Study on the Developmental Regularity of Faults in Jining No. 3 Mine Field

Yunping Zhao [1, a], Longqing Shi [1, b] and Xufeng Liu [2, c]

[1]School of Earth Sciences and Engineering, Shandong University of Science and Technology, Qingdao, 266590, China

[2]School of Mining and Safety Engineering, Shandong University of Science and Technology, Qingdao, 266590, China

[a]zhaoyunping1992@126.com, [b]cattony2002@163.com, [c]liuxufeng2836@163.com

Abstract

According to relatively developed faults of Jining No. three mine field are serious threats to the production progress and mine safety, the text statistics the fault property, fault throw, fault strike, fault tendency and fault dip firstly. Then, the No. 3 coal seam, which is being mined, is divided into many blocks of 500*500 m. Finally, the Surfer software is used to draw the contour map of fault density and the intensity index of fault, in order to analyze the developed degree of fault.

Keywords

Fault Density, Intensity Index of Fault, Surfer Software, Developmental Regularity.

1. Introduction

Small faults in Jining No. three mine field are serious threats to the progress of production and mine safety, so the developmental regularity of faults has to be analyzed and studied deeply, so as to lay the foundation for later prevention and control of faults. There are many methods for the evaluation of the fault [1-4], such as fault strike index [3], damage coefficient of tectonic area [3], fault density, fault intensity index [4], but because of the lack of data and not easy acquisition, fault quantitative evaluation indexes are not many. The paper uses the fault density and fault strength index as evaluation indexes of fault. Based on the contour map of the No. 3 coal mean, the Surfer software [5, 6] is used to draw the corresponding contour map. Study the development of fault of the mine filed, and put forward some suggestions.

2. Study Area

The Jining No. three coal mine is located in the southeast of Jidong coalfield, about 14 km from the urban area of Jining, about 42km west of Jining-Qufu airport, Shandong province, in eastern China. The north-south direction length and the east-west direction length are respectively 10km and 10-13km, and covering an area of around 105.0506km^2. The mine field is irregularly developed, extending between 116°34′04″-116°43′00″E and 35°13′39″-35°19′05″N. Sunshidian fault, in the east of the mine, is the boundary of between Jining No. three mine field and other mine filed. The main coal bearing strata in the mine field are Taiyuan group and Shanxi group of Carboniferous-Permian, and the No. 3 upper and lower coal seams of Shanxi group are being mined at present.

The mine is found in a monocline dipping gently near EW and near SN in the area (Figure 1).

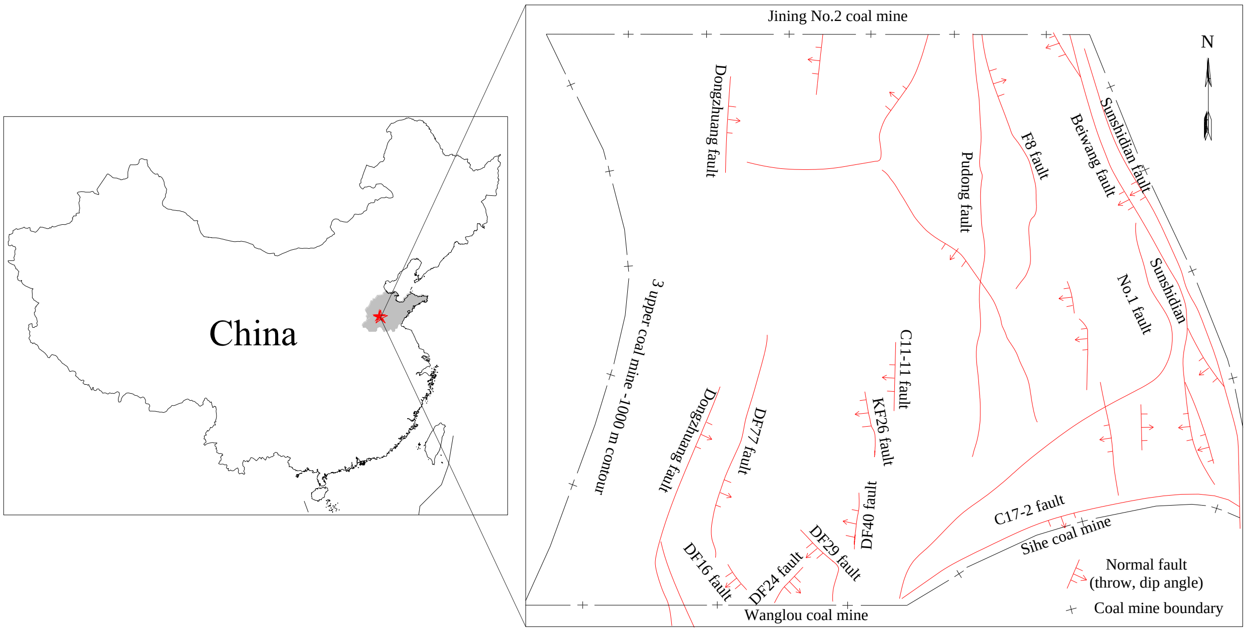

Fig. 1 Geographic location of the Jining No. three mine field and its fault distribution

3. Data

The NS striking faults are well developed in the area, such as Sunshidian fault, Beiwang fault, Balipu fault and so on. The number of faults in the area, which has been revealed, is totally about 1491, and there dips generally less than 10m. In this paper, the characteristics of fault property, fault strike, fault tendency and fault dip are analyzed.

3.1 Fault Property.

According to the geophysical and seismic data, it is known that the fault is dominated by normal fault in the mine field, which controls the principal structure of the area. Only a few of the reverse faults, such as DF8.

3.2 Fault Throw.

The intensity of geological movement is different in different regions, resulting in different regions, different sizes of the fault is not the same. The faults with fault throw of 0-10m are great developed, a total of 1399, accounting for 93.83% of the total; the throw of 10-20m, a total of 55, accounting for 3.69%; the throw of 20-50m, a total of 29; the throw of more than 50m, a total of 8, only 0.54% (Table 1).

Table 1. Statistics and accounting of fault throw

Fault throw /m	Quantity	Proportion /%
<10	1399	93.83
10-20	55	3.69
20-50	29	1.95
>50	8	0.54

3.3 Fault Strike, Tendency and Dip.

In the 92 faults, whose dip are less than 10m, there are 33 in NNE striking faults, 5 in NE, 3 in NEE, 4 in NWW, and 15 in NW striking faults. In the 37 faults, whose dip are more than 20m, there are 14 in NNE striking faults, 3 in NE, 9 in NW and 11 in NNW striking faults. In the mine field, the main faults are NNE and NNW, accounting for 67.50% of the total number of faults, whose dip are more than 20m. The rose diagrams [7] of the fault trend, tendency and dip of throw over 20m are shown in Figure 2-3.

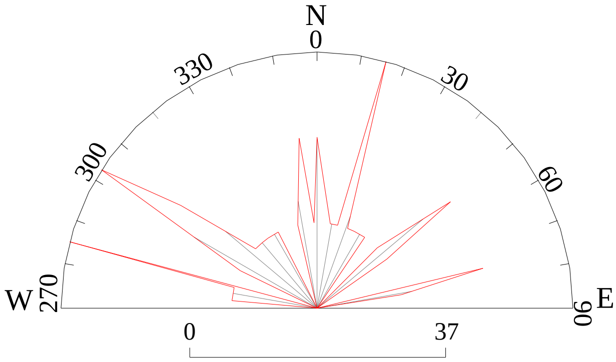

Fig. 2 The fault trend rose diagram of dip over 20m

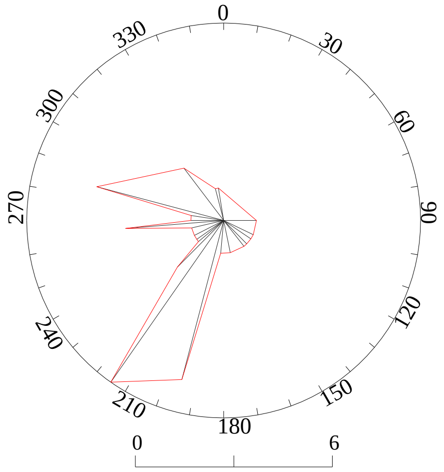

Fig. 3 The fault tendency rose diagram of dip over 20m

Dip of 37 main faults in the throw of more than 20m mainly concentrates between 60-75 °. Among them, there are 24 faults of the dip is 70 °, accounting for 64.86%; 12 the average dip is 65 °; 1 the dip is 75 °(Figure 4).

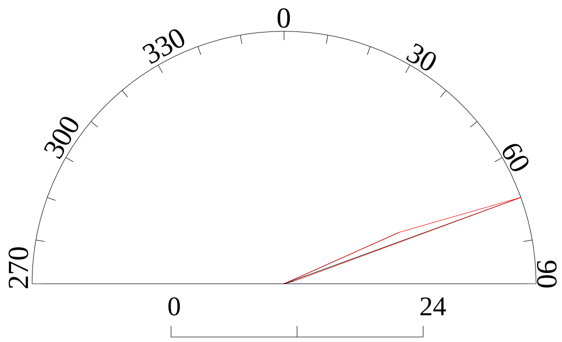

Fig. 4 The fault dip rose diagram of dip over 20m

4. Quantitative Evaluation

How many of the quantitative evaluation indicators of the fault, this paper quantitatively evaluates the developmental characters of the fault from the fault density and fault strength index.

4.1 Fault Density.

The fault density (M) [8] refers to the number of faults in the statistical area, which reflects the degree of development of faults in a certain area. The greater the fault density, the more developed the fault in the area. The formula can be expressive as

$$M=N/S \tag{1}$$

Where M is fault density, $n \cdot km^{-2}$; N is the number of fault; S is the unit statistical area.

Because the No. 3 coal seam is being mined at present, the contour map of fault density of the No. 3 coal seam is drawn on the basis of the outline of the structure. The contour map of the No. 3 coal seam floor is divided into 120 square grid blocks with 500m 500m square. Taking the site at the center of the block and its fault density, and using the Surfer software to draw the contour map of fault density (Figure 5).

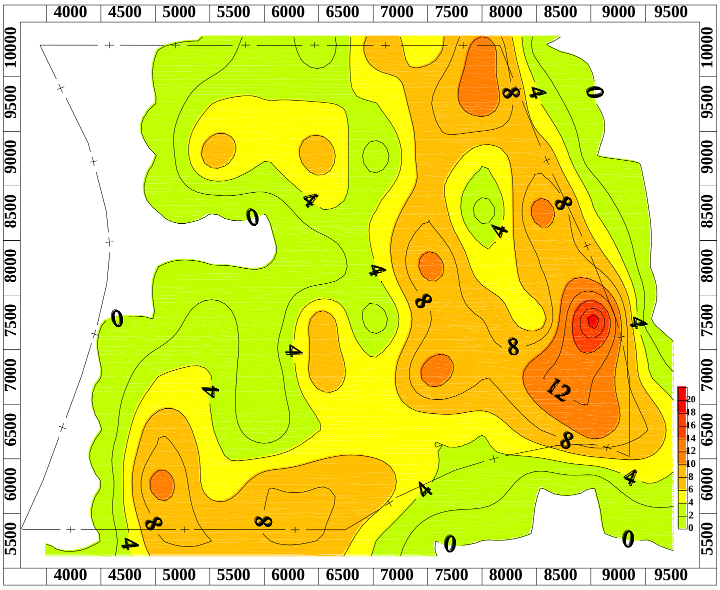

Fig. 5 The contour map of fault density

The fault density contour map shows that the fault density in the middle-east and the north-central region is 0-20n/km^{-2}, the fault is more developed; the fault density in the southwest region is 0-10n/km^{-2}, the fault is more developed; the fault density in the northwest region is 0-6n/km^{-2}, lower degree of fault development.

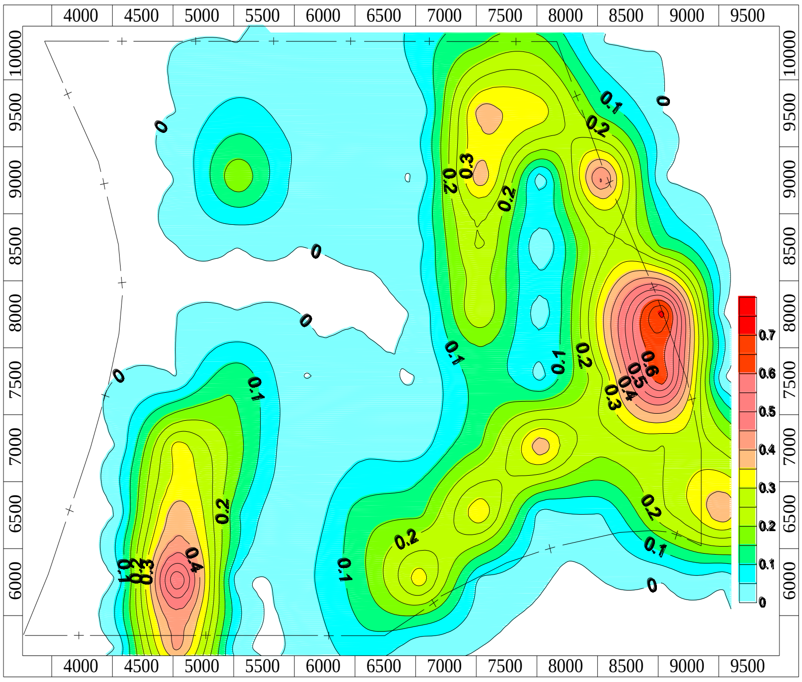

Fig. 6 The contour map of fault intensity index

4.2 Fault Strength Index.

The fault strength index (*F*) refers to the sum product of the horizontal extension length of all the faults in the statistical area and the fault throw, and then divided by the statistical area. Expression as

$$F = \frac{\sum_{i=1}^{n} H_i \cdot L_i}{S} \tag{2}$$

Where F is fault strength index; n is the number of faults in each statistical area; H_i is the i-th fault throw in the statistical area; L_i is the extension length of i-th fault in the statistical area; S is the statistical area.

According to the method of fault density, the surfer software is used to draw the contour map of fault intensity index of No. 3 coal seam (Figure 6).

The contour map of fault strength index shows that the fault strength indexes in the eastern and southwestern are biggest; the east-southern are bigger, and the fault strength indexes in the northwest are small, with lower developmental degree.

5. Conclusion

The fault is more developed in the mine, and the fault throw is mainly <10m, dominated by normal fault, and mainly by NNE and NNW striking. The dip angle is concentrated between 60-70°.

In the middle-eastern part of the mine field, the fault density is bigger, and the fault is more developed; The fault density in the northwest of the minefield is small, and the fault is not developed. In the East and southwest of the area, the intensity index of the fault is larger, and the intensity index is smaller in the northwest.

It is suggested to make a more detailed geological investigation of mine field in the eastern and southwestern regions, in order to further understand the influence of the fault on the production of the mine and take some protective measures.

Acknowledgements

Thanks are due to the financial support of the National Natural Science Foundation of China with grant No. 41572244, the Ministry of Education Research Fund for the doctoral program with grant No. 20133718110004, Natural Science Foundation of Shandong Province with grant No. ZR2015DM013 and the Taishan Scholars Construction Projects.

References

[1] Y.F. Lyu, W. Wang, X.L. Hu, et al. Quantitative evaluation method of fault lateral sealing, Petroleum Exploration and Development, vol. 43 (2016), 340-347.

[2] R. Goyal, P. Chandra, Y. Singh. Fuzzy inferencing to identify degree of interaction in the development of fault prediction models, Journal of King Saud University-Computer and Information Sciences, vol. 29 (2017) , 93-102

[3] P. Li. The analysis and evaluation of geological structure about Xingdong coal mine, Xi'an University of Science and Technology, 2010.

[4] L.Q. Shi, M. Qiu, J. Han, J.C. Wei: Quantitative prediction of mine geological structure (Coal Industry Press, Beijing, China 2010), p. 46-50. (In Chinese)

[5] B. W. Tsai. SURFER (Version 3.00) (Software), Professional Geographer, vol. 40 (1988), 345-347.

[6] Z. Si, S.Y. Li, L.Z. Huang, Y.L. Chen. Visualization programming for batch processing of contour maps based on VB and Surfer software, Advances in Engineering Software, vol. 41 (2010), 962-965.

[7] S.L. Chen, J.Y. Zhang, X.G. Lu. Calculation of rose diagrams, Acta Materialia, vol. 55 (2007), 243-250.

[8] M.O. Elish, M.A. Mohammed. Quantitative analysis of fault density in design patterns: An empirical study, Information and Software Technology, vol. 66 (2015), 58-72.