Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 5, No. 2, 2023

Study on Microseismic Activity Characteristics of Composite Coal Pillar in 21201 Coal Face of Hulusu Mine

Yan Gao[1, *], Chunfu Wei[1], Xiaodong Miu[2], Zhiwen Wang[2], Zhi Liu[2], Chenyang Liu[2], Xinkun Jing[2]

[1]Henan Polytechnic University, Jiaozuo 454000, China
[2]ZTHC ENERGY, Ordos 017000, China

[*] **Corresponding author**: gy17649863799@163.com

Abstract: Hulusu coal mine adopts "121 method" for back mining, and the coal pillar between adjacent workings is 30m. 21102 working have been mined for more than 3 years, leaving the auxiliary return airway has not been repaired for a long time which results in the serious deformation. If employs the adjacent 21201 workings to mine, the cost of reusing the 21102 auxiliary return airway is high. Therefore, the mine dug a new return airway 10m away from the mine, and forming a 45m composite coal column with double coal pillars and double return airways. Based on the ARAMIS M\E microseismic monitoring system, the spatial distribution characteristics of microseismic accidents near the composite coal pillar of 21201 coal face are studied, and explore the quantitative relationship among the retrieval rate of 21201 coal face, the frequency, and energy of microseismic accidents, which provided a theoretical basis and technical support for determining the scientific and reasonable retrieval rate of 21201 coal face.

Keywords: Microseismic Monitoring, Rock Burst, Composite Coal Pillar, Mining Speed.

1. Introduction

Rock burst is a dynamic phenomenon of instantaneous and violent destruction of the coal (rock) body around the shaft or coal face due to the instantaneous release of energy accumulated by elastic deformation. It is often accompanied by the production of coal and rock bodies, making loud noises and airsurge or other phenomena[1,2]. Nowadays, the most serious dynamic disaster of shaft mining around the world is rock burst, which poses a serious threat not only to the normal and high-efficiency running of the mine but also to the relevant staff[3,4], and the probability of rock burst occurring in China is also relatively high[5]. As the conditions under which rock burst occurs are very complex and influenced by many factors such as mining conditions and geological conditions, it is necessary to have deeper understanding in the rock burst prevention and control tech-niques under specific conditions according to the site conditions[6-8].

Microseismic monitoring is a complex and very broad cross-disciplinary technology, in-volving the knowledge of many other disciplines such as geology, rock mechanics, digital signal processing, analog signal and digital signal conversion, and communication sci-ence[9,10]. microseismic accidents are actually a series of dynamic evolution of the sur-rounding rock from stress, strain, to deformation, rupture, and finally destabilization and damage under the influence of external forces and temperature. Microseismic monitor-ing has many advantages that conventional methods do not have, such as 24-hour monitoring, 360° dead-end monitoring, long-distance monitoring, location capture, and unobstructed information transmission. In 1930, the microseismic phenomenon was discovered by two American coal workers in a deep mine by chance, which occurred when the rock body was subjected to external forces. In the 1960s, microseismic moni-toring was used in coal mining in some Western countries to improve the prevention and control of rock burst[11]. The U.S. Bureau of Coal Industry spearheaded a study aimed at making microseismic monitoring technology an effective detection tool for shaft mining. After starting this project, both software and hardware were developed and, during this period, research and field applications of monitoring technology were carried out succes-sively, laying the foundation for subsequent research. Since the mid-1980s, many mines in Canada have experienced many shockdia accidents, and therefore, more than 20 mines were installed with microseismic monitoring systems for uninterrupted monitoring. Since the end of 1980s, Canada has done more research on rock burst, which was initi-ated by the Canadian federal government, the Ontario government, and major mining groups. In recent years, the development of geology and digital signal processing has enabled the rapid development of this technology, microseismic monitoring is also be-coming more and more mature, China has introduced foreign microseismic monitoring equipment since the 1990s, dozens of existing mines have been installed and used, which has greatly improved the ability of prevention and control of mine power disasters, Ac-cording to China's "Safety Regulations in Coal Mine", microseismic monitoring is partic-ularly important in the prevention and control of rock burst, and is also an important to monitor coal and gas protrusion[12].

2. The Overview of the Project

The currently mined main coal seam in Hulusu coal mine is 2-1 coal, which is about 636m deep on average, according to the identification of impact propensity, the coal seam has strong impact, therefore, the mine is able to cause the rock burst, in the process of coal face pushing towards, the motive power has appeared (as presented in Figure 1). 21102 coal face has been mined for more than three years, and there is still 30 meters coal pillar between its coal face's return airway and auxiliary return airway. Now the auxiliary return airway has been basically closed (the gateway is 5 meters wide). At pre-sent, there is 10 meters coal pillar between 21201 coal face newly dug return airway and 21102 vice return airway. In order to guarantee the coal extraction of 21201 coal face, especially to prevent the 45 meters wide coal pillar on the side of the wind tunnel from inducing rock burst caused by the strong dynamic load, it is necessary to study the roof rock structure, stress distribution which is under the condition of 21201 coal face's wide coal pillar and the corresponding technology of preventing rock burst in detail, which is of great significance to ensure the safety of the production process[13].

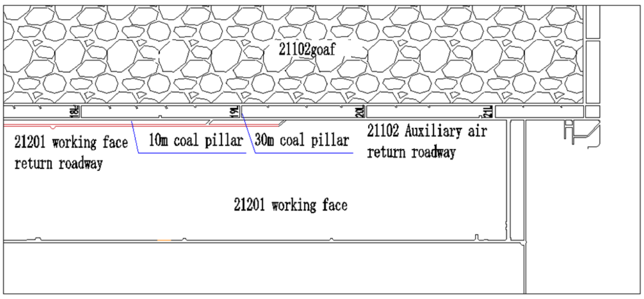

Figure 1. Overview of 21201 Coal Face

3. The Monitoring System of Microseism

The principle of microseismic monitoring is to collect signals through sensors and analyze them to get the location and energy magnitude of microseismic. Although China was the first to conduct microseismic monitoring, the research on this field is later than others. As monitoring equipment was first introduced in Beijing Mentougou Mine, the technology has been developed for 70 years in China since 1959. With the development of science and upgrading of equipment, microseismic monitoring has been developed in different fields. Due to the frequent occurrence of rock burst's accidents, it seems urgent to apply the technology more effectively[14].

Hulusu coal mine has adopted the ARAMIS M\E microseismic monitoring system, and as a regional monitoring measure, Microseismic monitoring system is used to predict the next power disaster through recording the energy of microseismic, determining the direc-tion of the event, and locating the microseismic when they occur. The main function of it is to monitor the mine shaft all day and record the location and energy of the microseis-mic, thus providing a guarantee for mine production and prevention of rock burst[15].

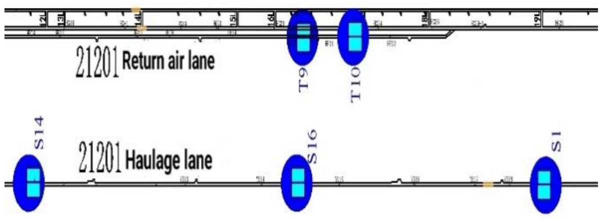

Figure 2. Layout of Microseismic Pickers

4. Analysis of Microseismic in Coal Seam Mining

4.1. Statistical Analysis of Microseismic

There are 210 microseismic accidents that were monitored from March 24 to April 25 in 2022, and among these accidents, there are 40 accidents which is larger than 103, and the statistical of microseismic accidents is displayed in Table 1.

Table 1. Microseismic event statistics

The Position of Coal Face	The Number of Microseismic Accidents on each Energy Level					The Whole Energy Produced by Microseismic on Each Coal Face\$10^5$J
	10^1	10^2	10^3	10^4	Total	
The Front of the Draw-down	19	52	21	1	93	1.10
During the Process of the Draw-down	18	16	4	0	38	0.32
After the Draw-down	27	30	9	0	66	0.42
Total	64	101	39	1	197	1.84

Table 1 shows that when the coal face was advanced to the front of the draw-down, there were 93 microseismic accidents, which occupied 47.2% of the total microseismic accidents; and it has produced 1.33×105J energy, which was 63.9% of the total energy; during the process of the draw-down, there were 38 microseismic accidents that occurred at the coal face, which has occupied 18.1% of the total, and produced 0.33×105J energy, which is 15.9% of the whole; after the draw-down, there were 66 microseismic accidents at the coal face, and the proportion was 31.4%, and it produced 0.43×105J energy, which is 20.7% of the total energy. According to data above, it is sufficient to predict that microseismic accidents in the vicinity of 21201 coal face mainly occurred in the ad-vancement of the coal face before the draw-down. When 21201 coal face was ad-vanced to the front of the draw-down, the occurrence of microseismic accidents was mainly influenced by the special structure of the draw-down, and after the advancement to the draw-down, it was mainly influenced by the mining activities.

According to Table 2, there are 25 microseismic accidents that occurred on the left of the coal face center line, which was 12.7% of the whole; the total energy was 0.67×105J, the proportion is 36.4%; and there is only 1 microseismic accidents which appeared on the coal face center line, and it is 0.5% of the whole; the total event energy was 0.01×105J, which is 0.5% of the total energy; there were 171 microseismic accidents occurred on the right of the coal face center line, and it occupied 86.8% of the total number of micro-seismic accidents; the total energy was 1.16×105J, which is 63% of the total energy; the data mentioned above is sufficient to show that the probability of microseismic that oc-curred from the center line of the coal face to the return airway is much greater than that from the center line of the coal face to the transportation roadway. Therefore, it can be indicated that microseismic accidents mainly occur on the side of the return airway of the coal face.

Table 2. Microseismic Event Statistics

The Position of Coal Face	The Number of Microseismic Accidents on Each Energy Level					The Whole Energy Produced By Microseismic On Each Coal Face\$10^5$j
	10^1	10^2	10^3	10^4	Total	
The Front of the Draw-down	1	13	10	1	25	0.67
During the Process of the Draw-down	0	0	1	0	1	0.01
After the Draw-down	63	84	24	0	171	1.16
Total	64	97	35	1	197	1.84

4.2. The Coal Face Advanced to the Front of the Composite Coal Pillar

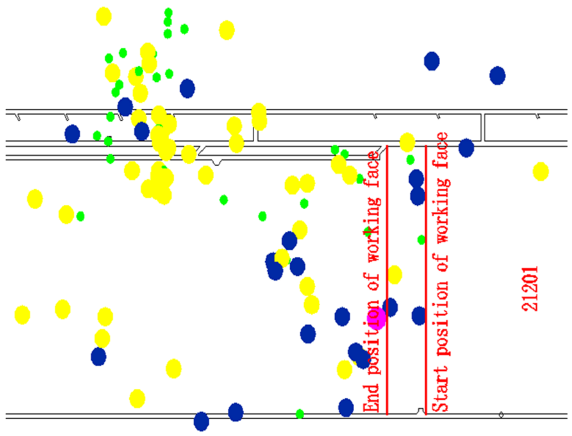

Figure 3. Microseismic Accident Plane Projection Before the Coal Face Advances to the Composite Coal Pillar

Figure 3 shows the plan projection of microseismic before the coal face advances to the composite coal pillar, the location of the coal face draw down is at 472m, and the range of 50m is regarded as the influence range of the coal face draw down. Therefore, the distance of coal face advance on the map is from 420m to 472m, from March 24, to April 9 in 2022. There are 106 microseismic accidents within 50m of the coal face ad-vance, among these accidents, there are 27 accidents that are greater than 103 and one accident greater than 104. According to the microseismic accidents plane projection map, the primary accidents are mainly distributed in the coal face and the side of return air-way, the quadratic accidents are widely distributed and the return airway side has occu-pied the majority of them, and the tertiary accidents are widely distributed while the coal face has occupied the majority.

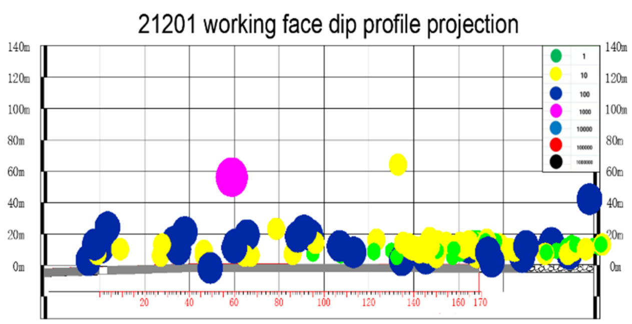

Figure 4. Projection of Microseismic Accident Profile Before Coal Face Advances to Composite Coal Pillar

Figure 4 shows the profile projection of the microseismic accident before the coal face advances to the composite coal pillar. According to the figure, it can be indicated that most of the microseismic accidents are distributed within 30m above the coal face, and a few accidents occur near 60m above the coal face.

4.3. The Coal Face Advances to the Composite Coal Pillar

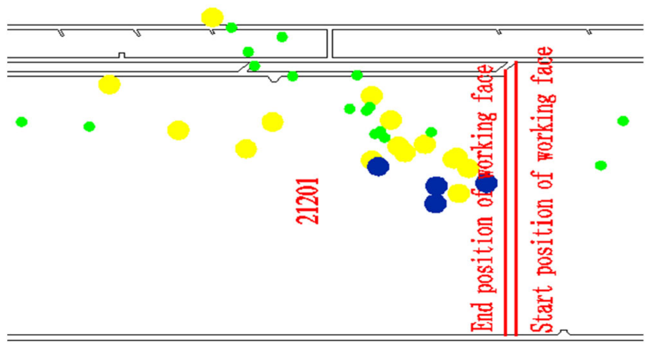

Figure 5. Microseismic Accident Plane Projection When the coal face Advances to the Composite Coal Pillar

Figure 5 shows the plan projection of microseismic accidents when the coal face ad-vances to the composite coal pillar, the location of the coal face draw-down is at 472m, and the end of the inclined connecting lane is at 482m of the coal face, so the distance of the coal face advance on the graph is from 472m to 482m, from April 10, 2022 to April 19 in 2022. There were 38 microseismic accidents within 10m of the coal face ad-vance, including 4 accidents greater than 103 and no event greater than 104. In terms of the microseismic accidents plane projection map, it can be indicated that the primary accidents are mainly distributed on the coal face and the return airway side, and the quadratic and tertiary accidents are mainly distributed on the coal face.

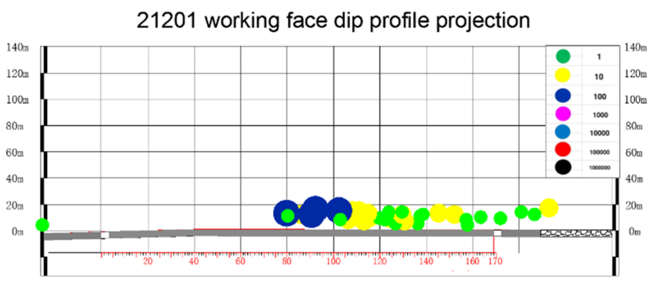

Figure 6. Profile Projection of Microseismic Accident when Coal Face Advances to Composite Coal Pillar

4.4. After the Coal Face Advances to the Composite Coal Pillar

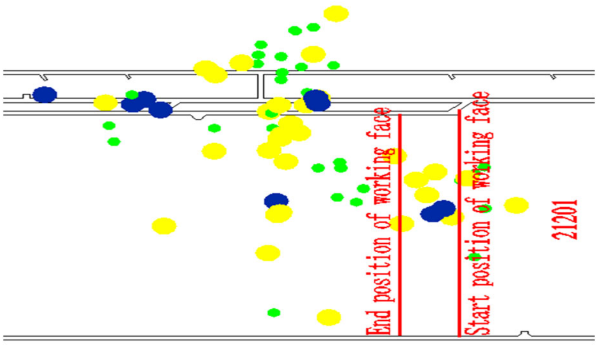

Figure 7. Microseismic Accident Plane Projection After the Coal Face Advancing to the Composite Coal Pillar

Figure 7 shows the microseismic accidents plan projection after the coal face advances to the composite coal pillar, the end of the coal face draw-down is at 482m, and the range of 50m is chosen as the influence range of the coal face draw-down. Therefore, the distance of coal face advance on the map is from 482m to 530m, from April 20 to April 25 in 2022. There are 66 microseismic accidents within 50m of the coal face advance, including 9 accidents greater than 103 and no event greater than 104. From the micro-seismic accidents plane projection map, it can be seen that the primary accidents were mainly distributed at the coal face and the return airway side, the quadratic accidents were mainly distributed at the coal face, while the tertiary accidents were mainly distributed at the coal face and the return airway side.

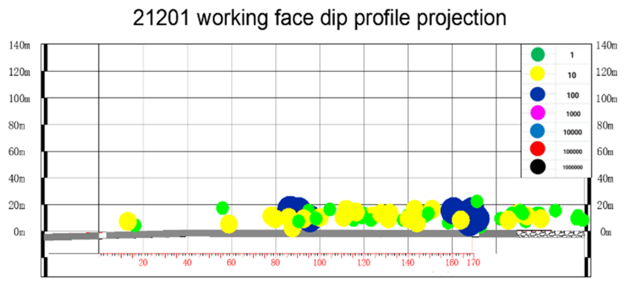

Figure 8. Projection of Microseismic Accident Profile After Coal Face Advancing to Composite Coal Pillar

Figure 8 presents the plane projection of microseismic accidents after the coal face is advanced to the composite coal pillar. It can be indicated that all microseismic accidents occurred within 20m above the coal face, and there are much more microseismic acci-dents that near the return airway than those near the transportation roadway.

5. The Relationship between Microseismic and Coal Face Ad-vancement

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your journal for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper.

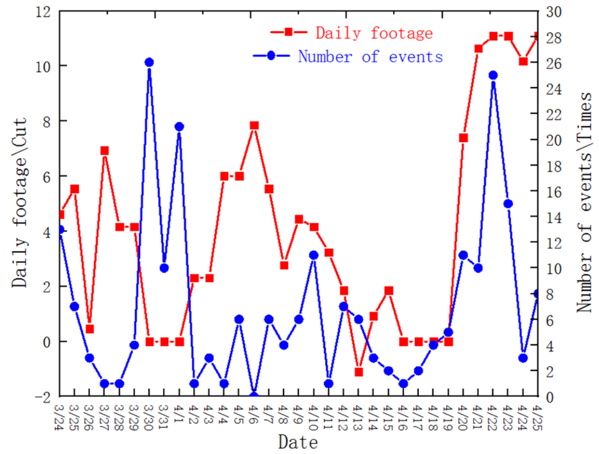

Figure 9. The Relationship between Footage and the Frequency of Accident

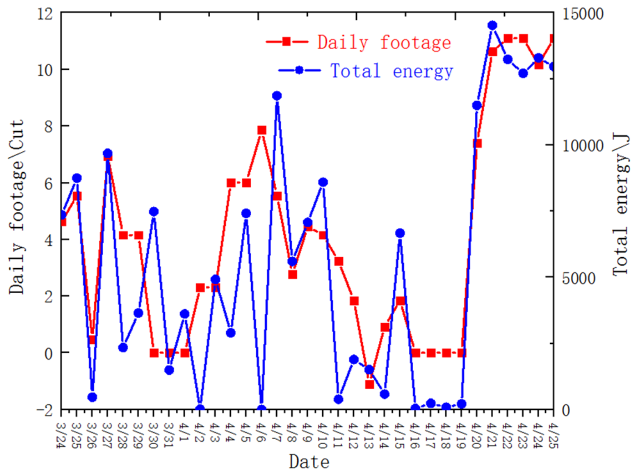

Figure 10. Relation between the Footage and Total Daily Energy

According to Figs. 9 and Figure 10, it can argue that there is a certain relationship among the daily feed and the frequency of microseismic accidents, the released energy, and the average energy released. There is certain hysteresis of frequency of microseismic acci-dents, the total energy released, and the average energy released, and they always change with the change of pushing mining speed. When the daily feed is greater than 8 cuts, the frequency, total energy and average energy of microseismic accidents will in-crease with the increasing of pushing speed, and when the daily feed is less than 8 cuts, the occurrence of microseismic accidents is less influenced by the pushing speed of the coal face, and the impact hazard is less influenced by the pushing speed. Moreover, when the daily feed is greater than 8 cuts, the occurrence of microseismic accidents is in-fluenced by the advancing speed of the coal face, and the advancing speed has a greater effect on the impact hazard, and the advancing speed is one of the main reasons af-fecting the rock burst of the coal face at this time

6. Conclusion

(1) As shown by the microseismic monitoring data, there were 93 microseismic accidents before the draw-down, which has occupied 47.2% of the total accidents. Therefore, mi-croseismic accidents mainly occurred in the area before the coal face draw-down during the process of coal face advancement to the draw-down.

(2) The microseismic monitoring data showed that the microseismic accidents on the coal face of 21201 mainly occurred on the coal face and the side of the coal face return airway, among which 171 microseismic accidents occurred to the right of the coal face center line, which is 86.8% of all accidents. It is mainly affected by the superposition of lateral support stress in 21102 mining area and the support pressure of 21102 sub return coal column.

(3) Before the coal face advanced to the composite coal pillar, 23 large microseismic en-ergy accidents (>103) occurred, and the proportion is 57.5%. The large microseismic en-ergy accidents were concentrated on the coal face, and there were a few microseismic accidents in both the transport roadway and the return airway.

(4) There is an obvious positive correlation among the length of a pull and the frequency of microseismic accidents, the total energy, and the average energy, and this phenomenon increases obviously when the daily length of a pull exceeds 8 knives. When the av-erage pushing speed is below 8 cuts, the total energy of microseismic accidents does not exceed 10,000 J. Therefore, it is recommended to maintain a reasonable pushing speed.

(5) In the vicinity of the inclined connecting drift, the main factor that influence the mi-croseismic accidents is the geological structure of the inclined connecting drift itself, and the main influencing factor in the rest of the coal face is the speed of its advance.

References

[1] Anye, C., Linming, D., and Yuhong, Qin et al. (2007) Technical achievements and prospect of microseismic monitoring of rock burst. Coal Mining,01, 20-23.

[2] Qiu P, Ning J, Wang J, et al. (2021) Mitigating rock burst hazard in deep coal mines insight from dredging concentrated stress: A case study. Tunnelling and Underground Space Technology incorporating Trenchless Technology Research, 115.

[3] Linming, Dou. Xinyuan, Tian. and Cao Anye, et al. (2022) Present situation and problems of rock burst prevention in coal mines in China. Journal of Coal,47(01), 152-171.

[4] Wang J, Wang E, Yang W, et al. (2022) Rock burst monitoring and early warning under un-certainty based on multi-information fusion approach. Measurement, 205.

[5] Qingxin, Qi. (2021) Guest editor of "Mine Rock Burst Prevention Technology and Engineering Practice" addressed to readers. Coal Science and Technology, 49(06), 2.

[6] Xiangjun, Meng., Xiufeng, Zhang. and Qingxin, Qi et al. (2019) Occurrence mechanism and key prevention technologies of rock burst in Ordos deep mining area..

[7] Chen, Y., and Zhang J, Chen J, et al. (2022) Special Issue: Rock Burst Disasters in Coal Mines. Energies, 15(13),

[8] Liang, Yuan and Qingxin, Qi. (2020) Invited editor-in-chief of the album "Research on Risk Identification, Monitoring and Early Warning Technology of Typical Coal Mine Dynamic Dis-asters" and "Research on Prevention and Control Technology of Coal Mine Deep Mining Rock Dynamic Disasters" addressed to readers. Journal of Coal Science, 45(05), 1555-1556.

[9] Zhigang, Deng. (2013). Rock burst monitoring technology based on ARAMIS M/E micro-seismic monitoring system. Coal Mine Safety, 44(05), 105-107.

[10] Shengshi, Meng., Yining, Zheng. and Xiangding, Hou. (2018) Study on optimal design of ARAMIS M/E microseismic monitoring network in Guotun Coal Mine. Shandong Coal Science and Technology, 08, 181-184.

[11] Qingguo, Sun., Cunwen, Wang. and Fuxing, Jiang . (2007) Application of microseismic mon-itoring system in rock burst prediction. Coal Mine Safety, 12, 55-57.

[12] Fengqin, Li., Xingmin, Zhang. and Jiang Fuxing. (2006) Coal mine microseismic monitoring system and its application [J]. Coalfield Geology and Exploration, 04, 68-70.

[13] Du Taotao. Joint monitoring technology of microseismic fluctuation in coal mine with rock burst. Coal Mine Safety, 53(07), 92-98.

[14] Yan Li., Huanwei,Wei. and Haibin, Wu et al. (2017) Study on microseismic activity character-istics of Xinhe Mine based on ARAMIS M/E monitoring system. Coal Mining, 22(05), 78-80.

[15] Yike, Lu. (2022) Study on ground microseismic monitoring and prediction of rock burst in a mine of 1000 meters deep in Liaoning. Liaoning University.