Porphyry-Related Mo-Pb-Zn-Ag Veins in the Fudian Ore Field, Southern North China Craton

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The Fudian ore field, located in the Waifangshan district of the southern North China craton, hosts the Donggou porphyry Mo deposit and numerous Pb-Zn-Ag veins around the Mo-mineralized porphyry. Fudian has a proven reserve of 0.63 Mt Mo and 0.93 Mt Pb + Zn. The Mo orebodies mainly occur along the contact zone between the Donggou granite porphyry and the Proterozoic Xiong'er Group volcanic rocks. On the basis of field and petrographic observations, four hydrothermal stages are recognized for the Donggou Mo deposit, consisting of K-feldspar-molybdenite (stage I), quartz-molybdenite (stage II), quartz-polymetallic sulfides (stage III), and quartz-calcite veins (stage IV). Sanyuangou is one of the important Pb-Zn-Ag deposits in the Fudian ore field, which is located about 3 km south of the Donggou porphyry. The Pb-Zn-Ag veins are structurally controlled by E- or NE-trending faults that cut intermediate volcanic rocks of the Paleoproterozoic Xiong'er Group. At least three hydrothermal stages are recognized for the Sanyuangou deposit, including quartz-pyrite (stage I), quartz-polymetallic sulfide (stage II), and quartz-calcite veins (stage III).

The Donggou granite porphyry has a LA-ICP-MS zircon U-Pb age of 117.8 ± 0.9 Ma (1σ). Early quartz-molybdenite and late quartz-polymetallic sulfide veins in the Donggou Mo deposit have molybdenite Re-Os model ages of 117.5 ± 0.8 and 116.4 ± 0.6 Ma (2σ), respectively. Muscovite separates from the hydrothermally altered rocks enveloping a Pb-Zn-sulfide vein at Sanyuangou yields well-defined $^{40}Ar/^{39}Ar$ plateau age of 115.9 ± 0.9 Ma and inverse isochron age of 116.0 ± 1.2 Ma (2σ), indistinguishable within errors from the molybdenite Re-Os ages of the Mo-bearing ores. Trace element LA-ICP-MS analyses of pyrite show that Mo and Bi are elevated at the Donggou porphyry deposit while Cu, Zn, Pb, Ag, and Au are enriched in the Sanyuangou vein. This distribution is consistent with the typical metal zonation in porphyry deposits. Cobalt and Ni contents in pyrite from Donggou and Sanyuangou are indistinguishable and Co/Ni ratios are mostly > 1. In situ LA-ICP-MS lead isotope analyses on pyrite grains from Donggou and Sanyuangou show similar lead isotope compositions. The geology, geochronology, and geochemistry all suggest a common magmatic-hydrothermal origin for Donggou and Sanyuangou. We conclude that the Mo ores and Pb-Zn-Ag veins are genetically linked to the Donggou porphyry intrusion. Polymetallic veins may provide an important exploration vector to porphyry Mo mineralization in the southern part of the North China craton.