Analysis of Tectonic Stress Characteristics of the Baniuchang Silver-Lead Polymetallic Mining Area, Yunnan Province, SW China

Jian Long¹, Dao Yan²,*

¹Kunming Metallurgy College, Kunming, China
²Yunnan Institute of Geological Survey, Kunming, China

*Corresponding author: daoyan@kmyz.edu.cn

Abstract. The southeastern of Yunnan metallogenic belt is an area with many large-super large deposits in the Metallogenic Province of South in China. The mineral deposits in the area are densely distributed and the geological structure is complex. This article studies the joints (cracks) of the super large bed in the Bainiu factory in this area, a total of 21 joint observation points, 685 groups of occurrence structural surfaces were observed, and uses Dips software to analyze the joints (fissures) in the mining area. It is concluded that there are three periods of tectonic stress in the mining area, which are closely related to the mineralization, there are North North West-South South East, North East-South West, and South-North.

Keywords: Tectonic Stress, Joints, Cracks, Baniuchang.

1. Introduction
The southeastern Yunnan metallogenic belt is an area with many large-super large deposits in the southern metallogenic province of China. It is the junction of my country's three major tectonic units (Yangtze, South China, Tibet and Yunnan), and one of the areas with densely distributed super-large deposits in China [1]. The area has complex geological structure, diverse deposition types, developed magmatic rocks, favorable mineralization conditions, and abundant non-ferrous and precious metal minerals (mainly silver). It has been identified that there are three super large deposits in the Southeast Yunnan metallogenic belt, namely Gejiu, Dulong and Baniuchang [2].

This article intends to conduct a field investigation on the morphological characteristics, occurrence, genesis, spreading rules of joints, fault scratches and the relationship with other structures. And using Dips software to analyze the tectonic stress characteristics of the Baniuchang silver-lead polymetallic mining area, Yunnan Province, SW China.

2. Regional structure
The Baniuchang silver polymetallic deposit belongs to the tin polymetallic metallogenic region in Southeast Yunnan. This area includes the area north of the Honghe Fault, south of the Wenma Fault, Jianshui in the west, and Maguan and Malipo in the east. It is about 230km long and 120km wide. It is located in the southwest margin of Caledonian fold system (Ⅱ) (grade I), Southeast Yunnan fold belt (III) (grade II), Wenshan-Funing fault fold bundle (Ⅱ₁) (grade III) and Bozhushan arch fold (Ⅱ₁), and...
(grade IV). It is connected with the Yangtze paraplatform (I) (grade I), in the West and the North Vietnam ancient land in the south, which is the junction of the three tectonic units. Due to the influence of adjacent tectonic units, it is an area with poor crustal stability, strong mobility and complex geological structure (Fig.1)[3,4,5,6].

![Geotectonic division of Gejiu Bozhushan Laojunshan tin polymetallic metallogenic belt in Southeast Yunnan](image)

**Figure 1.** Geotectonic division of Gejiu Bozhushan Laojunshan tin polymetallic metallogenic belt in Southeast Yunnan

1. Boundary of primary tectonic unit; 2. Boundary of secondary tectonic unit; 3. Boundary of tertiary tectonic unit; 4. Granite; 5. National and provincial boundaries; 6. Yangtze paraplatform; 7. South China fold system; 8. Tanggula-Changdu-Lanping -Simao fold system; 9. Kangdian axis; 10. East Yunnan platform fold belt; 11. Ailaoshan fault block; 12. Fold belt in Southeast Yunnan; 13. Luoping -Shizong fold fault bundle; 14. Gejiu-fold fault bundle; 15. Wenshan-Funing fault fold bundle; 16. Bozhushan arch fold; 17. Xichou arch fold; 18. Qiubei-Guangnan fold bundle

3. Structure of mining area
The internal structure of the mining area is complex, mainly fold structure and fault structure. The fold structures in the area are mainly composed of niuzuodi anticline, Yuanbaoshan syncline, awei anticline, maomaodong anticline, dajianpo syncline, etc., and the long axis NW trending Bainiuchang composite short axis anticline (the dome structure). Its fold pattern appears abrupt or does not have geometric regularities. Inconsistency is widespread. The fault structures are mainly NW faults (F₁-F₇), NE faults (F₉, F₁₀), N-S faults (F₁₁, F₁₂), and NW faults. Among the NWW trending fault structures, F₃ and F₇ faults play the most significant role in ore control, which represent the main ore control types and characteristics of faults in the area [3, 6].
4. Structural features of joints (cracks)
Joints are the product of superposition of long-term and multiple tectonic activities, with certain regularity. The occurrence of joints is basically in groups, and has a certain combination shape. It has a great significance for the study of the tectonic deformation process and paleotectonic evolution history in a certain area [7, 8].

Due to the influence of emplacement and uplift of rock mass and long-term activity of fault structures, dense joint fissures are developed in the rock mass or in the rocks (layers) on both sides of the fault. The joints and fissures are characterized by high dip angle (60-90°) (Fig.2A). The fracture surface is uneven, mostly zigzag and zigzag, with a width of several millimeters or even several centimeters, and is mostly filled by ore veins. Most of them belong to radial and annular tensile fractures formed by diapirism of concealed granite. Some of them are shear fractures and pinnate fractures derived from fault structures. The fracture zone composed of these dense joints provides a good space for ore storage and ore conduction. Especially in the Middle Cambrian Tianfeng formation stratum rock or mineralized body. From the aspect of production form, there are all kinds of directions, but the development degree of different fracture groups in different sections is different, but the most of them are steep dip angle.

In addition, on the surface of rocks, secondary joints are formed near the surface due to different weathering and denudation (Fig.2B). The joints gradually disappear to the deep, often in the form of veins and net veins.

![Figure 2. Photograph of joint structure in Bainiuchang silver polymetallic mining area](image)

A: The joints are characterized by high angle oblique intersection and mutual dislocation
B: Secondary high angle joints formed on the surface by weathering and denudation

5. Inversion of tectonic stress
In this paper, the simulation of Bainiuchang tectonic stress field is divided into four steps: the first step is to determine the relative tectonic evolution stages and carry out joint (fracture) observation; the second step is to establish the corresponding geological model of each stage; the third step is to determine the constraint conditions and establish mathematical and mechanical models; the fourth step is to analyze the simulation results of each stage.

A total of 21 joint observation points were measured in the surface and tunnels this time, and a total of 685 structural plane occurrences were measured. Among them, 17 in the middle section of 1500, 579 groups of occurrences, 1 fold observation point, 19 occurrences, 2 surface joint observation points, 87 occurrences. This downhole survey mainly selects the middle section of 1500 for joint measurement. The engineering scope of 1500 middle section tunnel is relatively wide, and the measurement range is correspondingly large, there are 17 joint observation points in the 1500 middle
section of the mining area. 579 sets of joint plane occurrence are measured, and the measurement range is about 2.01km².

In the computer inversion calculation, The dips software developed by M. S. diederichs and E. Hoek, Department of civil engineering, University of Toronto, Canada is used. We input the observation data into the software to generate the rose diagram, iso-density, pole diagram, pole density diagram and frequency histogram of the structure surface, etc. (Fig.3, Fig.4).

![Figure 3. Pole density map of joint system in Bainiuchang silver polymetallic mining area](image1)

![Figure 4. Isodensity map of joint system in Bainiuchang silver polymetallic mining area](image2)

It can be concluded from the figure that there are many dense areas, which indicates that there are many joint development periods in Bainiuchang silver polymetallic mining area. The occurrence distribution of ore bearing joint system in the survey area is relatively concentrated, and there are 10
dominant occurrences of joint poles: Three groups were relatively developed(J1: 182°∠78°, J2: 351°∠79°, J3: 23°∠65°); Seven groups of weakly developed(J4: 281°∠60°, J5: 257°∠54°, J6: 151°∠79°, J7: 85°∠78°, J8: 59°∠72°, J9: 326°∠75°, J10: 226°∠72°).

6. Conclusions
The Bainiuchang mining area in Southeast Yunnan is deeply influenced by the movement of Honghe fault and the southward movement of diamond block in Central Yunnan, the movement of the two blocks leads to the regeneration and expansion of secondary faults. In mechanical direction, it is compressed by NW-SE tectonic stress and tensioned by NE-SW direction. Therefore, there are a large number of NE trending faults and folds in the metallogenic area of Southeast Yunnan.

Within the mining area, the direction of the main structural line is NE, It is composed of a series of folds, compressional and compressional torsional faults, The second is NW and Sn trending fold structures and fault structures. Through field observation and statistical analysis of the joint system in the whole area, The orientation inversion of stress field is carried out on the joint data measured in Bainiuchang silver polymetallic mining area, it is concluded that there are mainly four orientations of extrusion, and it is concluded that there are three periods of tectonic stress in the mining area, which are closely related to the mineralization, there are North North West-South South East, North East-South West, and South-North (Table-1).

Table 1. Statistical stress azimuth table of joints in Bainiuchang silver polymetallic mining area.

| Period | Joint group | Principal stress orientation |
|--------|-------------|-----------------------------|
| First group | Second Group | σ1  | σ3 |
| Early   | J6          | J9          | 328°~148°  | 238°~58°   |
| mid     | J3          | J10        | 35°~215°  | 125°~305°  |
| late    | J1          | J2          | 356°~176°  | 266°~86°   |

Acknowledgments
This work was financially supported by Department of Education of Yunnan Province under grant number 2018JS549 and Department of Science and Technology of Yunnan Province under grant number 2019FD029.

References
[1] Yang Hanhai, Yang Qinsheng, The Metallogentic rule and ore prospecting of large and super-large ore deposit in SE Yunnan, J. Yunnan Geology, 29(2010) 245-250.
[2] Zhu Chaohui, Zhu shaohui, Zhang qian et al, Metallogenic element characteristics and ore controlling factors of Bainiuchang superlarge silver polymetallic deposit in Yunnan Province, J. Acta mineralogica Sinica. S1 (2007): 328-330.
[3] Zhang Hongpei, Bainiuchang Super-Large Silver-Polymetallic Ore Deposit Related to Granitic Magmatism in Mengzi, Yunnan, China. Central South University, Changsha,2007.
[4] Li Xiaoobo, The ore-forming geological features and metallogenic pattern of Bainiuchang polymetal deposit in Mengzi county, Yunnan province, Central South University, Changsha, 2005.
[5] Li Kaiwen, Geochemistry and geochronology of the Bainiuchang polymetallic deposit in southeastern Yunnan, Institute of geochemistry Chinese Academy of Sciences, Guiyang, 2013.
[6] The second Geological Brigade of Yunnan Bureau of Geology and mineral resources, Large scale metallogenic prediction report of Bainiuchang area, Mengzi County, Yunnan Province(1:50000). The second Geological Brigade of Yunnan Bureau of Geology and mineral resources, Kunming, 1993.
[7] Chen Guoda, Research method of metallogenic structure, Geological Publishing House, Beijing, 1978.