Ore-controlling factors and prospecting direction of Feimo Cu-Mo Polymetallic deposit in Yuanyang, Yunnan province, China

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Abstract. Major ore prospecting breakthroughs have currently been made in the Feimo Cu-Mo polymetallic deposit from the middle section of the Ailaoshan Orogeny Belt. Controlling factors of the ore body have the following distinctive characteristics: NNE and NW trending faults are the major mineralization passageways and ore-containing structures; the orebody exists in the Feimo section of the Along Formation within the Ailaoshan Group; and the concession around the granitic massif has multi-period dyke intrusions and is the preferred prospecting target. Through studies of orebody controlling factors, ore prospect orientations are determined in the Feimo deposit. The Feimo Cu-Mo polymetallic deposit extends along strike and dip directions and has considerable resource potential. In addition, there is considerable potential from the deep-seated Cu-Mo orebody in the area and the possible occurrence of a rich Cu-Mo ore body in surrounding areas such as Caishanping and Niujiaozai.

1. Introduction
The Ailaoshan Orogeny Belt has a distinctive geological background and is rich in mineral resources making it an important source of copper and gold production base in China [¹, ²]. Many successful previous studies undertaken in this area focused on determining Cu and Au ore-forming conditions, metallogenic regularity and ore prospecting [³, ⁴]. The recent discovery, through deeper geological exploration, of the Longbohe Cu deposit, the Daping Au deposit, the Tongchang Cu-Mo deposit, and the Feimo Cu-Mo polymetallic deposit in the Ailaoshan Cu-Au polymetallic belt has caused widespread concern in the mining industry [⁵, ⁶]. Furthermore, minimal access to the public for researching the Cu-Mo deposit is restricting exploration work in this area [⁷]. Thus, this study looks at the factors controlling the formation of the Feimo Cu-Mo polymetallic deposit and provides a directive for prospecting and important guidance for the exploration of similar ore deposits in this area.

2. Geological Background
The Feimo Cu-Mo polymetallic deposit is located at the central part of the Ailaoshan Orogenic Belt (Fig. 1). The strata that lie in the ore area comprised metamorphics that belong to the Ailaoshan Group of Proterozoic rocks. Given that this area is influenced by and located on the western side of Honghe
Fault Zone, folds and faults are relatively developed in the study area. Folds comprise NE-strike monoclinic structures, while the faults comprise NNE, EW, and NW trending groups. Magmatic rocks are observed within the area, particularly the Dapijia massif (binary monzogranite) that outcrops at the western part of the study area. There are also several metamorphosed basic dykes, granitic pegmatite, and rare granite dyke outcrops in the study.

Orebody is influenced and controlled by lithology and structure. The occurrences are stratiform, lentiform, and lense-shaped (Ptla2), with dimensional expansion, contraction, branched composite, and pinch out phenomena. Major metallic minerals include chalcopyrite, bornite, chalcocite, molybdenite, and pyrite. Dominant ore structures are disseminated structure, veinlet-stockwork structure, and massive structure. Observed ore textures include euhedral-subehdral, corona, dissolution, inclusion, and metasomatic relict texture. Wall rock is highly altered by diopsidic alteration, pyritization, silicification, carbonatisation, chloritization, epidotization, actinolitization, tremolitization, and sericitization, with the former three mentioned being closely related to mineralization. The orebody underwent three mineralization phases: the metamorphosed sedimentary period, the hydrothermal period (ore forming period), and the hypergene period. Hence, this is a sedimentary-metamorphism-magmatic hydrothermal overlapping modified Cu-Mo polymetallic deposit.

3. Ore-controlling factors
The Feimo Cu-Mo polymetallic deposit is located within the secondary fault on the western side of the HongHe fault. The Honghe fault is a large-scale strike-slip movement feature that formed a
complicated structural deformation metamorphosed zone. It provided a large pathway and space for ore-fluid large-scale transportation and storage. Granitic magma and ore-bearing hydrothermal fluid are controlled strictly by secondary NW–NWW faults induced, forming one of the largest ore-guiding faults and ore-hosting structures within this zone. In the study area, ore-bearing hydrothermal fluid settled and enriched along the intersection of the NW and the NE trending faults, or at the intersection between a fault bend with a micro fault and inter-bed peelings. These intersections are the major ore-hosting structures for Cu-Mo polymetallic deposits. Micro faults represent one of these important ore occurring structures.

The stratigraphy of the study area consists of the Feimo section of the Along Formation within Lower Proterozoic-aged Ailaoshan Group. The lithologies are characterized by light-gray colored diopсидic marble with intercalated light gray colored bio-plagioclase schist, gneiss, and plagioclase-amphibole granulite. The three latter ones are of volcanic origin with high Cu background value, and provide part of the ore forming materials. The diopсидic marble is chemically active, has good permeability, and is brittle and easily fractured, being easily replaced by ore-bearing hydrothermal fluid or settling of the fluid. It also promotes migration and settling of ore fluid, and together with dark colored metamorphic rocks, they are beneficial to mineralization. Rich orebodies occur within this lithology combination.

Magmatic activity promotes the creation of the ore-bearing layer by modification, superimposition and enrichment processes. Although no economically viable orebody is found within the massif, the granite has a high content of Cu (Cu 0.46%, Au 0.39g/t, Ag 6.6 g/t) benefitting copper mineralization. This clearly demonstrates that granitic magma is also a source of one of the ore-forming materials. Ore-bearing hydrothermal fluid, created by expulsion following a magmatic activity reaction with surrounding wall rock, then settled in the form of Cu-Mo polymetallic orebody around the outer contact zone of the Dapijia granite massif. The intrusion date of the granite massif is estimated to be 57.72 Ma and is related to the ore-forming date of 47.81±0.71 Ma, indicating that the granite massif is involved in controlling the mineralization process. As such, the area surrounding a granite massif, especially with multiple dyke intrusions, is a preferred prospecting target.

In particular, a large number of metamorphosed basic dyke outcrops in the area are closely related to the orebody at both sides of the orebody. The Cu, Pb, Zn, and Ni contents within the metamorphosed basic dyke are higher. Pyritization and Chalcopyrite can also be observed in the dyke, resulting in smaller sized and independent mineable copper orebodies. Hence, metamorphosed basic dykes are closely related to orebody formation.

4. Prospecting Direction

According to the comprehensive analyses of metallogenetic rule and geological information of the Feimo Cu-Mo polymetallic deposits, it is highly suggested that the polymetallic ore deposits of the Feimo Cu-Mo formation and its adjacent outer areas provide good prospecting potential.

(1) The Feimo Cu-Mo polymetallic deposit extends along the strike and dip directions, and the resource potential remains great. Favorable ore bearing zones are found at the Ailaoshan Group-Along Formation that is extensively exposed in the area. Furthermore, the intersections of the zones with existing structures also make it an excellent prospecting target. In the deeper zones and the surrounding mining area, it is essential to identify the features controlling the deposit formation and to seek the presence of zones with the aforementioned combination of favorable characteristics.

(2) On the southeast side of the mining area, magmatic activity remains active, with large quantities of granitic veins being formed along the tectonic intrusion. In the vicinity of the dyke, mineralized veins are exposed allowing sampling access. Samples taken from outcrops showed metal contents of Cu 1.25%, Au 0.091g/t, and Ag 9.01g/t. The analyses of samples showed that the samples have reached recoverable grade, thereby indicating that prospecting the concealed orebodies in the deeper zones is possible through the integration of observations of geological, geochemical, and other characteristics.

(3) Granitic dykes are found in several areas within the mining area. Additionally, the mineralized outcrop of Dapijia Granite Massif is also found in the adjacent area, implying that there may be concealed ore bearing granitic rocks. It is, therefore, inferred that in the deeper zone of the mining area, there is high likelihood of the existence of large-scale porphyry and contact metasomatism Cu-Mo
polymetallic deposits. Therefore, exploration of deeply concealed porphyry and contact metasomatism of Cu-Mo polymetallic deposits in the region will be the focus of further research and work. Based on the research results of the metallogenic model, the comprehensive study of the current project has revealed information regarding mineralization processes. Electromagnetic sounding and other means adopted to determine the target area as well as the implementation of deep drilling can be used to explore the concealed ore-bearing granite and possibly to find new types of orebodies.

(4) Recoverable grade copper orebodies have been found in the western Niujiaozhai area situated outside the mining area. It is also noted that the region between the copper orebodies and the Feimo Cu-Mo polymetallic deposit is located at the side of the Dapijia Granite Massif, on the western side of the Honghe fault zone, resulting in favorable metallogenic conditions. Furthermore, mineralized outcrops are also found within the area and the adjacent Malishu area. However, due to engineering oversight in the region, there is limited accessibility to geological information.

(5) Recoverable copper orebodies, mostly layered, are also found in the Caishanping area located outside the main mining area. Since the ore layers and lithology are similar to the Cu-Mo polymetallic deposit, the Caishanping area also possesses the prospective potential for mining the superimposed modified orebody of the Feimo deposit. The central section of the Ailanshan copper-gold metallogenic belt has great prospecting potential, however, due to the lack of similar studies, the understanding of its resource potential is still relatively shallow. Further work o research is needed in order to find the orebody within the contact zones of the rock and other favorable ore-bearing zones.

5. Conclusion

The Feimo Cu-Mo polymetallic deposit is situated within the Ailaoshan Copper-Gold metallogenic belt and provides excellent metallogenic conditions.

(1) The factors controlling ore formation in the Feimo Cu-Mo polymetallic deposit display the following characteristics: NNE, NW trending faults are the major ore-forming channels and ore-bearing structures; orebodies are mainly located within the Ailaoshan Group-Along Formation-Feimo Section; granitic rock areas surrounded by multiple dyke intrusions provide the main prospecting target.

(2) The Feimo Cu-Mo polymetallic deposit and its outer adjacent areas have great prospecting potential particularly as the orebodies extend along the strike and dip direction. It is likely that deeply buried ore-hosted Cu-Mo polymetallic deposits will occur in the larger porphyry and contact metasomatises. The Caishanping and Niujiaozhai areas that are located outside the main mining area also possess great potential of recovery similar to rich orebodies found in the Feimo mining area.

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