Rock Mass Analysis of -915m in a Gold Mine in Northwest Jiaodong

Guilin Li1*, Jianbo Wang1, Jie Zhao1, Huanxin liu1, Qinzheng Wu1 and Yuanhui Li2
1Deep well mining laboratory branch, Shandong gold mining technology co., LTD., Yantai, Shandong, 264000, China
2Key Laboratory of Ministry of Education on Safe Mining of Deep Metal Mines, Shenyang, Liaoning, 110819, China
*Corresponding author’s e-mail: liguilinstd@126.com

Abstract. According to the requirements of ore mining, this paper comprehensively evaluates the quality of rock mass below 915m in a gold mine in northwest Jiaodong by rock mass engineering geological survey and comprehensive quality evaluation. The results show that the rock mass near the ore body or the F1 fault area is gradually deteriorated, and the rock mass of the ore body or the F1 fault is still poor. The RMR index of the rock mass is in the range of 35~50, mostly the grade III poor rock mass.

1. Introduction
As the depth of gold mining continues to increase, the distribution and scale of different rock groups change. Mine impact ground pressure has an impact on mining stability. As one of the major disasters in the mine, impact pressure has always been an important research topic of academic and engineering circles at home and abroad [1-4]. Domestic scholars believe that when the stress of the well and the stope reach the limit of the rock mass, sudden damage will occur [5-8]. In order to solve the risk of rock burst, this paper evaluates and analyses the rock mass below 915m in an ore body in the northwest Jiaodong by means of rock mass engineering geological survey.

The rock mass structure surface is the key channel for the migration of nuclide in the repository, and it is also an important indicator for the quality evaluation of various rock masses [9-11]. The rock mass is a discontinuous geological body cut from structural planes with different mechanical properties and spatial conditions. Many examples of rock mass engineering show that the deformation and failure law of rock mass depends on the structural characteristics of rock mass, and the stability state of rock mass engineering is affected by the rock mass itself. In order to distinguish the stability of rock mass quality in engineering design and construction, it is necessary to make a reasonable classification of rock mass. As one of the parameters for selecting engineering structural parameters, scientific management of production and evaluation of economic benefits, rock mass grading is also a basic work in rock mechanics and engineering applications [12-13].

In the current design manual of our country, the general coefficient is mostly used to represent the rock type. The classification is based on uniaxial compressive strength of rock mass. However, because the method is based on the uniaxial compressive strength of small-sized rock blocks, it cannot reflect the rock mass strength and cannot be used as a basis for objective evaluation of rock mass and rock mass
stability. Therefore, since the 1950s, there have been dozens of rock mass classification methods at home and abroad, ranging from single factor classification to multi-factor classification. Among them, the most widely used are Rock Quality Designation (RQD) method, Norway Barton Q [14] classification method, ZT Bienawski RMR classification method and China National Standard Engineering Rock Mass Classification Standard (BQ) classification method [15].

2. Mass analysis of deep fractured rock mass

In the mining process of underground metal mines, the unreasonable structural parameters of the stope will cause the loss and depletion of the ore, resulting in safety hazards in production. Therefore, this paper combines a large number of on-site rock structure investigations and indoor rock mechanics experiments, based on on-site geological drilling information, using rock mass quality classification method to comprehensively analyse and evaluate the quality of deep fractured rock mass in gold mine.

2.1. Quality analysis of deep broken rock mass

In this paper, the gold deposit is a typical altered rock type gold deposit, and the joints of the rock mass develop. The RMR rock mass grading method proposed by Z. T. Bienawski is more suitable for rock mass developed by joint fissures. Therefore, this paper uses RMR rock mass classification method to analyse the quality of deep fractured rock mass. The RMR score of the rock mass depends on five parameters. They are rock compressive strength R1, rock quality designation R2, joint spacing R3, joint state R4 and groundwater state R5. Later, considering the influence of structural plane orientation on the project, the modified parameter R6 is introduced. According to the RMR value obtained from the sum of the above six parameters, the quality of the rock mass is divided into five categories, as shown in table 1.

| Rating value  | 100~81 | 80~61 | 60~41 | 40~21 | <20 |
|---------------|--------|-------|-------|-------|-----|
| Surrounding rock category | I | II | III | IV | V |
| Quality description | Very good | Good | General | Poor | Very poor |

Compared with Barton's Q grading method, the RMR grading method strongly regulates the influence of physical properties on rock mass stability. Therefore, RMR is suitable for the quality classification and application of jointed rock masses. The method flow is shown in figure 1.

![Figure 1. RMR classification method.](image-url)
The strength of the intact rock mass can be obtained by two means, namely the indoor uniaxial compression test and the on-site point load test. The scores of the obtained rock mass strength indicators are shown in table 2.

| load test index (MPa) | uniaxial compressive strength (MPa) | R1 rating value |
|-----------------------|-------------------------------------|-----------------|
| >8                    | >250                                | 15              |
| 4~8                   | 100~250                             | 12              |
| 2~4                   | 50~100                              | 7               |
| 1~2                   | 25~50                               | 4               |
| Not used              | 5~25                                | 2               |

2.2. RMR classification method based on geological drilling core cataloging

Due to the complexity of its ore body shape, underground metal mines often require many geological boreholes for ore body boundary control. This paper uses these core data to classify and evaluate rock mass quality. This paper grasps the characteristics of rock masses throughout the mine. Therefore, this paper uses an RMR grading method based on geological drilling core cataloging.

The method is divided into four parts. The first part is the basic data collection. This part is to calculate the information of the drilling (including the hole number, azimuth, inclination, starting point coordinates and length) and the picture information of the core. In this part, the basic information database and core image of the drilling are established. The second part is to divide the minimum measurement range. This section determines the extent of the area represented by each RMR rock mass grading indicator. The third part is the grading index measurement and acquisition, in which rock mass RQD index and rock mass point load is to be carried out. In this part, this paper needs to evaluate measurement of strength, joint spacing of rock mass, record joint state of rock mass and assessment of groundwater status. The fourth part is the RMR score, which summarizes the above measured and recorded indicators, and then calculates the RMR index of the rock mass in each of the smallest measurement units, and forms a rock mass classification index result database in this part.

3. -915m middle section RMR rock mass classification area

The drilling RMR grading work is carried out in combination with the current distribution of geological prospecting boreholes in the middle section of -915m. The drill holes recorded in the survey include: 1500# exploration line 68, 69# prospecting drilling, 1520# exploration line 78, 79, 80# prospecting drilling, 1580# exploration line 81# prospecting drilling, 1600# exploration line 82, 83, 84# prospecting drilling.

The drilling plan and section are shown in figure 2 and figure 3. From the figures, it can be seen that the RMR rock mass classification area is from the 1500# exploration line ~1600# exploration line, the elevation direction is from -925m~-870m, the average drilling. The length is 80m, covering the lower part of the ore body, the ore body and part of the upper part of the ore body.

4. RMR rock mass analysis

A reasonable minimum measurement range should be determined before the measurement and calculation of the rock mass grading index. When the range is too large, the range contains a plurality of different masses of rock mass, which reduces the accuracy of the rock mass classification result; when the range is too small, the workload of the rock mass classification will be greatly increased. Combined with the fracture degree of a gold ore body, the minimum measurement unit of RMR rock mass classification is set to 3m. On this basis, this paper conducts RMR grading for each geological borehole along the length of the geological borehole. In this paper, the distance square inverse ratio method is used to interpolate the rock mass region between the boreholes to obtain the rock mass RMR quality index. The range is from -930m to -870m in the elevation direction, the direction of the ore body is
1500# exploration line ~1640# exploration line, the direction of vertical ore body direction J2050~J2250. Finally, this paper generates contour maps of corresponding planes and sections based on the interpolation structure.

Figure 2. -915m distribution plan of geological boreholes in the middle section.
4.1. -915m middle section rock mass quality assessment

According to the RMR score of the middle section of -915m, the RMR classification result map of the exploration line is drawn. The data simulation is shown in figure 4. The scope of the exploration line includes 1500# exploration line 68, 69# prospecting drilling, 1520# exploration line 78, 79, 80# prospecting drilling, 1580# exploration line 81# prospecting drilling, 1600# exploration line 82, 83, 84 # prospecting drilling.
4.2. RMR rock mass analysis

In this paper, the rock mass grading index of exploration drilling is taken as the basic data, and the difference algorithm is used to calculate the difference of rock mass RMR grading index between exploration boreholes. Finally, the rock mass RMR quality index is obtained. A straight-line distribution diagram of the corresponding plane and section RMR is shown in figure 5. The range includes elevation direction -930m~870m, ore body direction 1500# exploration line ~1600# exploration line, vertical ore body direction J2050~J2250.

5. Conclusion

It can be seen from the paper that the rock mass quality has obvious correlation with F1 fault and ore body distribution. The mass of rock mass in the lower part of the ore body is relatively good, and its RMR index value is >50, mostly for type II and III rock masses. The mass of the rock mass is gradually worsened near the ore body or the F1 fault zone, and the rock mass quality of the ore body or the F1 fault is still poor. The RMR index of the rock mass is in the range of 35~50, mostly the grade III poor
rock mass. From the direction of the ore body, the south mining body is relatively broken and the rock mass RMR index is low. The quality of the northern ore rock mass is good, and the rock mass RMR index is high.

References

[1] Li Wen, Ji Hongguang, Wei Xiaowen. (2007) Research Progress on Classification, Mechanism and Prediction of Rock Burst in Mine. China Mining Industry, 16(4): 86-88.

[2] Fu Jianhua, Li Xueping, Yu Guiliang. (2014) Exploration and Practice of New Methods for Comprehensive Evaluation of Rock Burst Risk. Coal Mine Safety, 45(12): 46-50.

[3] Pan Junfeng, Qin Zikai, Wang Shuwen. (2015) Comprehensive evaluation method of impact risk source weights. Journal of China Coal Society, 40(10): 2327-2335.

[4] Qin Zikai, Peng Yongwei. (2011) Research on Regional Impact Risk Assessment Method Based on Dynamic Weights. Journal of Coal Science and Technology, 39(10): 18-21.

[5] Li Jianpeng, Nie Qingke, Liu Quansheng. (2018) Research on risk assessment method of karst ground collapse based on weight back analysis. Rock and Soil Mechanics, 39(4):20-24.

[6] Xue Yiguo, Li Shucai, Qiu Daohong, Wang Zichao, Su Maoxin. (2013) Classification model and application of surrounding rock reservoirs in underground oil storage caverns based on weight back analysis and efficiency coefficient method. Rock and Soil Mechanics, 12: 003549-3560.

[7] Tan Yunliang, Sun Zhonghui, Du Xuedong. (2000) Prediction model of AE time series wavelet neural network for rockburst pressure. Chinese Journal of Rock Mechanics and Engineering, 19(S1): 1034-1036.

[8] Liu Baoguo, Du Xuedong. (2004) Viscoelastic analysis of the interaction between surrounding rock and structure of circular caverns. Journal of Rock Mechanics and Engineering, 04(4):30-34.

[9] Lei Guangwei, Yang Chunhe, Wang Guibin. (2017) Evaluation and application of rock mass quality based on comprehensive index of structural planes. Rock and Soil Mechanics, 38(8): 2343-2350.

[10] Yuan Quan, Chen Jianping, Gao Yan. (2009) Research on rock mass quality evaluation method based on fractal dimension of structural plane distribution. National Geotechnical Engineering Conference, pp.165-174.

[11] Liu Yanzhang. (2004) Fractal characteristics of rock mass structural surface distribution and evaluation of rock mass quality. Wuhan University of Science and Technology, Wuhan.

[12] Sheng Jianlong. (2002) Study on the mechanical characteristics of rock mass structural plane and the stability of underground engineering structure. Wuhan University of Technology, Wuhan.

[13] Yang Ming. (2009) Numerical calculation of mechanical properties and anchoring effect of rock mass plane. Central South University, Nanjing.

[14] Ranasooriya J, Nikraz H. (2009) Reliability of the linear correlation of Rock Mass Rating (RMR) and Tunnelling Quality Index (Q). Australian Geomechanics Journal, 44(2):47-54.

[15] Chen Changyan, Wang Guirong. (2002) Discussion on the Correlation of Various Rock Mass Quality Evaluation Methods. Chinese Journal of Rock Mechanics and Engineering, 21(12): 1894-1900.