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Mineralogy of the Dahu Au-Mo Deposit, Xiaoqinling Region, Central China: Evidence for a Magmatic-hydrothermal Origin

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1 Introduction

The quartz vein type Dahu Au-Mo deposit is located in the Xiaoqinling region and belongs to the Qinling-Dabie Orogen of central China. This deposit has proven reserves of 31 t gold (grade: 4.7 g/t Au) and 30,000 t molybdenum (grade: 0.13% Mo) (Feng et al., 2011). Four molybdenite samples yield a Re-Os isochron age of 206 ± 4 Ma (MSWD = 0.88), suggesting ore formation in the Late Triassic (Jian et al., 2014). Mineralized quartz veins are controlled by several small to medium size E-W-striking faults, from north to south, F1, F8, F7, F35, F5, and F6.

2 Vein Mineralogy and Paragenesis

The mineralized quartz veins mainly consist of quartz and sulfides, with the width typically varying from tens of centimeters to several meters. Gold and molybdenite often appear together on the hand specimen scale, but a direct contact of gold and molybdenite has not been observed under the microscope.

Four mineralization stages are recognized. They are, from early to late, quartz-K-feldspar stage (I), pyrite-molybdenite stage (II), sulfide-telluride-sulfosalt-gold stage (III), and carbonate-barite stage (IV).

Quartz-K-feldspar stage (I): The quartz-K-feldspar stage is the earliest recognized hydrothermal alteration stage. Compact milky white quartz makes up more than 80% of the entire vein volume. Abundant minerals occur as solid phases in fluid inclusions in stage I quartz. They are: $\text{Cu}_{1.65}\text{S}$, covellite, chalcopyrite, bornite, molybdenite, pyrite, colusite, anhydrite, and celestine. Except colusite, all the minerals have also been observed as mineral inclusions in stage I quartz or as anhedral aggregates in stage I quartz micro-fractures. K-feldspar is the second most abundant gangue mineral. Aggregates of coarse-grained (>5 mm) K-feldspar disseminate in the veins, and

are most abundant at the vein margins. Green biotite rarely occurs as fine-grained flakes (0.1–1 mm) in quartz. Pyrite is the dominant metallic mineral. It occurs as coarse-grained cubes (>5 mm), which are often fractured, and subsequently, filled by ore minerals of later stages. Black rutile aggregates (up to 2 mm in diameter) occur within quartz or K-feldspar. Rutile is often intergrown with molybdenite, and locally intergrown with monazite. Rutile has high niobium content, and shows both patchy and oscillatory zoning.

Pyrite-molybdenite stage (II): This stage is the major molybdenite deposition stage. Fine to very fine-grained (0.005–1 mm) pyrite and molybdenite fill fractures in stage I quartz, or occur as stage I quartz-K feldspar-pyrite breccia matrix. Pyrite is characterized by abundant voids and mineral inclusions, including molybdenite, anhydrite, celestine, and monazite. Molybdenite is commonly observed in textural equilibrium with pyrite and suggests a common mineral paragenesis during the pyrite-molybdenite stage. Later galena, chalcopyrite, and tellurides locally occur as micro-veinlets in stage II pyrite, suggesting that molybdenum mineralization preceded gold mineralization.

Sulfide-telluride-sulfosalt-gold stage (III): The gold deposition stage is characterized by galena, pyrite, and chalcopyrite forming clusters, bands, or veinlets in the early quartz veins. Gangue minerals are rare. Quartz occasionally occurs as coarse-grained (> 5 mm) crystals enclosed in galena. Metallic minerals include galena, pyrite, chalcopyrite, minor gold, tellurides, sulfosalts and sphalerite, and rare pyrrhotite. Pyrite occurs as fine-grained subhedral to euhedral cubes (0.1–1 mm). Pyrite of this stage contains no molybdenite inclusions and is intimately associated with gold and chalcopyrite. This distinguishes stage II and III pyrite. Chalcopyrite is intergrown with or replaced by galena, or occurs as anhedral aggregates filling pore spaces between pyrite grains. Gold has various occurrences, occurs as free gold aggregates in quartz micro-fractures, in contact with

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pyrite, chalcopyrite, and galena, or along with sulfosalts and tellurides. Sulfosalts and tellurides either occur within or marginal to galena, or fill micro-fractures in early pyrite. These minerals are often present in two types of contact assemblages, including a telluride dominated assemblage and a sulfosalt dominated assemblage. Gold, wittichenite, and tetradymite are present in both assemblages. The sulfosalt dominated assemblage consists of gold, wittichenite, tetradymite, aikinite, lindstromite, and two rare sulfosalts: kupcikite and salzburgite. The telluride dominated assemblage consists of gold, wittichenite, altaite, tellurobismuthite, hessite, petzite, tetradymite, calaverite, and a rare sulfotelluride, buckhornite.

Carbonate–barite stage (IV): This last stage marks either the waning of hydrothermal activity or a later unrelated supergene episode. It is characterized by the deposition of calcite, ankerite, barite, and oxide alteration products of early sulfides in unsealed fractures in quartz or in the matrix of porous breccias.

3 Conclusion

Metal signature and mineral association imply that the ore-forming fluids were derived from an oxidized magmatic system. Anomalous enrichment of Mo, Bi, and Te is a feature of magmatic-hydrothermal systems related to felsic magmatism (e.g., Afifi et al., 1988; Mao et al., 2008), and Mo deposits are associated with oxidized magmatic systems rather than reduced magmatic systems (e.g., Ishihara, 1981; Lehmann, 1990). The oxidized fluid environment of the Dahu deposit is indicated by the vein

mineral association, such as the widespread presence of anhydrite and celestine in stage I, the abundance of pink K-feldspar (owing to the presence of Fe^{3+} or hematite), and the abundance of pyrite and scarcity of pyrrhotite. Hypogene bornite and covellite commonly occur in magmatic-hydrothermal systems, such as porphyry and epithermal deposits. Niobium-rich rutile is also a typical magmatic-hydrothermal mineral.

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