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Geology, Geochemistry, and Genesis of the Tongcun Porphyry Mo (Cu) Deposit, NW Zhejiang Province, China

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1 Alteration, Mineralization Stage, Mineralogy Assemblages and Fluid Inclusion Types

The Tongcun Mo (Cu) deposit in the Kaihua country of Zhejiang province, eastern China, which occurred in or near the Songjiazhuang granodiorite porphyry, is a middle size and important porphyry deposit.

Two Cu–Mo orebodies are irregular-shaped with various types of hydrothermal veinlets. Intensive hydrothermal alteration in this deposit is characterized by skarnization, chloritization, carbonatization, silicification and sericitization. The primary Mo–Cu mineralization is associated with the primary silicification characterized by the quartz+sulfides veins, and the late Cu mineralization is closely related to sericitization by sericite+chalcopyrite.

Based on the mineral assemblages and crosscutting relationships of veins, the ore-forming process can be divided into five stages, namely: the early stage of garnet+epidote±chlorite associated with skarnization and K-feldspar+quartz ±molybdenite veins associated with potassic alteration; the quartz-sulfides stage of quartz+molybdenite±chalcopyrite±pyrite veins; the carbonatization stage of calcite veinlet or stockworks; sericite+chalcopyrite±pyrite stage, and the late calcite+quartz stage.

The primary ore styles are disseminated and veinlet. Ore minerals are very simple and include molybdenite, chalcopyrite, pyrite, sphalerite, as well as a minor galena and limonite. The molybdenite and chalcopyrite are found in both of the skarn and granodiorite, but sphalerite and limonite are only found in skarn. The main gangue

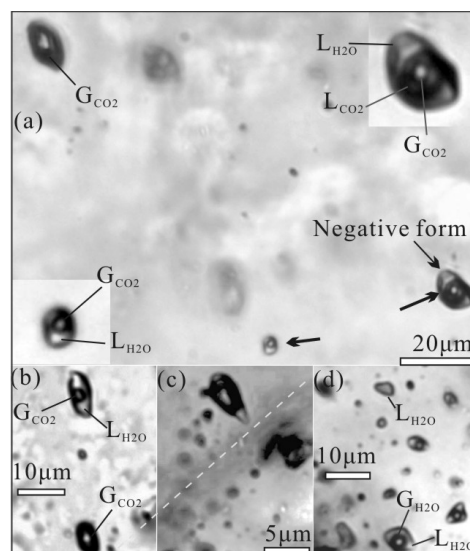


Fig. 1. Types and characteristics of fluid inclusions in Tongcun Mo–Cu deposit.

(a)–(b) Fluid inclusions assemblage (FIA) of the early stage in quartz phenocryst; (c)–(d) The FIA in quartz-sulfides stage.

minerals are garnet, epidote, chlorite, quartz, sericite, and calcite.

Four types of fluid inclusions (FIs) were observed at this deposit: 1) CO₂–CH₄ single phase FIs (Fig. 1a and b, G_{CO2}), 2) CO₂–H₂O two or three phase FIs (Fig. 1a, b and c, G_{CO2}+L_{H2O} or G_{CO2}+L_{CO2}+L_{H2O}), 3) NaCl–H₂O two phase FIs (Fig. 1d, G_{H2O}+L_{H2O}), and 4) NaCl–H₂O single phase FIs (Fig. 1d, L_{H2O}). FIs of the early stages are predominantly CO₂-rich FIs of CO₂–CH₄ and CO₂–H₂O type; whereas the quartz-sulfides stage minerals contain CO₂-rich FIs of CO₂–H₂O type and liquid-rich FIs of NaCl–H₂O type.

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2 Microthermometry, H-O-S Isotopes

2.1 Characteristics of ore-forming fluids

The average value of homogenization temperature, salinity and density of FIs trapped in the early-stage minerals are $\sim 347^{\circ}\text{C}$, $< 8.89\text{wt.}\%$ NaCl equiv. and 0.81 g/cm^3 , in quartz-sulfides stage minerals are $\sim 321^{\circ}\text{C}$, $10.69\text{ wt.}\%$ NaCl equiv. and 0.87 g/cm^3 , respectively. CO_2 and CH_4 content and the reducibility (indicated by CH_4) of FIs trapped in quartz-sulfides stage minerals are lower than those in the early stage.

2.2 Sources of ore-forming fluids and materials

Fluids trapped in quartz-sulfides stage, yield the $\delta^{18}\text{O}$ values from 6.4% to 9.4% , and δD fluid values from -71.8% to -88.9% , indicating a primary magmatic fluid source.

The $\delta^{34}\text{S}_{\text{V-CDT}}$ values of sulfides are from $+1.6\%$ to $+3.8\%$, which indicate that the sulfur in ores was sourced from magmatic origins.

2.3 Mineralization age

Twelve molybdenite separates, which include three and six samples from Zhang et al. (2013) and Zeng et al. (2013), respectively, yield the Re-Os isochron age of $163.0 \pm 2.4\text{ Ma}$, which is consistent with the age of emplacement of the Tongcun and Songjiazhuang granodiorite porphyries.

3 Metallogenic Mechanism and Ore Genesis

Phase separation, which was possible attributed to the

progressive decompression or degassing, occurred from early stage to quartz-sulfides stage and resulted to the ore-metal precipitation during the fluid evolution.

The characteristics of alteration and mineralization, fluid inclusion, S and H-O isotope data, and molybdenite Re-Os dating demonstrate that the Tongcun Mo (Cu) deposit is perhaps a reduced porphyry Mo (Cu) deposit associated with the granodiorite porphyry in Tongcun area.

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