

Genesis and Prospect Evaluation of Sinongduo Skarn Type Lead-zinc Deposit in Tibet

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Abstract: Tibet Sinongduo lead-zinc mine is one of the largest lead-zinc mines in Tibet Autonomous Region, located in Gongjue County, Changdu City, Tibet Autonomous Region. The deposit mainly produces lead, zinc and other metal elements, which is one of the important metal resources in Tibet. This paper mainly introduces the geological characteristics, ore body characteristics, ore types and wall rock alteration of the Sinongduo lead-zinc deposit in Tibet, further analyzes the genesis of the deposit in the region, sorts out the prospecting indicators in the region, and makes a prospect prediction. It is found that there is a prospect of expanding the scale of the deposit in the deep, southern and northern abnormal areas of the No.1 ore belt in the mining area.

Keywords: Ore genesis, Clue for prospecting, Resource prediction, Lead-zinc deposit.

1. Introduction

The Sinongduo Skarn-type lead-zinc deposit is located about 70 km northeast of Xietongmen County. It is a large lead-zinc deposit with geographical coordinates of 88 ° 38 ' 10 " east longitude and 29 ° 52 ' 45 " north latitude.

2. Regional Geological Background

The tectonic structure of the mining area is located on the Gangdise-Nyainqentanglha composite volcanic magmatic arc and the southern margin of the Longgeer-Nyainqentanglha island arc belt[1].

2.1. Strata

The main strata in the region from old to new are the young Tanggulashan Group (AnO or Pt₂-Pt₃) of the Meso-Neoproterozoic basement, Paleozoic metasedimentary rocks, Mesozoic sedimentary rocks and Mesozoic volcanic-magma arc composition[2].

2.2. Structure

The area where the Sinongduo deposit is located has strong magmatic activity and tectonic action, and various large-scale structures are developed as regional east-west compressive main faults (Tazila-Gola-Kanzhuxiang fault). The secondary faults formed by tectonic stress compression are developed in the north-south direction. Local northeast and northwest strike-slip faults occurred[3,4].

2.3. Magmatic rock

The intrusive rocks on the Nyainqentanglha arc-back fault-uplift belt where the mining area is located are very developed and widely distributed. The main magmatic activities are divided into Middle Permian-Late Triassic, Middle Jurassic-Late Cretaceous, Paleocene-Eocene, Oligocene-Miocene according to chronological data.

3. Geological Characteristics of The Deposit

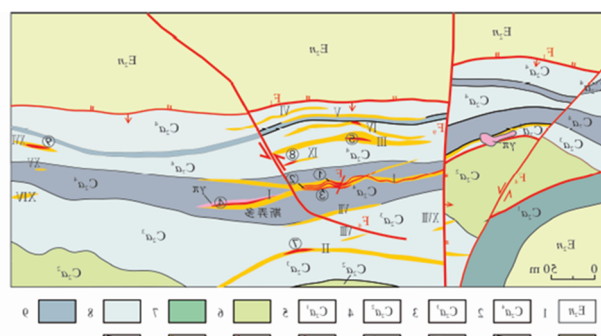


Figure 1. Geological map of Sinongduo lead-zinc deposit, Tibet

1. year wave group ; 2. The fourth lithologic section of Angjie Formation ; 3. The third lithologic section of Angjie Formation ; 4. Second lithologic section of Angjie Formation ; 5. The first lithologic section of the Angjie Formation ; 6. Gravel intercalated quartz sandstone ; 7. metamorphic quartz sandstone with sericite slate ; 8. limestone ; 9. Dolomite ; 10. Rhyolite, breccia tuff lava ; 11. Granite porphyry ; 12. Geological boundaries ; 13. Normal faults ; 14 reverse faults ; 15. Translational faults ; 16. Mineralized bodies and numbers ; 17. Mineralized bodies and numbers

3.1. Strata

The exposed strata are Upper Carboniferous Angjie Formation (C_{2a}) and Eocene Nianbo Formation (E_{2n}) (Figure 1.). The Angjie Formation is mainly dolomitic limestone, dolomite, sericite slate, metamorphic quartz sandstone, and locally exposed conglomerate ; the Xunianbo Formation is mainly composed of intermediate-acid pyroclastic rocks, sedimentary pyroclastic rocks and tuffaceous sedimentary rocks, and a small amount of intermediate-acid breccia tuff lava and breccia tuff.

3.2. Structure

Folds and faults are well developed in the mining area. The

folds are mainly near east-west ; the faults are mainly near east-west and near north-south, followed by northwest and northeast. Along with the east-west fold, the east-west fault is mainly manifested as a series of longitudinal compressive fracture alteration zones. The north-south faults are mainly characterized by transverse tensile faults, and the northeast and northwest faults are characterized by right-lateral translation faults.

3.3. Magmatic rock

The magmatic rocks in the mining area are widely distributed and can be divided into volcanic rocks and intrusive rocks according to their occurrence. The volcanic rocks are mainly produced in the Nianbo Formation and are distributed in the northern part of the mining area. The intrusive rocks are mainly Himalayan granite porphyry, followed by lamprophyre small rock mass, distributed in the carbonate rocks in the southern part of the mining area, mainly distributed along the nearly east-west compressive fracture zone.

3.4. Orebody characteristics

There are 1 ~ 9 ore bodies in the mining area. The ore bodies are lenticular and cystic, locally lenticular, all produced in the altered fracture zone, and the ore-bearing surrounding rock is dolomite limestone and dolomite of the Angjie Formation. The ore body is nearly EW, 100 ~ 500m long, 0.85 ~ 31.93m wide, generally 4 ~ 8m wide. The ore body tends to the south, a few to the north, and the dip angle is steep, 57° ~ 88°. The average grade of Pb in single orebody is 1.46 % ~ 8.06 %, the average grade of Zn is 3.01 % ~ 7.59 %, and the average grade of Pb + Zn in mining area is 11.25 %. The mineralization types are mainly structural fracture zone hydrothermal filling type and skarn type. Among them, the No.1, No.2, No.3 and No.4 ore bodies are the main lead-zinc ore bodies, which occur in the structural fracture zone of dolomite and dolomitic limestone. There are a large number of gray-white fine-grained granite porphyry veins intruded in the fault zone of No.2, No.3 and No.4 ore bodies (Figure 2.), and the skarnization zone is formed in the contact area with dolomite and limestone. The inner bandwidth of the skarnized zone is 2 ~ 5m, and the outer bandwidth is 2 ~ 10m. The mineralization is good. Due to the further transformation and superposition of the later structure, the hydrothermal filling ore body is formed along the structural fracture.

3.5. Ore characteristics

According to the characteristics of ore structure, structure and mineral assemblage, the ore can be divided into three types : brown (yellow) iron mineralization carbonate type lead-zinc ore, brown (yellow) iron mineralization skarn type lead-zinc ore and lead-zinc oxide ore. The ore structures mainly include massive structure, veinlet structure, intermittent vein structure, spotted structure and disseminated structure (Figure 3.) ; the ore structure mainly includes semi-automorphic-automorphic granular structure, allotriomorphic granular structure, cataclastic structure, opalescent structure and metasomatic structure. The material composition of the ore is relatively complex. The metal minerals are mainly galena, sphalerite and pyrite, followed by pyrrotite, chalcopyrite, tetrahedrite, limonite, smithsonite, cerussite and malachite. Non-metallic minerals mainly include quartz,

dolomite, calcite, plagioclase, epidote, sericite, diopside, garnet, gypsum, etc.

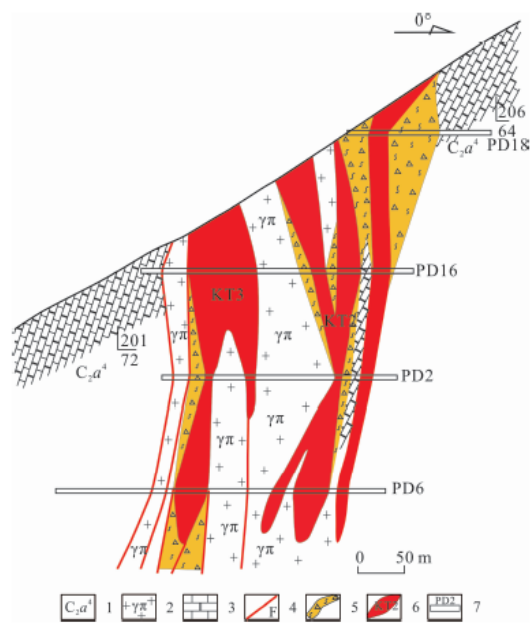


Figure 2. Section of No.5 exploration line in Sinongduo lead-zinc mine, Tibet

1.the fourth lithology section of Angjie Formation ; granite porphyry ; 3. Dolomite ; 4.Fault ; 5 fracture zone alteration zone ; 6. Ore bodies ; 7. Adit and numbering

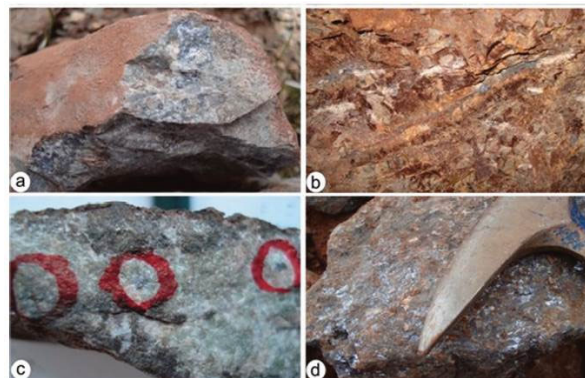


Figure 3. Ore structure types of Sinongduo deposit
a. Disseminated lead-zinc ores ; b. fine vein lead-zinc ore ; c. agglomerated lead-zinc ore ; d. massive lead-zinc ore 2.6 Wall rock alteration

The main alteration types are pyritization, silicification, sericitization, skarnization, carbonation, chloritization and kaolinization. Pyritization, silicification, sericitization and skarnization are closely related to lead-zinc mineralization.

4. Genesis of Deposit

4.1. Analysis of ore-controlling factors

(1) Relationship between strata and mineralization

The lead-zinc ore bodies in the mining area are obviously controlled by the lithology of the strata. The main ore bodies are produced in the dolomitic limestone and dolomite of the Upper Carboniferous Angjie Formation in the south. The carbonate rock layer is subjected to strong compression deformation and fragmentation, which provides space for migration and precipitation for later ore-bearing hydrothermal alteration. Skarnization and carbonation are

closely related to lead-zinc mineralization.

(2) Relationship between structure and mineralization

The occurrence of lead-zinc polymetallic ore belt is controlled by the regional east-west compressive tectonic belt, which is manifested in the distribution of a series of deposits (spots), remote sensing iron staining and hydroxyl anomalies in the region. The deformation of fold faults in the mining area is very strong, and the ore-controlling structure is characterized by a set of parallel compressive fault zones. The ore body is lenticular, veined and irregular, and is produced in the inverted wing of the east-west fold in a multi-layered manner. It is strictly controlled by the east-west fault zone and its intersection with the transverse fault and the oblique fault. The mineralization intensity is closely related to the intensity of tectonic deformation. The ore is often fine veined, reticular and disseminated.

(3) Relationship between intrusive rocks and mineralization

The east-west compressional tectonic belt not only controls the output of lead-zinc ore bodies in the mining area, but also controls the output of granite porphyry bodies. The ore-related intrusions are often subjected to late tectonic deformation and hydrothermal alteration. The ore body is inseparable from the granite porphyry, often located near the contact surface of granite porphyry and carbonate rock.

The above characteristics show that the Angjie Formation strata, regional faults and granite porphyry are the three basic metallogenic control factors in the mining area, especially the structure plays a vital role in mineralization.

4.2. Source of ore-forming materials

According to the research of Ge Liangsheng et al. and Cheng Wenbin et al. on the adjacent area and the Gangdise-Nyainqentanglha block[5,6], it is believed that the ore-forming materials are derived from the new lower crust source area formed by the partial melting of the wedge mantle during the subduction of the Neo-Tethys Ocean and the underplating to the lower crust after the material exchange with it. Therefore, the ore-forming materials are derived from the mantle and the activation of the ore-bearing minerals of the Nyainqentanglha basement gneiss. According to Wang et al.[7], the ore-bearing rock series of the Sinongduo lead-zinc deposit are mainly the limestone and dolomite limestone of the Middle Carboniferous Angjie Formation, and the ore-forming materials are speculated to be mainly derived from this set of strata. Sun Xiaoxuan et al[8]. considered that the volcanic rocks, pyroclastic rocks and porphyry formed by multi-stage volcanic-magmatic activities in the area are the metallogenic parent rocks of lead-zinc deposits and gold-molybdenum deposits (mineralization) in this area. This project team initially believes that the source of ore-forming materials may be multiple sources, namely, deep mantle, basement gneiss, Angjie Formation, and various magmatic rocks.

4.3. Metallogenic epoch

Early Cretaceous, the Yarlung Zangbo River Neo-Tethys Ocean subducted to the Gangdise-Nyainqentanglha block (180 ~ 68Ma) ; during the Late Cretaceous-Eocene (including the eve of the collision) (68 ~ 40Ma) of the main collision period of the Indo-Asian continent (including the eve of the collision), nearly EW-trending regional fault structures were developed, and layered (lenticular) skarn-type lead-zinc ore bodies were formed at the contact between

the early intrusive porphyry and the surrounding rock, which constituted the first stage of lead-zinc mineralization[1,9,10]; the second stage of lead-zinc mineralization occurred in the extensional tension stage (17-13 Ma) after the main collision period, and the development of near SN-NE trending faults and the emplacement of granite porphyry further activated the migration, superposition and enrichment of lead-zinc mineralization, forming lenticular skarn lead-zinc deposits in the contact zone of rock mass and forming tectonic hydrothermal filling metasomatic lead-zinc deposits in the tectonic fracture zone[7,11].

4.4. Mineralization and genesis analysis

The Sinongduo lead-zinc mining area is located in the uplift fold belt of carbonate ore-bearing formation in the Paleo-Tethys rift zone. Due to the subduction of the Indian plate, the rigid rock dolomite limestone, brecciated dolomite, limestone and dolomite in the mining area are strongly broken, forming dense tension-torsional fractures and nearly EW-trending regional tectonic fault zones. The fault structure and rock joint fractures provide migration channels and ore-bearing sites for ore-forming hydrothermal fluids, and play a role in ore-conducting and ore-bearing. The mineralization is directly controlled by the tectonic fracture zone, and the lead-zinc mineralization is developed in the tectonic fracture zone. The secondary tectonic fracture zone is widely developed near the regional fault F1. The regional fault structure roughly controls the distribution and output of the rock mass in the mining area. In the local section of the tectonic fracture zone, fine-grained granite porphyry, diorite porphyrite vein and rock strain are penetrated. With the intrusion of fine-grained granite porphyry veins, magmatic hydrothermal extracts lead, zinc, silver, copper and other ore-forming materials from carbonate rock, and the ore-bearing hydrothermal fluid migrates upward along the fault channel, forming some skarn ore bodies in the contact area with carbonate rock. On the other hand, the ore-bearing hydrothermal fluid is filled in the fractures of the structural fracture zone, forming a structural fracture filling metasomatic lead-zinc ore body. Two types of mineralization, skarnization and structural fracture filling and metasomatism, are superimposed and transformed by different degrees of late tectonic hydrothermal mineralization. In the structural composite site, thick lead-zinc ore bodies are often formed.

5. Prospecting Indicators

(1) The impure limestone and breccia dolomite formation of the Angjie Formation are the stratigraphic markers for prospecting in this area.

(2) The iron-bearing breccia dolomite formed by submarine turbidity current and the skarn and skarnized limestone formed by contact metasomatism are the most important lithologic markers.

(3) Limonite mineralization, pyritization, chalcocopyrite mineralization, malachite, dolomite, silicification and other mineralization alteration is the direct sign of looking for lead-zinc mine.

(4) EW tectonic fracture zone and tectonic breccia are important structural indicators for prospecting.

6. Perspective Evaluation

Due to the influence of interlayer tectonic fracture zone and later tectonic transformation, the oxidation depth of the

deposit is large, generally 80 ~ 160 m. With the increase of depth, the oxidation degree of the deposit will decrease, and sulfide ore will appear. In the deep, southern and northern anomalous areas of the No.1 ore belt in the mining area, there is a prospect of expanding the scale of the deposit.

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