# Metallogenic Epoch and Metal Sources for Deposits of the Tongshanling Cu-Pb-Zn-Polymetallic Ore Field, Southern Hunan Province, China

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The Tongshanling Cu-Pb-Zn-polymetallic ore field, located in the collisional zone between the Yangtze block and the Cathaysia block, is one of the many ore fields in the Nanling metallogenic belt, China. Zircon U-Pb dating studies on the No. I and No. III Tongshanling granodioritic pluton show that there probably had been three magmatic stages of 177-167 Ma, ~161-157 Ma, and 149-148 Ma in the ore field, but just two mineralization ages of ~155 Ma and ~167 Ma have been reported to date. To confirm whether there are three mineralization stages corresponding to the three magmatic stages, the mineralized skarns and sulfide ores were sampled from the Beihoushan deposit located in the northeastern part of the No. I Tongshanling pluton. The garnets picked from the skarns define a Sm-Nd isochron age of 173±3 Ma. The sphalerites from the ores define three Rb-Sr isochron ages of 144±7 Ma for minerals, 141±6 Ma for sulfide residues after diluted acid leaching, and of 141±3 Ma for minerals and sulfide residues, which are consistent within the error ranges. Considering the published Re-Os model (isochron) age of 155±3 Ma for molybdenite and Sm-Nd isochron age of 155±8 Ma for garnets from the Qiaotoupu deposit, and the published Re-Os isochron age of 167±15 Ma for molybdenite from the Yulong deposit and 159±8 Ma for molybdenite from the Weijia deposit, we suggest the ore field may have been the product of three mineralization stages at ~173-167Ma, ~159-155 Ma, and ~144-141 Ma that correspond to the three magmatic stages.

There are also divergent opinions about the ore-forming material sources for the Tongshanling deposits. We carried out S-Pb-C isotopic analyses on various types of rocks, ores, and minerals. The $\delta^{34}S$ values vary from -1.9‰ to +5.7‰ with an average of +2.6‰, implying the sulfur mainly comes from a magma with homogeneous S isotopic compositions. The Pb isotopic compositions of rock samples and sulfides have characteristics of upper-crust lead, indicating the lead mainly originates from the upper crust that is relatively enriched in uranium lead and with slight losses in thorium lead. In addition, mantle-derived igneous material may be involved in the mineralization. The $\delta^{13}C$(PDB) values of rocks and calcites range from -9.88‰ to +1.32‰, showing a variation tendency of mantle-derived carbon to mineralized-strata-derived carbon from the early to late stages of mineralization, which indicates the carbon in the ore-forming fluid comes from magma in the early mineralization stage, but in the late stage the carbonate strata has made a significant contribution to the mineralization.