

Fluid Evolution and Ore Genesis at the Dalingshang Deposit, Dahutang W-Cu District, Northern Jiangxi Province, South China

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The Dalingshang deposit is located in the middle part of the Dahutang W-Cu-(Mo) district, northern Jiangxi Province, south China. Tungsten-copper mineralization is temporally and genetically associated with late Yanshanian S-type granitic rocks and three major types of mineralization, including large wolframite-chalcopyrite quartz veins, disseminated scheelite veinlets, and polymetallic hydrothermal breccias. Fluid inclusion work shows mainly two types of inclusions: dominantly two-phase fluid inclusions but also some three-phase fluid inclusions containing a solid crystal. The ore fluids can be approximated by the NaCl-H₂O system with minor amounts of volatiles that include CH₄, N₂, and CO₂. Solid phases such as chalcopyrite, muscovite, sphalerite, and quartz are commonly recognized in fluid inclusions, whereas common phases within melt inclusions and fluid-melt inclusions in quartz phenocrysts from ore-associated muscovite granites comprise crystals of albite, muscovite, quartz, monazite, chalcopyrite, and rutile. Infrared fluid inclusion microthermometry on coexisting wolframite, scheelite, apatite, and quartz in large quartz veins shows that the homogenization temperatures for primary inclusions in wolframite (~330°C) are similar with those in scheelite but about 30°C higher than those of apatite (~300°C) and generally 50°C higher than those in quartz (~280°C). The ore-forming fluids belong to a high- to medium-temperature, low-salinity, and low-density hydrothermal system. A similar temperature gradient is observed in mineral assemblages of veinlet-type ores, whereas hydrothermal breccias have a more complicated fluid evolution history than the mineralization styles. We suggest that fluid inclusions in ore minerals can truly reflect the depositional conditions, whereas inclusions in gangue minerals shed light on fluid evolution. Laser Raman analyses indicate fluid inclusions in the early silicate-oxide stage contain CH₄ and N₂ without CO₂, whereas inclusions from the sulfide-quartz stage contain variable CO₂ content with CH₄/CO₂ ratios from 0.97 to 2.83. In situ LA-ICP-MS sulfur isotope analyses reveal that the $\delta^{34}\text{S}$ values of sulfides shift from around -2.0~ +0.5‰ in the early stage to -14.4~ -0.9‰ in the late stage. These discoveries, together with potential Mn-in-apatite oxybarometry, indicate the evolution of fluid from a much reduced to a relatively oxidized one. Sulfur and lead isotopes of sulfides indicate a crust-derived, magmatic origin for ore-forming materials. H-O isotope analyses of quartz show the ore-forming fluids having measured δD from -81 to -102‰, and calculated $\delta^{18}\text{O}_{\text{water}}$ from 1.9 to 5.6‰. The Dalingshang scheelite is characterized by two distinct REE_N patterns within single scheelite grains: the inner zones with bright CL exhibit hump-shaped or flat patterns with negative or small positive Eu anomalies, whereas the vast blue CL rims display flat REE_N patterns with variable positive Eu anomalies. We suggest that the ore-forming fluids were likely originally derived from intergranular solutions, which were evolved from the exsolving fluids in the magmatic-hydrothermal transition during magmatic cooling and solidification. The change of redox conditions is the possible metal transport mechanism for the ore fluids, whereas cooling, fluid mixing with meteoric water, and fluid-rock interactions are considered the effective depositional mechanisms for different ore types in the deposit.

