

Genesis and prospecting perspective of Xianglushan iron deposit, Sichuan Province, China

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Abstract. More than 30 ore bodies have currently been discovered in the Xianglushan iron deposit in the central part of the Huili–Dongchuan Aulacogen. The main orebody is stratiform or stratoid within the volcanic sedimentary metamorphic rock of the Paleo–Mesoproterozoic Yinmin formation. Minor ores intrude as veins in the country rock and the mineral components of the iron ore are mainly magnetite and hematite. The ore evolved through the Paleo–Mesoproterozoic submarine volcanic eruption deposition period and the Neoproterozoic iron slurry superimposed transformation, and is identified as a sedimentation–transformation-type deposit. A study is conducted on the regional metallogenic background and geological characteristics of the ore deposit; results show that the ore-forming setting of the Xianglushan iron ore is excellent and that the potential of finding large-scale rich iron deposit is considerable.

1. Introduction

The Huili–Dongchuan Aulacogen, which is located at the western margin of the Yangzi Plate, is the most important Fe–Cu metallogenic structural belt in Sichuan and Yunnan, with occurrences of large- to giant-scale copper and iron deposits, of which the most famous is the Dongchuan copper deposit^[1,2,3,4]. The Xianglushan iron ore is located in the middle of the Fe–Cu metallogenic belt. The Yunnan–Dongchuan Cu–Fe–Au mining area is separated by the Jinsha River and the ore body occurs within the Yinmin Formation of the Kunyang Group. In the course of recent mining exploration, it was discovered that there are still large areas for prospecting, as well as good prospecting potential in the deeper and peripheral zones. This paper has chosen the Xianglushan mining area as the focus of research by using modern regional metallogeny to study the formation mechanism of the deposit in terms of ore-bearing intrusive magma that was superimposed and modified by the Presinian volcanic deposition–metamorphism process, and finally proposes the steps required for future prospecting. It is of great significance for deepening the understanding of Fe–Cu mineralization in the Huili–Dongchuan Aulacogen.

2. Geological Background

The Xianglushan iron deposit is located at the western margin of the Yangzi Plate; specifically, in the middle of the Proterozoic Huili–Dongchuan Aulacogen (Fig. 1-a). It is considered to be the most



important metallogenic structure in the passive continental margin rift system found in Sichuan–Yunnan^[5,6]. The aulacogen has a length and width of approximately 250 km and 80 km, respectively. There are several sets of N–S-trending fault zones, with the major Yimen–Luchang and Puduhe faults separating the entire aulacogen into three parts: Huili–Lixi, Tongan–Lunanshan, and Huidongxiaojie–Dongchuan, respectively (Fig. 1-b).

The aulacogen experienced complicated and varied tectonic, magmatic, deposition, and metamorphism processes, which formed a very thick series of Presinian Na-rich volcanic and sedimentary rocks (Kunyang Group or Huili Group), as well as being intruded by basic and ultrabasic magma, which resulted in an E–W-trending basement structure and thus created good geological background conditions for the formation of layered and layer-like iron and copper deposits^[7]. After the closure of the Neoproterozoic rift, the formation of a S–N-trending structural belt and corresponding basic and acidic magmatic activity strongly modified and superimposed the layered/layer-like Fe-Cu deposits found in the Kunyang Group^[8,9,10]. The platform stage of the Sinian period formed a set of conglomerates of marine–coastal facies, carbonates of platform–shallow marine facies and sediments of continental–lacustrine facies.

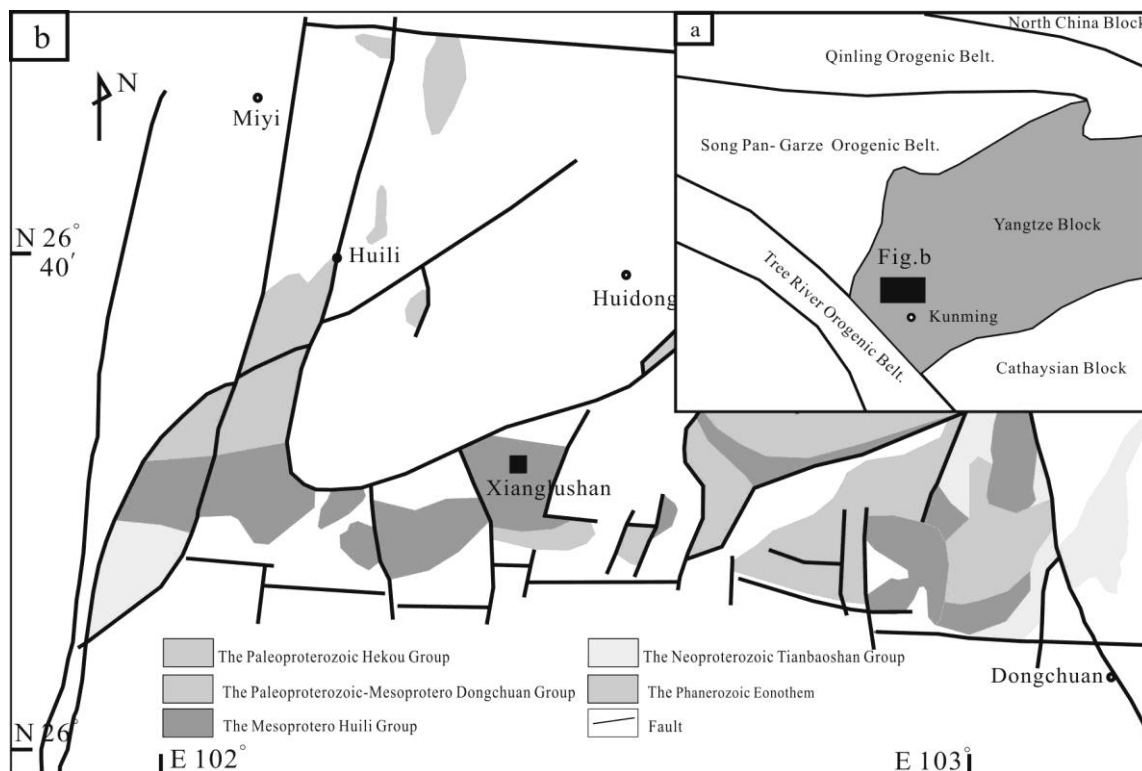


Figure 1. Sketch map of geology in the Huili-Dongchuan Aulacogeosyncline.

3. Geological Setting of Mining Area

The Xianglushan iron deposit is situated in Sichuan Province between the counties of Huili and Huidong. Huili county is governed from Bajioxiang, whereas Huidong county is governed from Longshuxiang. The exposed strata found in the mining area have been determined to be from the Presinian Kunyang Group, which, from bottom to top, is divided into the Yinmin, Luoxue, Heishan, Qinglongshan and Shuangshuijing formations. The volcanic rocks found in the Yinmin Formation have the highest Cu-Fe-S content and also contain exhalative sedimentary iron (copper) deposits. They are known to be the most important Fe-Cu source beds and the main ore-bearing strata found in the area. The structures of the mining area are complicated, with the presence of two distinct regional

tectonic lines, of which one is E–W-trending and is represented by the Xianglushan and Tongchangding anticlines; the other is approximately S–N-trending and is mainly represented by the F1 fault. There are other secondary structures with NW and NE trends. The volcanic rocks in the area are mainly from the Yinmin Formation, whereas the tuffaceous sands and slates are from the Luoxue, Heishan, and Shuangshuijing formations. Metamorphism and intrusive dykes are observed.

The Xianglushan magnetite–hematite deposit is found in the Xianglushan, Yaopengzi, and Hejiawan ore sections; these were formed in the metamorphosed series of volcanic and sedimentary rocks of the Yinmin Formation, which contain magnetite and hematite. From the northern end of the ore belt, the Xianglushan ore section is approximately E–W-trending. Then, the ore belt develops a NW or NNW trend on moving southeast to the Yaopengzi ore section, and becomes approximately S–N-trending on moving south to the Hejiawan ore section. The intermittent length of the ore belt reaches 3600 m. At present, more than 30 ore bodies have been discovered, with the larger ore bodies identified as Nos. 1, 7, 8, 9, 22, and 24.

The ore bodies are stratified and lenticular (or lentil-shaped), with their occurrence being similar to that of the surrounding rocks. However, their strike–dip continuity is bad and their tendency starts to be poor, resulting in common cases of reappearance after pinch-out and complex branching phenomena. The average length of an ore body is 100 m, with the longest reaching 170 m. The average thickness was found to be 2–8 m, with the largest ore body reaching 24.57 m. The total iron grade is 25–45%, with the presence of localized rich ore bodies with a total iron grade reaching 60%. The metallic minerals found in the area mainly consist of magnetite, limonite, hematite, and small amounts of chalcopyrite and pyrite. The ore textures are dominated by euhedral, subhedral, and anhedral granular textures; the ore structure is dominated by massive structures. Alterations such as chloritization, epidotization, silicification, calcification, sericitization, and discoloration can be observed in the wall rocks.

Altered diabase dykes that were intruded into the volcanic and sedimentary rock series of the Yinmin Formation were first discovered in the middle of the formation at an elevation of 2512 m (No. 6 cave) and in its lower corresponding part at an elevation of 2434 m (No. 11 cave) in the M64 magnetic anomaly area. In the inside diabase dykes and at the margin of the contact zone are seen irregularly distributed lenticular, irregular, and droplet-like blocks of magnetite-rich ore strips and aggregates. These massive magnetite-rich ore strips and aggregates are identified as having a spongy meteorite-like structure. This could be due to the crystallization of iron slurry. Therefore, this area has the potential to contain formations of ore slurry injection–metasomatism-type magnetite-rich ore bodies.

4. Genesis of deposits

On the basis of the mineralization and geological background of the Xianglushan iron ore and its geological characteristics, it is suggested that the deposits are mainly stratigraphically controlled iron deposits of Proterozoic submarine exhalative sedimentary origin, with secondary iron slurry injection–metasomatism-type magnetite-rich deposits. The ore-forming process is described as follows: activity of the Kunyang Rift during the Paleo–Mesoproterozoic era formed the Huili–Dongchuan E–W-trending aulacogen basin. E–W-trending and S–N-trending faults intersected in the M64–Hejiawan area. Large-scale magmatic activity occurred during the Yinmin period, which resulted in the early Jinningian alkaline ferric Ti-rich volcanic intrusion (ancient volcano structure) in the M64–Hejiawan area, forming the submarine exhalative sedimentary-type magnetite–hematite layer in the Yinmin Formation, which is known as the Xianglushan magnetite–hematite deposit. During the period of inactivity of the submarine volcanoes (Neoproterozoic), gabbro and diabase (dykes) intruded, which was subsequently followed by the closure of the rift. This formed the ore slurry injection–metasomatism-type magnetite-rich ore body and the vein-like rich ore body and at the same time strongly modified, superimposed, and destroyed the existing stratified iron deposits and caused the bad continuity. Therefore, the Xianglushan iron deposit is determined to be a sedimentary–superimposition transformed deposit.

5. Prospecting Direction

The Xianglushan magnetite–hematite deposit basically extends parallel to the bedding layer of basic volcanic rocks within the Yinmin Formation. Owing to the strong structural deformation of the area, the ore-bearing layer and the ore body found within the Yinmin Formation formed a boudin, in which the layers are highly overturned and fragile with poor continuity. The dolomites at the top of the Yinmin, Luoxue, and Qinglongshan formations are mixed, and contrast between horizons is difficult to determine. The current results of surface and tunnel drilling are not good and drilling and shaft explorations have had a low prospecting hit rate, only suggesting millions of tons of recoverable ore reserves.

This situation is not compatible with the excellent metallogenic conditions of the study area, namely, the Xianglushan–M64–Yaopengzi–Hejiawan arcuate structure, which can be compared with those from the Keshu–Sikeshu–Yinmin–Luoxue–Shijiangjun–Lanniping structure in Dongchuan area, with the scale of the former being larger. Toward the southeast, the large-scale Dongchuan Cu-Fe (Au) ore field lies just across the Yangzi River. Toward the west, there are the large-scale Lala Cu-Fe ore deposits, which indicate that this area should have the geological potential to contain large iron-rich deposits. Therefore, the next suggestions for exploration are as follows:

- 1) Stratigraphic determination: Via tunneling and detailed drill core logging, determine the separation indicators of the Yinmin, Luoxue, and Qinglongshan formations.
- 2) Structural restoration: Restore the patterns of the structure prior to deformation by using three-dimensional geological mapping, statistics of the occurrence of faults, joints, and fractures, and the relationship between bedding and cleavage.
- 3) Predict the possible occurrence of the metamorphosed volcanic and sedimentary rocks of the lower Yinmin Formation, design drilling programs and mineshafts, and initiate experimental drilling.

Conclusion

The Xianglushan iron deposits are found within the Huili–Dongchuan metallogenic belt, which has excellent metallogenic conditions. The deposits mainly consist of stratigraphically controlled iron deposits of Proterozoic submarine exhalative sedimentary origin and secondarily consist of iron slurry injection–metasomatism-type magnetite-rich ore deposits. The tectonic deformation of the study area is strong, which leads to the ore body having a shallow section with poor continuity; however, the deeper section of the ore body possesses the potential of containing iron-rich ores on a large scale.

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