# Metallogenic regularity of the Masiluo–Zhangjiapingzi area, Western Sichuan, China

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**Abstract**. The Masiluo–Zhangjiapingzi area is one of the most important target areas for ore exploration in western Sichuan, which has abundant gold and copper ore deposits. Substantial ore deposits in this area include the Masiluo gold deposit, Zhangjiapingzi gold deposit, Dongjia wuji specular hematite deposit, Gonglikong Cu–Au deposit, and Bazhe Cu–Au–Fe deposit. This study characterized the metallogenic regularity of the Masiluo–Zhangjiapingzi area using observations of the regional geological background and the characteristics of a typical deposit in this area. The ore deposits were found to be controlled by stratigraphy, geological structures, and magma with distinctive zoning characteristics—gold mineralization on the west part, Cu–Au mineralization on the northeastern part, and Fe–Cu–Au mineralization on the southeastern part.

## 1. Introduction

The Masiluo–Zhangjiapingzi area is located in the southwestern China transition zone encompassing the Sanjiang and Kangdian metallogenic belts that are located at the southwestern margin of Yangtze Plate [1, 2]. In recent years, many gold, copper, and iron ore deposits (spots) has been found and make this region a major target area in western Sichuan [3, 4,]. However, geological research and ore exploration in the area is still nascent and full of uncertainties regarding metallogenic regularity and directions. Hence, this study aims to determine the metallogenic regularity of the Masiluo–Zhangjiapingzi area to solve this key challenge and achieve a breakthrough in ore exploration.

## 2. Geological Background

The Masiluo–Zhangjiapingzi area is located at the Jinpingshan thrust nappe belt in the center of the Longmenshan–Jinpingshan orogenic belt belonging to the southwestern margin of Yangtze Plate. It is located at the juncture between the Southwestern China Sanjiang structure belt, Songpan–Ganzi orogenic belt, and Yangtze Plate [7, 8]. The regional geological setting of this area reflects complicated structural alteration and frequent magma activity. The substrate formation phase occurred in the Precambrian. The passive continental margin phase occurred in the Sinian–middle Triassic. During the early to middle Variscan, the earth's crust in this area was subsiding and dipping toward the sea, resulting in the sedimentation of a series of Devonian–Permian terrestrial clastic rocks and limestone, whose lithology and thickness were controlled by the Caledonian northwestern-trend tectonic uplift and rifting. During the late Variscan to early Indosinian, the crustal rifting movements caused massive-scale central fissure eruptions of basic magma and formed Permian–middle Triassic-aged basalt, overlain by middle Triassic marine limestone facies (Fig. 1). The orogeny phase occurred in the late Triassic–Cretaceous. During the late Triassic, the study area was thrust napped and uplifted toward the east owing to the eastward extrusion of the Tibetan Plateau amid the late Traissic Indosinian movement. This resulted in the formation of the parallel beds of the Devonian–mid-Triassic strata involved in the folding that underwent a series of deformation and metamorphism phases. This formed an NNE-trending, mostly dry, compression–shear fault that comprises the basic outline of the regional structures. The later Yanshan movement further reinforced this fault. During the Cenozoic era, this region entered an intracontinental orogenic phase. The Himalayan movement intensified the nappe structure in the study area and entered the collisional orogeny phase at around 78–52 Ma. At approximately 44–28.7 Ma, the detach-thrust phase of the suture zone occurred following the collision phase, after which the structural outlines were further fixed and the revival of compression–shear faults was clear; after 18.9 Ma, the region entered a rapid uplift phase and formed the current deeply cut, high-mountain topography [5, 6].

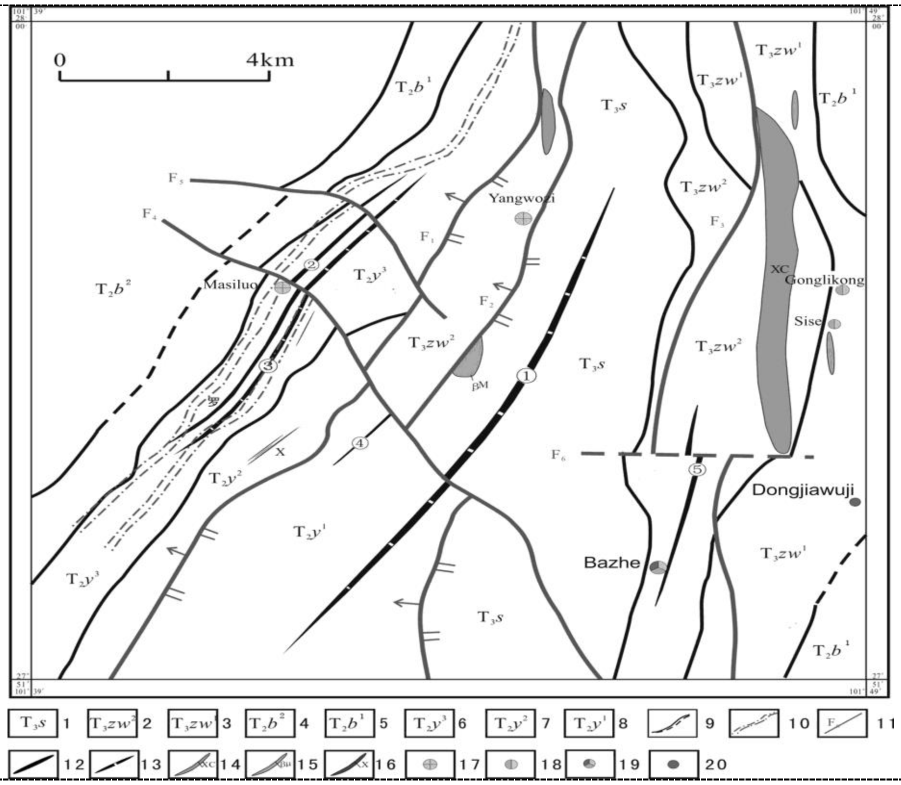


**Figure 1**. Regional geologic map of Masiluo- Zhangjiapingzi area.
1- Songgui formation; 2- The first menber of Zhongwozu formation; 3- The second member of Zhongwozu formation; 4- The second menber of Baishan formation; 5- The second menber of Baishan formation; 6- The third menber of Yantang formation; 7- The second menber of Yantang formation; 8- The first menber of Yantang formation; 9- Geological boundary; 10- Mylonite; 11- Fault; 12- Anticline; 13- Syncline; 14- Carbonatite dykes; 15- Diabase dikes; 16- Lamprophyre dikes; 17- Au occurrence; 18- Cu-Au occurrence; 19- Fe-Cu-Au occurrence; 20- Fe occurrence

## 3. Metallogeny of typical ore deposits

The Masiluo–Zhangjiapingzi area has a long history of mining and good metallogenic geological conditions. Based on incomplete statistics, there are 4 gold deposits, 33 gold or mineralized spots, more than 20 Au geochemistry and mineral sand anomalies in this area, and there are also some massive alterations and mineralization which related to the process of gold mineralization [7, 8, 9]. Furthermore, uranium(U), rare-earth elements(REE), fluorite($CaF_2$), and polymetallic deposits are distributed throughout the study area. Some substantial ore deposits in this area include the Masiluo gold deposit, Zhangjiapingzi gold deposit, Dongjia Wuji specular hematite deposit, Gonglikong Cu–Au deposit, and Bazhe Cu–Au–Fe deposit [10, 11].

(1) Masiluo gold deposit: A hydrothermal gold deposit, where the Au-mineralized stratum is the limestone layer of the Yantang formation, which has the highest Au grade in this region. To the north of the mine, the deposits comprise selective metasomatism bedding of altered rock ore or mineralized rocks, while the south comprises structurally altered rock ore. The wall rock alteration, comprising metallic mineral assemblages and ore-controlling factors of the Yangwozi Au-mineralized spot, was discovered to the east of the Masiluo gold deposit and is similar to the Masiluo deposit, also a hydrothermal gold deposit.

(2) Dongjia Wuji Iron deposit: The occurrence of orebody is strictly controlled by faulting. It is formed by deep magmatism-related hydrothermal fluid injection into extension faults.

(3) Gonglikong Cu–Au deposit: The Gonglikong Cu–Au deposit is a hydrothermal Cu–Au deposit. Cu–Au mineralization occurred in the shear fracture zone and is related to intermediate felsic magma fluid. The recent discoveries of Cu–Au mineralization in the Sishe and Gangou areas within this region have similar wall rock alteration and metallic mineral assemblages as the Gonglikong Cu–Au deposit, all of which are also potentially hydrothermal Cu–Au deposits.

(4) Bazhe Cu–Au–Fe deposit: The orebodies occur within the interlayer faults and intense cleavage zone, which are clearly controlled by faulting. It is a magmatic fluid– hydrothermal fluid superimposed reformation-type deposit. Hydrothermal-type siderite deposits were formed earlier by magmatism-related fluids, and later superimposed by hydrothermal Cu–Au mineralization. During the superficial oxidation period, part of the siderite and sulfides oxidized into limonite.

## 4. Metallogenic regularity

Mineralization of the Masiluo–Zhangjiapingzi area has distinctive zoning characteristics. The carbonatization–quartz vein-type gold ore series (I- Au series) is dominant in the west, typical of the Masiluo gold deposit and the Yangwozi Au-mineralized spot. The metallogeny underwent two stages of gold mineralization, namely carbonatization-related and pyrite–quartz vein-related. The hydrothermal Cu–Au ore series (II- Cu, Au series) dominates the northeastern part and is represented by the Gonglikong deposit and Sishe Cu–Au mineralized spot. The metallogeny underwent Cu–Au-bearing hydrothermal fluid activity along the fractures, a process in which the fluid fills up the joints beside the faults and forms Cu–Au ore veins. The southeastern part is dominated by a late-stage magmatic fluid–hydrothermal fluid with superimposed Fe, Cu, and Au ore series (III- Fe, Cu, and Au series), typical of the Dongjia Wuji specular hematite and the Bazhe Fe, Cu, and Au polymetallic deposits. The metallogeny was mostly characterized by deep-seated specular hematite–siderite hydrothermal fluid injection into extension faults, and later superimposed by hydrothermal Cu–Au mineralization.

The metallic ore deposits in this region are structurally controlled. Magma and ore-forming hydrothermal activities are characteristic of fault-developed areas, where intense mineralization areas are found on both sides of the strata of regional and secondary faults. Examples of such include the Yangwozi Au-mineralized spot distributed along the NNE-trending fault as well as the Gonglikong and the Sishe Cu–Au mineralized spots distributed along the NS-strike fault. Substantially mineralized areas are typical of secondary faults along the major faults. For example, the highly mineralized areas of the Masiluo Au deposit are along the $F_1$ and $F_2$ faults, while the strongest mineralized area is found at the intersection of the $F_3$ fault with the $F_1$ and the $F_2$ faults. At the same time, some extensive faults are ore-bearing ones such as the major orebodies of the Dongjia Wuji specular hematite and Bazhe hematite deposits.

Magmatism controlled the metallic deposit formation in this region. It constitutes ore-bearing magmatic fluid injection into extensive faults forming an injection-type rich orebody such as the

Dongjia Wuji specular hematite and Bazhe Fe–Cu–Au polymetallic deposits. They were formed via deep-seated, ore-bearing magmatic fluid injection into the nearby NS-strike extensive fault. Concomitantly, the hydrothermal fluid formed by magma that is rich in metal elements metasomatized and enriched the strata by leaving the ore-forming metal elements in the strata, such as the high Au-rich carbonatized strata in the gold mine of this region. The metasomatism of sedimentary strata by magmatic fluid from deep-seated carbonate magma intrusions caused the massive high Au background value in the carbonatized strata of this region. The results from the geochemistry survey indicated a close relation between the Au anomaly zone and the carbonatization zone in the Masiluo gold deposit. From a dimensional distribution perspective, the known occurrences of such hydrothermal deposits are closely related to large-scale, deep regional faults, and acidic rocks.
Strata control the formation of metallic ore deposits in this region. The gold deposits in this region primarily occur within the second limestone layer of the Triassic-aged Yantang Formation, indicating that mineralization is controlled by strata.
The brittle limestone has many good characteristics such as high chemical reactivity, high permeability, easy fracturing, which make the rock can be metasomatized and precipitated deposits from ore-bearing hydrothermal fluid. It is also beneficial to precipitation and migration of ore-bearing fluids. Among these properties it helps a major proportion of the economically viable gold orebodies to occurred in the altered marble.

## 5. Conclusion

The Masiluo–Zhangjiapingzi area is one of the most important and prosperous target areas for ore exploration in western Sichuan. The ore deposits of this region show distinctive zonal characteristics. The western part is a gold metallogeny zone typical of the Masiluo gold deposit and the Yangwozi gold mineralized spot. The northeastern part is a Cu–Au metallogeny zone typical of the Gonglikong Cu–Au deposit and the Sishe Cu–Au mineralized spot, whereas the Dongjia Wuji specular hematite deposit and the Bazhe Fe–Cu–Au polymetallic deposit typical of the Cu–Au–Fe metallogeny zone are present in the southeastern part. The ore deposits in the study area are controlled by strata, geological structures, and magmatism.

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