

# Analysis of Early Warning Information of Impact Mineral Pressure By Microseismic Monitoring of Cutting Top and Unloading Pressure Along The Air-retained Roadway

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**Abstract:** Taking the return air lane of 8201 working face of a mine as the research object, statistically analyze the microseismic monitoring and the change of mine pressure data before the occurrence of the impact mine pressure accident in the process of mining back. Summarize the cut top pressure along the empty stay in the case, microseismic monitoring impact pressure early warning information law, as a similar condition of the mine under the impact pressure prevention and control basis. The corresponding prevention and control measures have been proposed and implemented, and good control effects have been achieved. These measures effectively guarantee the safe production of coal seam mining.

**Keywords:** Microseismic monitoring; Impact mine pressure; Stay along the airway.

## 1. Introduction

Impact mine pressure refers to the change in the distribution of geological stress in the mine triggered by the movement of the workings in the direction of the underground ore body in the process of coal mining, which leads to sudden and violent rupture and deformation of coal and rock seams, and is usually accompanied by the release of huge energy. Impact mine pressure is one of the main causes of coal mine accidents, as well as an important bottleneck that restricts the efficiency and safety of coal production. In order to prevent and mitigate the hazards caused by impact mine pressure, it is necessary to carry out in-depth research on the mechanism of its generation, and at the same time take corresponding prediction, monitoring and management measures to improve the safety and efficiency of coal production.

Coal pillar-free roof-cutting and pressure-removing along-air retention technology is a new type of coal mining technology, which is the development of traditional retention technology. Years of research and industrial practice have proved the high efficiency of this technology. The "110" and "N00" methods proposed by Academician He Manchao's team in recent years have revolutionized the technology of coal-free pillar along-channel technology, which can reduce the incidence of coal mine accidents and improve the efficiency and economic benefits of coal mining. [1] The "110" and "N00" methods have revolutionized the technology of no-pillar along-road technology in recent years, reducing the occurrence of coal mine accidents and improving the efficiency and economic benefits of coal mining.

## 2. Overview of the Working Face

8201 working face is the first working face of No.8 seam in No.2 mining area of a mine, No.3 coal seam is being mined on top of No.8 seam, No.7 seam has been mined, and No.11 seam has been mined in the lower part of No.8. 8201 working face has a mineable length of 730m, with an inclined length of 81m. 8201 working face has a working face of 8202 in the northern part, the former mining empty area in the southern

part, the No.8 seam disk area alley in the western part, and the boundary of the field in the eastern part. 8 seam lies in the middle of the Datong Formation strata, 9.37~11.97m away from No.7 seam. The No.8 coal seam is located in the middle of the stratum of Datong Group, and the upper distance from the No.7 coal seam is 9.37-11.97m, average 10.26m. The thickness of the No.8 coal seam is 0.83-1.90m, average 1.10m, and the inclination angle is 1-5°, average 3°.

In order to cancel the protection of coal pillars between the working faces, reduce the loss of coal resources, improve the extraction rate of the mine, increase the mine's recoverable reserves, enhance the economic benefits of the mine, and extend the service life of the mine. The mine in the No. 8 layer of the upper and lower stirrups in the case of cutting the top of the pressure along the air to stay in the program. 8201 face in the early mining process along the air to stay in the area of the accident occurred many times impact mine pressure manifestation, 410 ~ 450m occurred in the coal wall of the large area of the slice of the gangs, the bottom of the bulge, the roof plate is broken, the anchor rods and anchors pulled off the phenomenon of great safety hazards, a serious impact on the mine's safe production.

## 3. Microseismic Monitoring Principles and Programs

### 3.1. Principles of microseismic monitoring and localization

Microseismicity refers to the process of rapid release of localized energy in the form of parabolic elastic waves when a material such as a rock mass is subjected to external forces and temperature. Microseismic signals are recorded and processed by sensors, and signal data are analyzed by combining with computer technology to infer and analyze the characteristics of the earthquake source and obtain geological information. Microseismic monitoring technology is based on the development of seismic monitoring technology and acoustic emission monitoring technology [1], which both utilize the principle of elastic waves generated by the rock

body when it is damaged by force. In the process of microseismic monitoring, P-wave localization technology is used to determine the location of the earthquake source. This is because P-waves propagate the fastest in the rock mass and the first arrival time is easy to recognize. In practice, P-wave localization requires the deployment of monitoring stations in at least four different locations, the measurement of the first arrival time of the P-wave at the monitoring point P1 P2 P3 P4  $t_i$ , and the distance from the point q of the earthquake source S1 S2 S3 S4, and assuming that the rock mass is a uniform velocity model and the P-wave propagation velocity is known. The location of the earthquake source can be determined by calculation.

$$\begin{cases} S_i = V(t_i - t_0) \\ S_i = \sqrt{(z_i - z_0)^2 + (y_i - y_0)^2 + (x_i - x_0)^2} \end{cases}$$

( $i=1,2,3,4$ )

In the system of equations, the first arrival time of the P-

wave  $t_i$  ( $i=1,2,3,4$ ) and the average propagation velocity of the sound wave  $V$  are known, and the system of equations can be solved to find the starting moment of the source of the earthquake,  $t_0$ , and the coordinates of the source of the earthquake ( $x_0, y_0, z_0$ ), which can be used to obtain the location of the source of the earthquake. [2] The location of the source can be obtained by solving the equations.

### 3.2. Microseismic monitoring program

In order to monitor the microseismic events in the process of roof-cutting and depressurization without coal pillar mining, based on the principle of microseismic localization, the experiment designed the following sensor arrangement: on the basis of the underground field investigation, each sensor is spaced at an interval of 80m, and 8 sensors are arranged in each of the stay-channel roadway and the rubber transporting tunnel roadway to form a balanced and symmetrical distribution state overall. [3] The overall distribution is balanced and symmetrical, as shown in Figure 1.

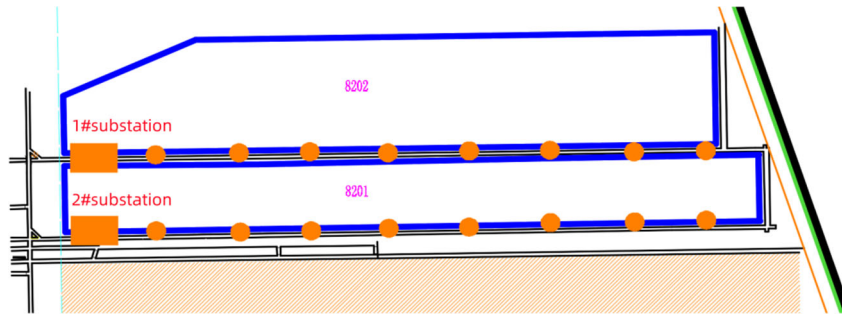


Figure 1. Arrangement of microseismic sensor measurement points

The 8 sensors are arranged in 3 layers vertically on the top-cut side of the stay-along roadway, and ensure that they are arranged in the relatively stable rock layer of the top-cut cantilever beam. This arrangement can stabilize the work during the face mining period and effectively monitor the microseismic events generated. [1] The specific arrangement is shown in Figure 2. See Figure 2 for details of the arrangement.

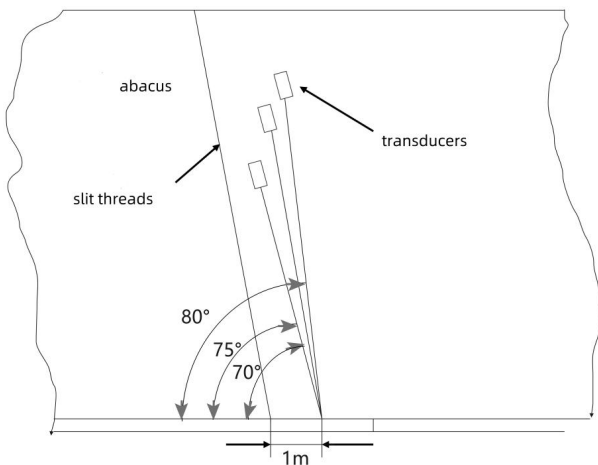
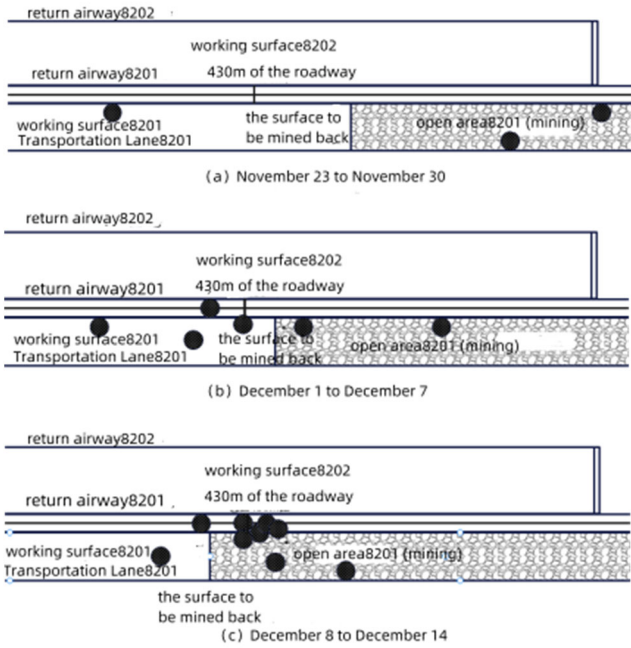


Figure 2. Detector tunnel layout

### 4. Early Warning Law of Impact Mineral Pressure Along the Air Retained Tunnel

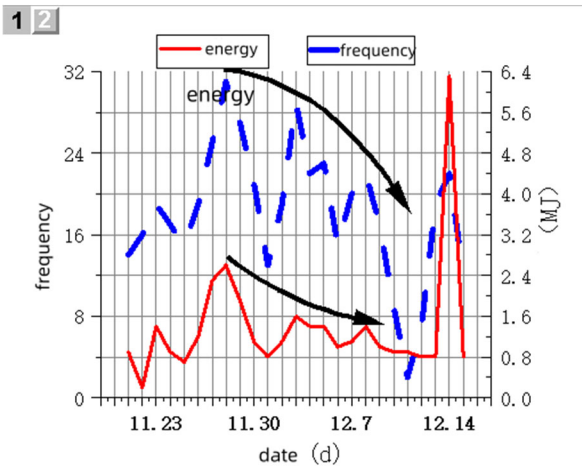
At 10.45 p.m. on December 14, 2022, a shock accident occurred in the section of 8201 working face along the empty stay lane, the energy of the shock source reached  $1.8 \times 10^6$  J, the bottom drum appeared in the section from 415 to 430m, about 600mm, the top plate at 410 and 450m was severely broken, the steel mesh net sheet was cracked, the tape racks were scattered, and the top plate was sunk about 200mm, due to the early warning, there were no casualties and equipment damage. Because of the early warning, there were no casualties and equipment damage. The positioning of the shock source before the occurrence of the impact mineral pressure, the change of the total daily energy frequency of the microseismic, the impact deformation energy, and the change of the mineral pressure all gave obvious precursor information.

Between November 23rd and December 14th, 2022. The distribution of source localization of large energy microseismic events (greater than 10 to the 5th power J) every 7 d is shown in Fig. 3, from which it can be seen that the large energy events are relatively small and scattered at the beginning, but with the passage of time, the large energy events gradually increase and converge at 430 m along the empty stay lane, and are eventually released suddenly to trigger the impact accident.



**Figure 3.** Spatial distribution of seismic sources in the 8201 working face

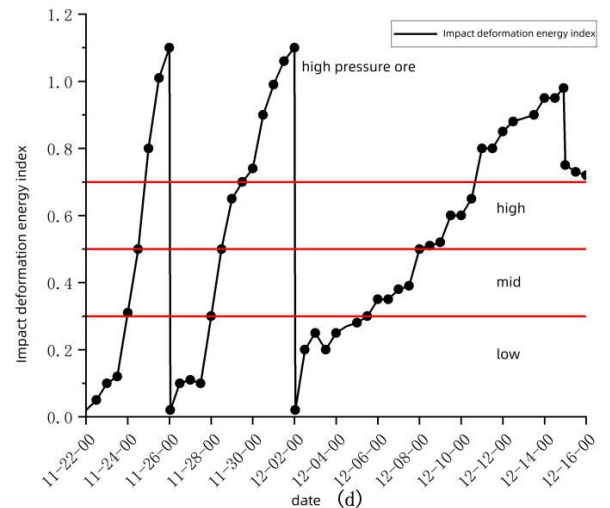
During the period from November 15 to December 14, 2022. The trend of the total daily microseismic energy and frequency of the 8201 working face is shown in Fig. As shown in Fig. 4, the total daily microseismic energy is periodically increased but the overall trend is decreased in the period before the impact accident, which can be seen that this period is a period of energy accumulation with a high stress concentration.



**Figure 4.** Variation of daily total energy frequency in 8201 working face

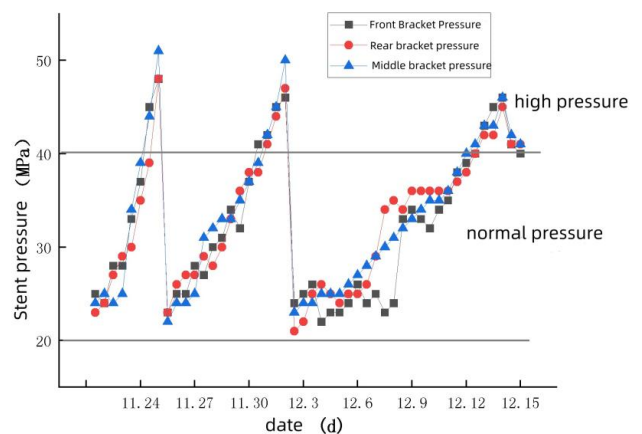
The impact deformation energy index from November 23 to December 14, 2022 is shown in Figure 5, from which it can be clearly seen that the impact deformation energy is cyclically increasing and decreasing, but in the 13 days from December 2 to December 14, the impact deformation energy index is increasing slowly and the cycle is getting longer, which indicates that the energy of the 8201 working face is gathering, and it is in the state of high danger and strong mine pressure for 4 consecutive days since December 10, and it decreased on December 14, but it did not drop to the lowest state directly as before, but it was close to one day in the

strong danger state, and then suddenly had an impact mine pressure accident. Since December 10th, it has been in high danger and strong mine pressure for 4d consecutively, and it was reduced on December 14th, but it did not drop to the lowest point directly as before, but it was in strong danger for nearly one day, and then the impact mine pressure accident occurred suddenly, so it can be seen that the continuous peak of the impact deformation energy index or the abnormal change predicts the occurrence of the impact mine pressure accident.



**Figure 5.** Impact deformation energy index of working face

During the period from November 23, 2022 to December 14, the pressure change of the hydraulic strut in the working face is shown in Figure 6, which shows that the cycle of incoming pressure has an increasing trend, and the peak value of incoming pressure has a decreasing trend, and according to the actual production situation, it can be derived from the three cycles of incoming pressure step, as shown in Table 1. From Table 1, it can be clearly seen that the cycle to pressure step gradually increased, indicating that the energy accumulation can not be released, there is a high stress concentration, which ultimately led to the occurrence of impact accidents.



**Figure 6.** Pressure diagram of working face support

**Table 1.** Cyclic pressure step change table

time period	Cyclic pressure step/m
November 23rd to November 25th	16
November 26 - December 1	27
December 2 - December 14	61

Through the above analysis on the positioning of the seismic source before the impact accident, the change of the total energy and frequency of microseismic events, the impact deformation energy, and the change of the mine pressure, we can draw the following points as the early warning information for the occurrence of a strong mining quake along the open channel of the cutting roof and unloading pressure: before the occurrence of a strong mining quake, the large-energy microseismic events will be gathered towards the vicinity of the source of the quake center, and the overall trend of energy and frequency of microseismic events is decreasing, and the peak of the impact deformation energy indexes is persistently peaked or abnormally varied. The peak value of the cycle pressure is decreasing and the step of the cycle pressure is obviously increasing. [4] [5] The energy and frequency of microseismic events tend to decrease.

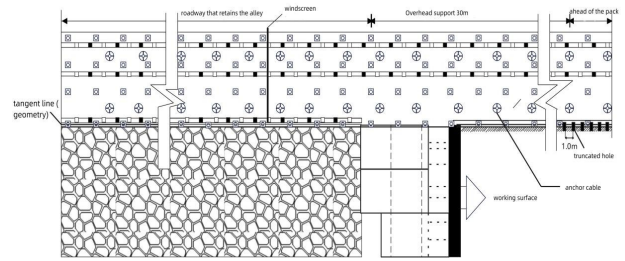
## 5. Control and Effectiveness Testing

### 5.1. Control

According to the theory of cutting the top and releasing the pressure and leaving the lane along the air, the factors of impact ground pressure in this mine are mainly due to the insufficient cutting of the top and the failure to form a continuous and effective slit surface. Therefore, temporary strengthening support measures are proposed.

The dynamic pressure influence on the surrounding rock of the roadway is not only reflected in the static force, but also includes the dynamic influence of the movement of the overlying rock layer on the surrounding rock. In the area of intense dynamic pressure influence, in order to temporarily strengthen the support, 2.8m suspended monolithic hydraulic pillars are used. The bearing capacity of each mono-pillar is 250kN, and the row spacing of the roof-cutting row is 0.5m, and the row spacing of the other row is 1.0m, with a maximum working resistance of 750kN. However, the effect of the roof-cutting may be affected to a certain extent due to the drilling bottoming problem of the mono-pillar in the overrun section. In order to solve this problem,  $\Phi 15.24\text{mm} \times 6000\text{mm}$  anchor cable is used for supplementary support near the side of the empty stay lane.

In order to enhance the stability of the roof-cutting row, temporary reinforcement of the support can be carried out by using mono-pillar articulated roof beam support. The articulated roof beam should be arranged along the axis of the roadway, the length of 1200mm, the shape of the iron shoe can be round or square, the diameter or length of the side should be 40cm, in order to ensure the effect of cutting the top of the iron shoe under the floating gangue must be cleaned up to the solid bottom. In addition, the use of monolithic pillars instead of end brackets for support can reduce the impact of end brackets on the roof plate of the stay lane when repeatedly supported. Temporarily strengthen the support schematic as shown in the figure [6] [7] The diagram of temporary strengthening support is shown in the figure.



**Figure 7.** Schematic diagram of temporary reinforced support

According to the program of cutting the top and unloading the pressure, the theoretical calculation of the permanent support strength of the roadway has a large surplus coefficient, and the support strength is sufficient to ensure the stability of the roadway along the air to stay in the roadway. However, in the actual visit to the well, it is found that because of the drilling problem of the monolithic pillar in the over-anterior section, the effect of cutting the top is greatly affected, and a continuous and effective slit surface is not formed. In order to ensure the effect of roof cutting, it is necessary to use anchor ropes for reinforcement support near the side of the empty stay roadway. The anchor cable specification is  $\Phi 15.24\text{mm} \times 6000\text{mm}$ , between two rows of anchor cables, a single arrangement, 1500mm away from the side of the roof cut.

### 5.2. Effectiveness testing

According to the analysis of the mine pressure observation data, the deformation of the roadway along the air retaining lane during the subsequent mining process is within the safe range.

(1) Analysis of supporting monolithic hydraulic pillars: the maximum force of the monolithic monolithic hydraulic pillars in the 8201 lane is 3,750 KN, and the monolithic hydraulic pillars are subjected to a more average force, and the maximum sinking amount is 200mm.

(2) Analysis of anchor anchoring delamination amount: the delamination inside and outside of anchor anchoring have been stabilized, there are 14 places in the range where the delamination amount is 0, and the maximum delamination amount of the remaining 8 places is 15mm, and the maximum delamination amount of 1 place outside the range is 60mm, and the other places are smaller. The roof subsidence is within the safe range.

(3) The displacement of the top plate off-layer observer: a set of off-layer observers is set up on the side of the 410~450m roadway mining area along the 8201 hollow stay lane. Deep base anchor head The deep base point anchor head is fixed at 5m in the deep part of the drilling hole, and the shallow base point is fixed at 2.5m in the drilling hole, and the total displacement is 55mm after observation, which has been stabilized.

## 6. Summarize

(1) According to the principle of microseismic monitoring and the principle of optimized arrangement, this paper arranges the microseismic monitoring system in the working face of cutting top and unloading pressure along the hollow stay, collects and statistically analyzes the microseismic mine pressure early warning information of the impact pressure accident before the occurrence of the impact pressure accident

in the section of the hollow stay, which can be used as the basis for the prevention and control of the impact pressure in the mines under the similar conditions.

(2) According to the theory of cutting the top and unloading the pressure along the air to stay in the roadway and the law of micro-seismic monitoring of the mining pressure, the temporary strengthening of the support measures along the air to stay in the roadway section, after the later test in the process of mining back to the roadway to stay in the roadway situation is stable, the impact of the risk of mining pressure is significantly reduced, the prevention and control effect is very significant, no impact on the occurrence of accidents in the mining pressure.

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