thickened lithosphere.

Three types of fluid inclusions are recognized in samples from the Zhibula deposit: liquid-rich two-phase inclusions (L-type), vapor-rich, two-phase inclusions (V-type), and daughter mineral-bearing three-phase inclusions (S-type). From prograde through retrograde and to the last stage of skarn formation, ore-forming fluid evolved from high temperature (405°−667°C), high salinity (up to 44.0 wt % NaCl equiv), and high pressure (500−600 bars) to low temperature (130°−184°C), low salinity (0.4−4.3 wt % NaCl equiv), and low pressure (100−200 bars). Isotopic data, $\delta^{34}S$: –0.1 to –6.8‰, estimated $\delta^{34}S_{fluids}$ = –0.7‰, $\delta D_{H2O}$: –91 to –159‰, and $\delta^{18}O_{H2O}$: 1.5‰ to 9.2‰, suggest that ore-forming material and fluid were magmatic-hydrothermal, whereas the last stage fluid was mainly meteoric water ($\delta D_{H2O}$ = –137‰, $\delta^{18}O_{H2O}$ = –10.7‰). Fluid immiscibility and boiling likely occurred during prograde and retrograde stages

of skarn formation, respectively, and are the most important Cu deposition mechanisms for the deposit.