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Analysis of Fault Strike Based on Multi-point In-situ Stress Data in Jinchuan Mining Area

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Abstract **-** In the process of mineral exploration, considering the significant difference of in-situ stress field at the fault, the research on the distribution of stress near the fault is carried out. The relationship between the deflection characteristics of the principal stress direction and the fault strike is analyzed, and a method for judging the extension of the fault strike based on the measured direction of in-situ stress is proposed. The stress distribution is verified by theoretical study, numerical simulation analysis of fracture mechanics and engineering examples using the measured in-situ stress measurement data in Jinchuan Mining Area for many years.

Keywords**:** Geologic structure, Rock mechanics, In-situ stress, In-situ measurement.

1. Introduction

At the stage of mineral exploration, core data obtained by core drilling are important reference materials for the assessment of regional geologic structure. Due to manpower and material resources, the number of exploration holes is bound to be limited. In order to make full use of the existing prospecting boreholes, and to accurately predict the direction of fault strike, the in-situ stress test in existing prospecting boreholes is necessary. By performing the multi-point measurement in the mining area, the regularity of the measured data is compared and analyzed, and the numerical calculation method is used to expand the measurement result of the single measurement point to the numerical calculation result between the two measurement points. In this paper, the direction of fault strike is inferred, according to the direction of principal stress of in-situ stress and based on in-situ stress test results and fracture mechanics theory, which plays an important role in accurate delimitation of the scope of fault.

2. Prediction and Analysis of Jinchuan Mining Area

When the roadway axis is consistent with the fault strike, it is likely to lead to the tunnel rock cracking, collapse and other damages. It is necessary to avoid the roadway axis is consistent with the fault strike in the roadway construction inside the mining area. It is a meaningful research to gain an effective method of predicting the direction of fault strike in the orebody.

2.1. Distribution of The Direction of In-situ Stress in The Mining area

Jinchuan Nickel Mine is one of the world famous large-scale copper sulphide nickel deposits with polymetallic symbiosis, and it is the largest nickel production base in China. Many scientific research units have carried out research on stress field and rock mechanics in Jinchuan mining area. Since 1973, many in-situ stress measurements have been carried out in this mining area, and a lot of in-situ stress test data have been accumulated. The horizontal projection of survey points for in-situ stress measurement in Jinchuan Mining Area is shown in Fig. 1.

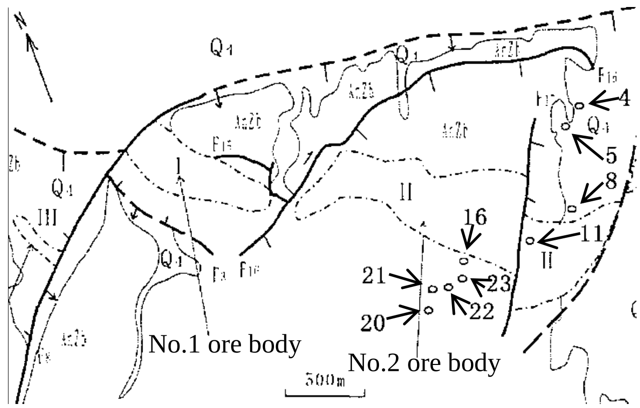

Fig. 1: Distribution Diagram of Horizontal Projection of Survey Points for In-situ Stress Measurement in Jinchuan Mining Area.

The first stage of in-situ stress measurement in the mining area is mainly shallow in-situ stress measurement, and the maximum measurement depth is 525m. According to the data of in-situ stress in Qingshanbao and Pingkouxia , there are 40 kilometers away from Jinchuan Mining Area, we can see that the direction of principal stress in Qingshanbao is N59°E, and the direction of principal stress of in-situ stress in Pingkouxia is N43°E.[3] By analyzing the in-situ stress measurement data, it is considered that the direction of regional stress field of the mining area is about N51 ° E. The test results of in-situ stress obtained by in-situ stress test of boreholes are shown in Table 1.

Table 1: In-situ Stress Test in Jinchuan Mining Area.

Borehole No.	Depth	Direction of principal stress (°)	Borehole No.	Depth	Direction of principal stress (°)
4	20m	333	20	700m	177
5	44m	20	21	700m	18
8	375m	3	22	700m	348
11	480m	32	23	700m	13.2
16	550m	34			

As shown in Fig. 1, the borehole No. 16 and boreholes No. 20-23 are located in the host rock on the west side of the fault, and the spatial distribution is close to a straight line. The spatial distribution of boreholes No. 4, No. 5, No. 8, and No. 11 on the east side of the fault is also close to a straight line. The direction of the east and west prospecting lines is S60°W or N60° E. Remove abnormal data on 20, 22, and 4. The changes of the direction of horizontal principal stress of in-situ stress on the east prospecting line and west prospecting line are shown in Fig. 2.

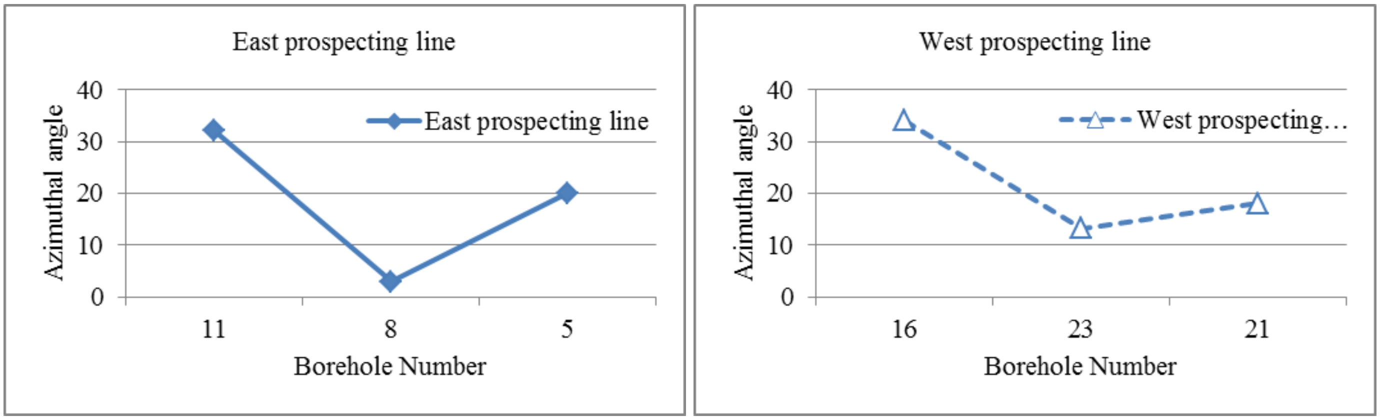

Fig. 2: Changes of The Direction of Horizontal Principal Stress of In-situ Stress on The East and West Prospecting Lines.

It shows that the nearer the distance from the fault, the more the deflection direction of the horizontal principal stress of in-situ stress is closer to 30°. As for the measurement data obtained in position far away from the ore boundary, the horizontal principal stress of in-situ stress is close to the direction of principal stress of stress field in the region. Therefore, it is considered that the stress direction of the regional stresses is the average value of the measured data of No. 5 and No. 21. The average value of measurement data for No. 5 and No. 21 is N19 ° E.

2.2. Analysis Method of Fault Strike Direction

It can be known from the fracture mechanics that the disturbed stress field will be generated in the vicinity of the crack, causing the deflection of the direction of principal stress near the crack. The direction of principal stress around the crack is centrally symmetric. According to the changes of the direction of horizontal principal stress of in-situ stress on the prospecting lines (the east prospecting line and the west prospecting line), the stress direction of borehole No. 16 and borehole No. 11 is almost the same, and the changing trend of the direction of principal stress on the two prospecting lines is almost the same. Taking the whole mining area as the research subject, the fault inside the ore body is considered to be a crack.

Thus the fault is abstracted as type II crack, and the simplified mathematical model of the ore body is formed as shown in Fig. 3. Suppose that the crack length is 2*a*, the normal direction is in the *y* direction, and the crack direction is in the *x* direction. After the superposition of the disturbed stress and the background stress field, the contour line of direction of total principal stress, that is, the contour line of the direction of principal stress can also be drawn, as shown in Fig. 3.

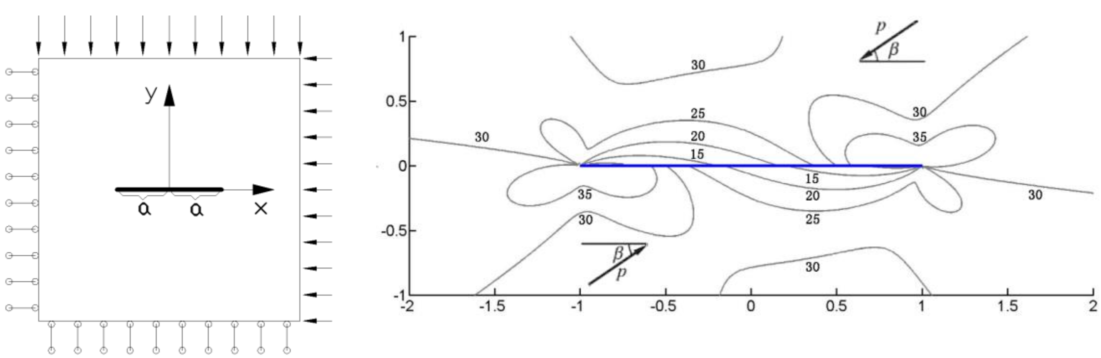

Fig. 3: Crack Model under Stress Superposition and Contour Line of Direction of Absolute Principal Stress.

The principal stress direction of the regional stresses field (N19 ° E) and the direction of the prospecting line (S60°W) are known. Therefore, the fault strike and position can be predicted according to the change of the space among the positions of the prospecting boreholes and of the direction of horizontal principal stress of in-situ stress in the borehole.

The different directions of crack have different effects on the measurement results. The direction of crack, the direction of principal stress and the direction of prospecting line form a variety of spatial combinations. As shown in Fig. 4, the crack directions of N45°E, N30°E, and N15°E are taken. According to the relative relation between the direction of crack and the direction of principal stress, the directions of crack are divided into three curves as shown in the left and right diagrams below.

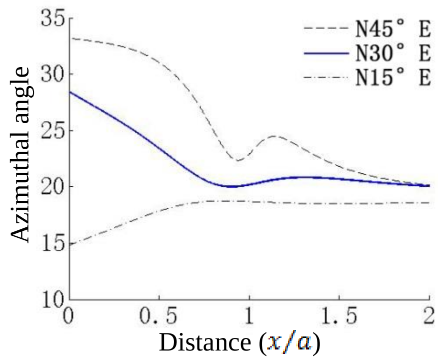

Fig. 4: Changes of The Direction of Principal Stress on The Extension Direction of Measuring Line.

Through the forward calculation of Fig. 4, we can see that when the direction of crack is near N30°E, there is a same deflection in the vicinity of the crack finally. When the direction of crack is N30°E, the deflection of the direction of principal stress as same as the deflection of in-situ stress on The east and west prospecting line, as shown in Fig. 2. The result and the extension direction of fault in the distribution diagram of horizontal projection of the geological structure of Fig. 1 can verify each other, so it is considered that the result of the forward calculation is correct. It is proved that the direction of fault affects the final deflection direction.

3. Conclusion

Through the distribution found in the field in-situ stress tests, combined with the theoretical analysis of fracture mechanics, it is considered that the direction of in-situ stress can be used as an analytical method to infer the form and orientation characteristics of underground structures. Theoretical analysis of the field data as follow:

(1) The distribution of the direction of horizontal principal stress of in-situ stress is affected by the fault, and the variation gradient is also affected by the spatial location between the fault strike, trend of the prospecting line and direction of regional in-situ stress field.

(2) In the fault area, the influence of fault on the direction of in-situ stress is larger than that of ore body on the direction of in-situ stress and the influence of ore body in the region can be neglected when calculating the regional fault strike.

(3) The measurement of the direction of in-situ stress is relatively easy to obtain in the field test work, and it is not affected by physical properties of rock. It will be an effective way to infer the underground structure based on the direction of in-situ stress.

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