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Research Article

Case Study of the Characteristics and Mechanism of Rock Burst near Fault in Yima Coalfield, China

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Deep mining near faults may easily cause rock bursts, which seriously threaten mining safety. Based on the engineering background of deep mining near fault in Yima coalfield, by collecting the rock burst events that happened near fault during deep mining, the correlation between fault structure and time-space features of rock burst was analyzed. The results show that the deep rock burst accounts for 84% in Yima coalfield at 600 m and 93% in the mining area within 1000 m from F16 fault. The risk of rock burst is positively correlated with mining depth and negatively correlated with the distance between mining area and F16 fault, and the frequency and intensity of rock burst near F16 fault increase significantly. Rock burst occurs in high stress concentration area, mainly in roadway, releasing energy level of 1.1×10^4 J–3.5×10^8 J, with impact damage range of 60–500 m. The mechanism of rock burst was explained from the view of the distribution of mining stress in surrounding rock. The stress of coal seam in deep mining near fault increases, and the disturbance effect of fault is obvious. Rock burst is easy to be induced under static and dynamic loads. The occurrence and mechanical characteristics of fault have different effects on rock burst and should be considered when evaluating the risk of rock burst.

1. Introduction

Rock burst is a dynamic phenomenon due to the sudden and instantaneous release of elastic energy in the surrounding rock, which poses a great threat to the safety of underground personnel and the operation of equipment [1–3]. However, the mechanism of rock burst is extremely complex. The traditional rock burst theory including strength theory, stiffness theory, and energy theory cannot fully explain and predict rock burst. So far, the mechanism of rock burst is still unclear [4–8]. Mining conditions, geological structure, and stress state of surrounding rock are the major objective factors that determine the risk of rock burst [9–12]. Their single or combined action can cause obvious changes in rock burst type and risk degree. Almost every rock burst event has different geological and mining conditions, which need to be explained by corresponding theories. The mechanism of rock burst can be further understood by counting the previous rock burst events and summarizing the basic conditions of their occurrence. Rock bursts are either mining induced or dynamically induced [13]. Understanding rock burst source mechanisms is critical for the prevention and control of rock burst in site.

Yima coalfield is one of the most serious areas affected by the rock burst disaster in China. With the increase of mining depth and intensity, the risk of rock burst is becoming increasingly prominent. When mining activities near faults, rock bursts or strong tremors are happening more frequently. For example, on 22 February 2020, a rock burst occurred in the Xinjulong coal mine, resulting in four deaths. On 9 June 2019, a rock burst occurred in Longjiabao coal mine, resulting in nine deaths. These rock burst accidents are both related to mining induced fault slip. Research on the rock burst occurrence rule near fault structure in deep mining is necessary to safety production. Many attempts have been made to understand the mechanism of rock bursts in Yima coalfield. According to the results of microseismic monitoring, fault activation can be divided into stress appearance stage, energy storage stage, and structural activation stage [14]. The mechanical genesis of the Yima thrust structure was studied comprehensively using geomechanics, fault mechanics, elastic mechanics, and Coulomb's law of friction [15]. By employing physical and numerical simulation, the stress evolution around the F16 fault is analyzed. Normal stress is relatively greater than shear stress on the fault plane, and the normal and shear stress on the fault plane near the coal seam are greater than that far away from the coal seam [16]. Xu et al. [17] analyzed the occurrence law of rock burst from the geological perspective and delineated the high-risk rock burst area in Yima coalfield. Zhao [18] took F16 thrust fault as the engineering background and studied the overlying strata movement characteristics, strata behavior law, and dynamic response characteristics before and after fault activation. Lu et al. [19] established a simplified mechanical model based on the structural characteristics of F16 fault and analyzed the distribution characteristics of fault additional stress. Wu et al. [20] measured the in situ stress of the Yima deep mining area by the hydraulic fracturing method and analyzed the in situ stress of the Yima deep mining area stress distribution law.

It can be seen that the F16 fault is the main geological structure, which has an important role in the occurrence of rock burst in Yima coalfield. However, the geomechanical properties of faults tend to be complex, so it is difficult to accurately grasp the mechanical properties and stress state of faults, which restricts the study of related theory and numerical simulation. Through the cases of rock burst near the fault area, this paper analyzes its appearance characteristics and then reveals the mechanism of fault structure on coal mine rock burst so as to provide theoretical reference for deep mining near fault to preventing rock burst.

2. Geological Structures of Yima Coalfield

Yima coalfield is located in Sanmenxia City of Henan Province, China. The coalfield is 24 km long from east to west and 3–7 km wide from south to north and covers a total area of 110 km^2. The coal seam is concealed outcrop in the north, F16 thrust fault in the south, and subsidence boundary in the east and west. The mine distribution of Yima coalfield is shown in Figure 1.

The coal seams in the Yima coalfield were deposited during the Mesozoic Jurassic and contain two groups of mineable coal seams with five layers in total. No. 1 coal seam includes the 1-1 and 1-2 layers, and No. 2 coal seam includes the 2-1, 2-2, and 2-3 layers. No. 2 coal seam is distributed across the entire coalfield and is the main mineable coal seam. The three layers gradually merge together, and the 2-1 and 2-2 layers finally merge with the 2-3 layer. The ground elevation of the Yima coalfield ranges from +415 to +670 m above sea level, and the terrain is high in the west and low in the east. As shown in Figure 2, the No. 2 coal seam has a dip of 10–15° with the immediate roof is mudstone and sandy mudstone; the floor is coal mudstone interbedding and carbonaceous mudstone.

After continuous mining over years, the coal resources in the shallow section have been exhausted while the deep area near the F16 fault contains abundant coal resources with total reserves of approximately 43,680,000 tons. Mining activities have transitioned to the deep coal seams in Yima coalfield (with average mining depths exceeding 600 m and maximum mining depths reaching 1,060 m). Figure 3 presents the mining depth of Yangcun mine is 400 m–600 m, Qianqiu mine is 750 m–980 m, Gengcun mine is 500–650 m, Yuejin Mine is 650 m–1060 m, and Changcun mine is 600 m–800 m. When the coal seam reaches a certain depth, the energy of accumulation is much higher than that of the shallow part. The frequency and intensity of rock burst increase significantly.

F16 fault is the most significant geological structure in Yima coalfield. It is a large compression torsion thrust fault, which is basically consistent with the strike of the coal seam. The deep mining of Yima coal field is controlled by its distribution. Table 1 summarizes the influence of F16 fault on the mining engineering of each mine.

Rock bursts that have occurred in Yima coalfield have the following characteristics:

(1) All mines in Yima coalfield have experienced rock bursts. Rock bursts in Qiuqian and Yuejin mine occurred earliest and are the most serious. In recent years, rock bursts in Gengcun mine and Changcun mine showed an increasing trend. Due to the complicated geological conditions and mining near F16 fault, the shallow Yangcun mine (average mining depth 500 m) also suffered from rock burst, but the damage caused by rock burst is relatively light.

(2) Due to the effects of the large geological structure, the disturbances caused by mining activities in adjacent mines are significant. For instance, the mining activity in the eastern area of Gengcun mine and in the No. 21 mining area of Qianqiu mine (the "12.22" rock burst accident occurred in Gengcun mine in 2015) interact with each other, and mining activity in the No. 21 mining area of Changcun mine and in the No. 23 mined-out area of Yuejin mine also interact with each other [21].

3. Characteristics of Rock Bursts near Faults in Deep Mining

According to statistics from 2006–2015, 112 destructive rock burst accidents have occurred in Yima coalfield [22]. Since 2016, Yima coalfield has no more disastrous rock burst accidents, but the risk of rock burst is serious, and the concept of giving priority to rock burst prevention has always been implemented in production. A large number of rock burst events in Yima coalfield were further screened, in order to study the characteristics of rock bursts near fault in deep mining.

3.1. Location of Rock Bursts. A statistical analysis of the rock burst locations shows that 18 rock burst events occurred above mining depths of 600 m, which represent 16% of the

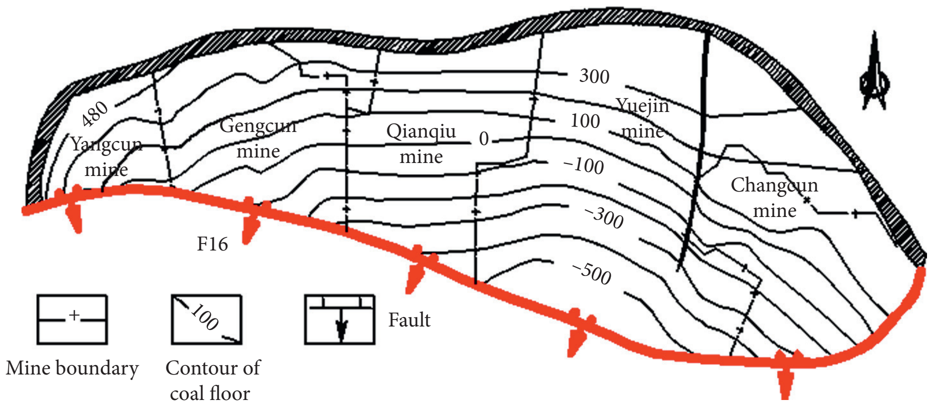


FIGURE 1: Mine distribution of Yima coalfield.

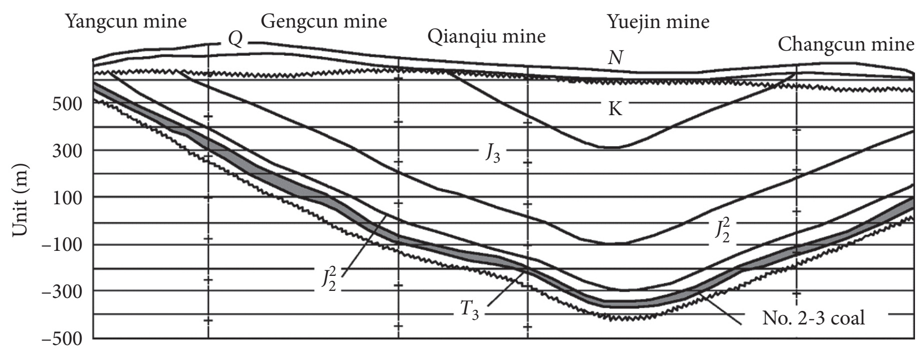


FIGURE 2: Geological profile of Yima coalfield.

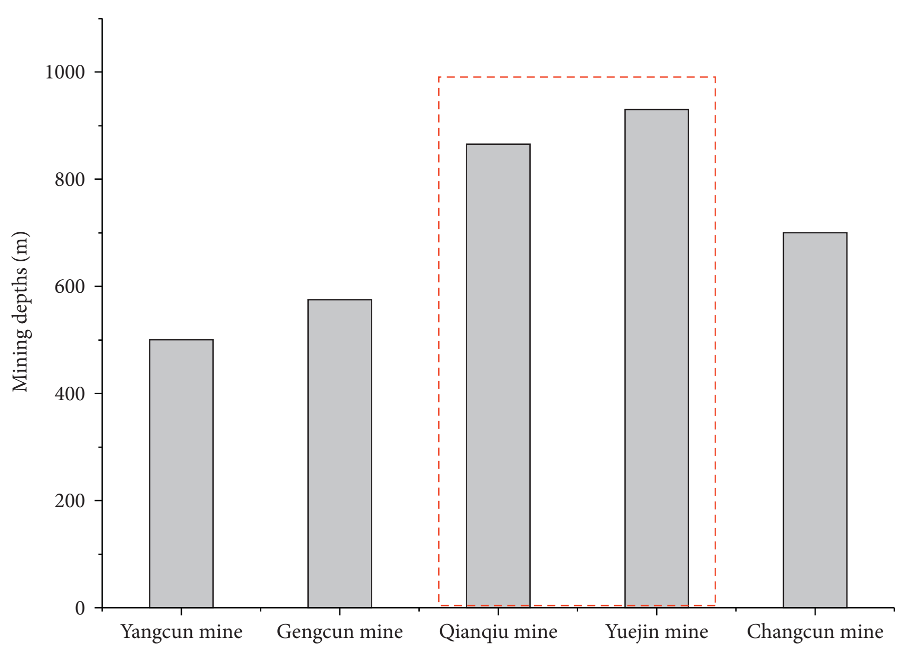


FIGURE 3: Depth distribution of each mine in Yima Coalfield.

total number of events, and 94 rock burst events occurred below this depth, which correspond to 86% of the total. It demonstrates that rock bursts are positively correlated with mining depth. With increasing mining depth, the stress of surrounding rock increases, the elastic deformation energy accumulates, and the risk of rock burst increases. There were

Table 1: The influence of F16 fault on mining engineering of each mine.

Mining areas	Affected by fault
Yangcun mine D13171 tail roadway	Exposed F16 fault, a complex structure of coal seams in the fault area, interbedded coal gangue, three occurrences of rock bursts. The floor heave is 0.8 m, and large collapse pits appear along the fault plane.
Gengcun mine 12200 tail roadway	Exposed hanging wall of F16 fault, disordered coal seam bedding. The deformation of the roadway is 0.3 m–1.3 m, one occurrence of rock burst.
Changcun mine 21170 tail roadway	The distance from the F16 fault plane is 135 m, complex geological structure, broken roof, sags, and swells observed along the fracture surface. The in situ stress in coal seam increases.
Qianqiu mine 21221 tail roadway	The distance from the F16 fault plane is 150 m; the thickness of coal seam becomes larger; the stress increases obviously. Several serious rock bursts occurred, the roadway collapse is serious, and many sections are closed.
Yuejin mine 25110 tail roadway	The distance from the F16 fault plane is 100 m, development of a secondary fault. The rock burst occurred many times and the roadway was damaged seriously.

8 rock burst events in the mining area over 1000 m away from the F16 fault, which represent 7% of the total number of events, and 104 rock burst events in the mining area within 1000 m away from the F16 fault, which represent 93% of the total number of events. It shows that the rock burst is negatively correlated with the distance between the mining area and F16 fault. As shown in Figure 4, under the condition of deep mining, it interacts with fault structure, and the mining area near fault F16 in the deep is a high incidence area of rock bursts.

Additionally, most rock bursts have occurred in the coal bearing areas below the F16 fault plane. The F16 fault plane rises steeply but drops slowly and has a dip angle of 75° in the shallow part and 15–35° in the deep part. The "11.3" rock burst accident that occurred in 21221 tail roadway is about 150 m away from the plane of F16 fault, but from the geological section of the West Wing of 21 mining area in Qianqiu mine; Figure 5 presents the accident site is within the influence range of F16 fault.

It can be seen that fault occurrence (dip angle) can affect the pressure exerted on the surrounding rocks [14, 15]. Under the effect of gravity, the influence of fault on footwall mining is greater than hanging wall mining. The magnitude of the mining-induced stress, which is formed when the mining face is extracted, gradually increased during the mining process. The vertical pressure acting on the coal seam is called "abutment pressure." Figure 6 shows the coal seam abutment pressure curve affected by fault dip angle. The influence distance of low angle fault is far, and the pressure change is mild while the influence distance of high angle fault is short, and the pressure change is sharp.

3.2. Case Study of Rock Bursts near F16 Fault. Qianqiu and Yuejin mine in Yima coalfield have experienced the most serious rock burst disaster, while the deep mining conditions near fault are the most typical. Therefore, the statistics of rock burst events that occurred in the No. 21 mining area of Qianqiu mine and the No. 25 mining area of Yuejin mine were analyzed (shown in Table 2). The characteristics of rock burst events such as time sequence, location and destroyed level are analyzed.

According to the in situ stress test results of Yima mining area, the rock burst is located in the stress concentration area. The vertical stress of Qianqiu mine is 19 MPa, the maximum horizontal stress is 20 MPa, the compressive strength of the coal seam is 18.6 MPa, the stress intensity ratio is 1.07, and the maximum stress level exceeds the strength of the coal seam. The vertical stress of Yuejin Mine is 22 MPa, the maximum horizontal stress is about 17 MPa, the compressive strength of coal seam is 28.6 MPa, the stress strength ratio is 0.77, stress levels are close to the strength of coal. Scene photos of roadway rock burst accident in Qianqiu mine are shown in Figure 7.

The mining depth of Yuejin Mine is greater than that of Qianqiu mine, but the occurrence times of Yuejin mine are less than those of Qianqiu mine. It shows that the occurrence of rock burst is not only related to mining depth but also related to stress strength ratio. Scene photos of roadway rock burst accident in Yuejin mine are shown in Figure 8.

From the mining sequence when rock bursts occurred, there were 8 cases occurring in the excavation process, accounting for 44.4%; 9 cases occurred in the mining process, accounting for 50%; 1 case occurred in other processes (roadway repair), accounting for 5.6%. From the locations of rock bursts, there were 2 cases in working face, accounting for 11% and 16 cases in roadway, accounting for 89%. Rock burst has mainly occurred in roadway, mostly in the advance working face roadway, which is consistent with the statistical law of other mining areas. Since the retreating roadway for mining employs the technique of gob-side entry driving, the upper roadway of the working surface is located within the pressure-release area and as a result, all rock bursts occurred in the tail roadways of working surfaces located in the solid coal.

The rock burst process is accompanied by energetic microseismic events whose energies range from 1.1×10^4 to 3.5×10^8 J, and the energy released during retreating mining is greater than that released during excavation. After the occurrence of rock burst, the main failure form of roadway is floor heave (0.09–2 m), accompanied by side heave (0.4–0.6 m), and the failure length of roadway is generally 60–500 m. The single column and hydraulic lifting shed in the roadway incline to different degrees, and the single hydraulic prop is mainly damaged by structural instability.

Besides mining disturbance, blasting vibration can also induce fault rock burst. During the excavation process of 23130 roadway (mining depth 890 m) in Yuejin mine, the bolt mesh cable support was used. Before crossing the

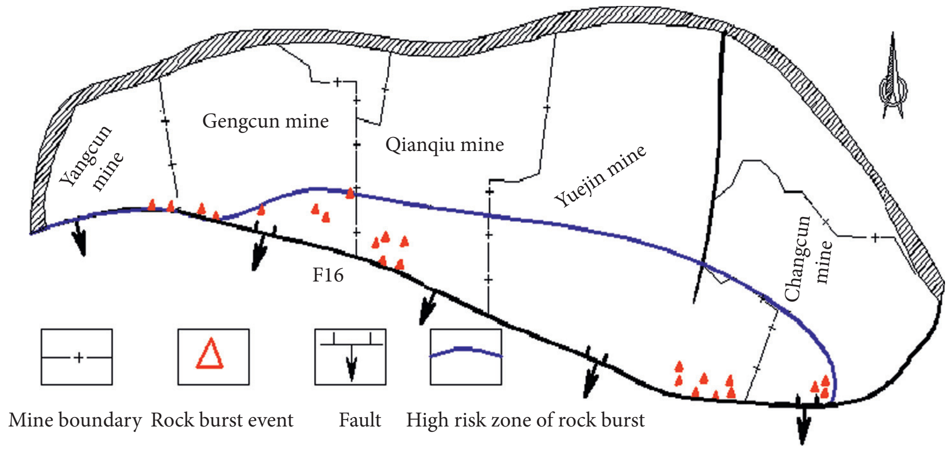


FIGURE 4: Distribution of high incidence area of rock burst in Yima coalfield.

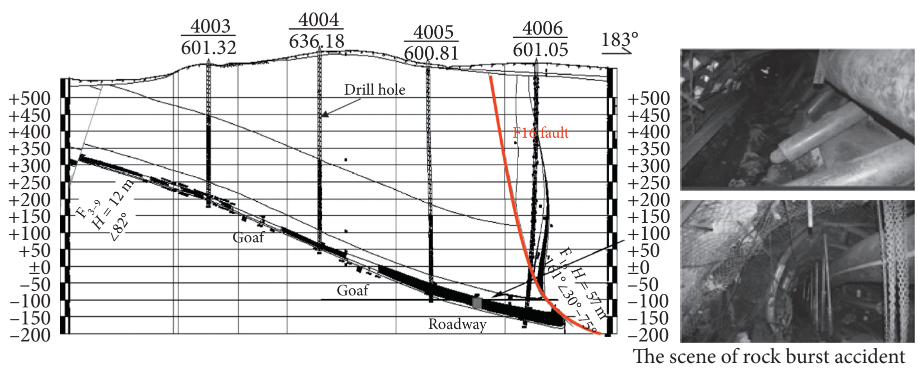


FIGURE 5: Geological profile of the No. 21 mining area of Qianqiu mine.

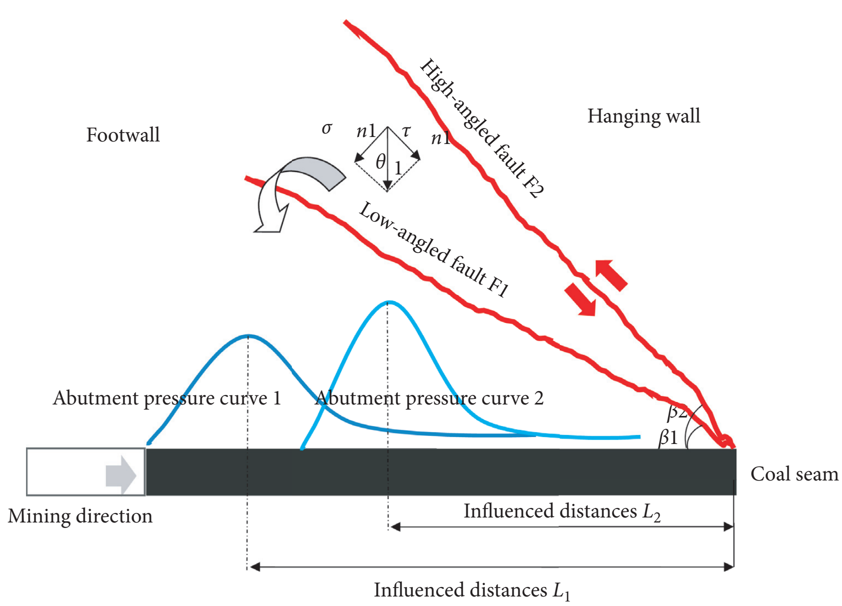


FIGURE 6: Effect of fault dip on surrounding rock pressures.

Table 2: Statistics of rock burst cases in deep mining near the fault.

Site	Case study of rock burst events
Deep mining in the No. 21 mining area of Qianqiu mine	*Geological and mining condition*: The strike length of 21201 working face is 1555 m, the dip length is 130 m, the coal thickness is 23 m, the dip angle of coal seam is 10–14°, the overlying thick rock layer is 500 m, and the buried depth of 21201 tail roadway is 740 m. The working face is fully mechanized caving mining, and the roof is managed by the full caving method. The tail roadway of 21221 heading face passes through 2 coal merging areas, with a buried depth of 760 m. The compressive strength of coal seam is 18 MPa, and the in situ stress is $\sigma_H > \sigma_V > \sigma_h$. The location of rock burst accident is about 150 m away from F16 fault plane. *Description of rock burst failure*: The cross section of the roadway shrinks instantaneously, the partial cross section is less than 1 m^2, the coal seam has a dull sound before rock burst, and the gas concentration exceeds the limit after rock burst; the description of all the rock burst events can be found in the literature [22]. *Measures of preventing rock bursts*: The tail roadway of 21221 with large section (25 m^2 area), supported by a combined means of "anchor net + steel band + anchor cable + U-shaped steel support." Measures to release stress concentration: deep hole blasting, water injection into the coal seam, and large diameter drilling.
Deep mining in the No. 25 mining area of Yuejin mine	*Geological and mining condition*: The average buried depth of 25110 working face is about 900 m, the working face width is 191 m, the strike length is 1092.5 m, the coal thickness is 11.5 m, and the coal seam dip angle is 12°. The compressive strength of coal seam is 28.6 MPa, the thickness of overlying thick rock is 190 m, and the in situ stress is $\sigma_V > \sigma_H > \sigma_h$. The north of the working face is 25090 goaf, and the south is about 80–100 m away from F16 fault. The mining of the working face is also affected by F2504 and F2509 normal faults. *Description of rock burst failure*: The 25110 tail roadway is dominated by floor heave and upper wall deformation, and the released energy ranges from 1.10×10^4 to 1.57×10^8 J. *Measures to prevent rock bursts*: The tail roadway of 25110 with large section (24.5 m^2 area), the three-level support mode of anchor mesh cable + filling structure and "O" shed + portal support is adopted, with the support range 200 m ahead of the working face. Measures to release stress concentration: water injection into the coal seam, and large diameter drilling.

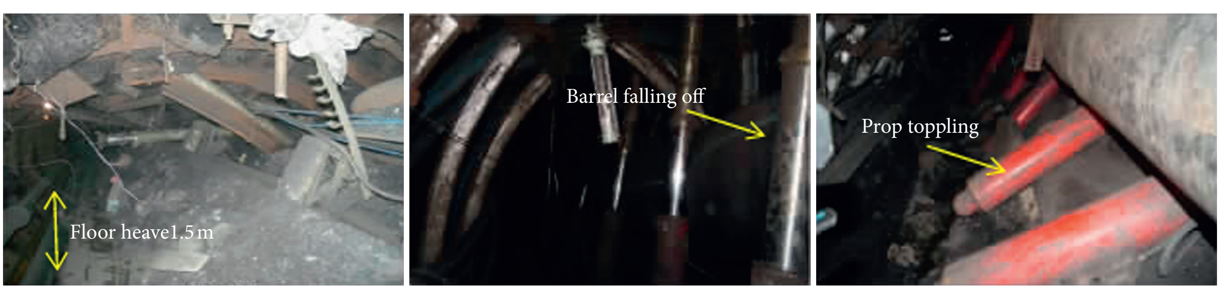


Figure 7: Scene photos of roadway rock burst accident in Qianqiu mine.

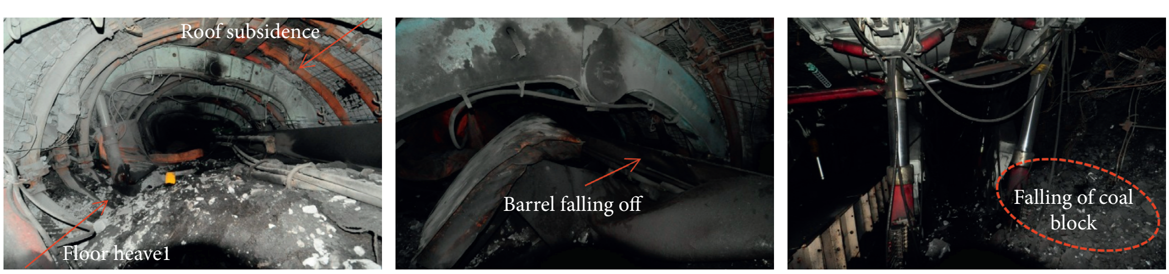


Figure 8: Scene photos of roadway rock burst accident in Yuejin mine.

normal fault with 1 m drop and 70° dip angle, blasting (with a charge of about 15 kg) induced rock burst, resulting in instant deformation of roadway (floor heave of 0.5 m–2.0 m, failure length of 50 m, coal output of 650 tons). When the excavation head crosses the fault for 15 m, the blasting induces rock burst again (floor heave 0.5 m–1.4 m, upper wall of roadway deformation 0.5–1.0 m, failure length 130 m). The location of two rock bursts is shown in Figure 9.

Two rock burst events show that rock burst may occur in the hanging wall and footwall of the fault, and multiple rock bursts may occur in the same fault under disturbance conditions (mining, blasting, and roadway repair), which is

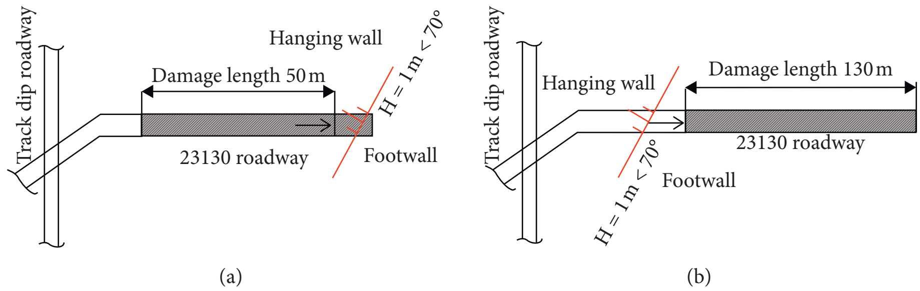


FIGURE 9: Blasting vibration induce fault rock burst. (a) The rock burst occurred in the hanging wall of the fault. (b) The rock burst occurred in the footwall of the fault.

related to the repeated process of stress accumulation, stress release by slip dislocation, and stress recovery [23–25].

3.3. Influence of Fault Feature on Rock Burst. The fault structure in the Qianqiu mining area can be divided into EW compressional fractures (one strip, F16 fault) and north-northeast- (NNE-) NE tensile fractures (eight stripes, F_{3-7}, F_{3-9} faults, and others). The fault structure in the mining area is relatively simple and consists mainly of small fractures. These faults are not densely distributed, and their strikes are NNE, mostly at 10–20°. Changcun mine is affected by its regional geological structure, and fault structures develop within the mining area. A total of 170 faults are exposed in the underground mines, including 129 normal faults and 41 reverse faults. The strikes of the faults are mostly 50–80° and differ from the general fault strike in the Qianqiu mine. The fault strikes in the two mines are illustrated by the rosette diagrams in Figure 10.

Although the geological and mining conditions are similar in the Qianqiu and Changcun mine, the number of rock burst cases in the Changcun mine (12 cases) is significantly lower than that for the Qianqiu mine (43 cases). It suggests that fault characteristics (including fault densities, fault mechanical properties, fault strikes, and dominant stress angles) play a specific role in influencing rock bursts. In the fault developed area, the roof integrity is poor, and it will collapse fully after mining, so it is not easy to accumulate bending deformation energy, and the risk of rock burst will be reduced. Compared with compression shear fault, tension fault is more conducive to stress release, and the risk of rock burst is also reduced. Fault strike and principal stress angle affect fault activity, and then affect the risk of rock burst.

4. Calculation of Energy Released by Fault Slip

The static shear strength of a fault can be expressed as

$$\tau = C + \mu_s \sigma_n. \qquad (1)$$

When the shear stress of the fault exceeds the static shear strength, the convex and concave parts of the fault will be cut off and the fault will slip. The dynamic shear strength of a fault can be expressed as

$$\tau_d = \mu_d \sigma_n. \qquad (2)$$

After the fault slips, the shear stress decreases can be calculated as

$$\Delta\tau = \tau - \tau_d. \qquad (3)$$

The seismic moment after the fault slips and the associated released energy can be expressed by the following equations:

$$M_0 = GDA, \qquad (4)$$

$$E = 0.5\Delta\tau DA, \qquad (5)$$

in which C is the fault coherence, μ_s is the fault static friction coefficient, μ_d is the fault dynamic friction coefficient, σ_n is the fault normal stress, G is the fault shear modulus, $\Delta\tau$ is the average decrease in shear stress for the fault, D is the fault average slip displacement, and A is the fault area.

After a fault slips and fractures, shear stresses can help release energy and result in microseismic events, as illustrated in Figure 11.

From the expressions (4) and (5), it can be concluded that the larger the fault area, the greater the shear modulus and the greater the slip, the greater the seismic moment and the greater the energy released by the slip. F16 fault cutting roof rock is hard and thick conglomerate, which is a rigid fracture with a drop of 50–500 m. Once it slips and dislocates, it will produce a large energy mine earthquake. The "11.3" rock burst in the Qianqiu mine released 3.5×10^8 J, which corresponds to a seismic magnitude of 4.1, and the "3.1" rock burst in the Yuejin mine released 1.45×10^8 J, which corresponds to a seismic magnitude of 3.2. These two rock burst events impacted a large area; the adjacent mines and the ground have a sense of earthquake.

5. Causes of Rock Bursts near Fault in Deep Mining

Based on the geological conditions of the No. 21 mining area of Qianqiu mine in Yima coalfield, a 3D numerical simulation model was constructed and was verified according to measured in situ stress data and laboratory rock mechanical parameters. Figure 12 presents a variation of vertical stress in coal seam through numerical simulation.

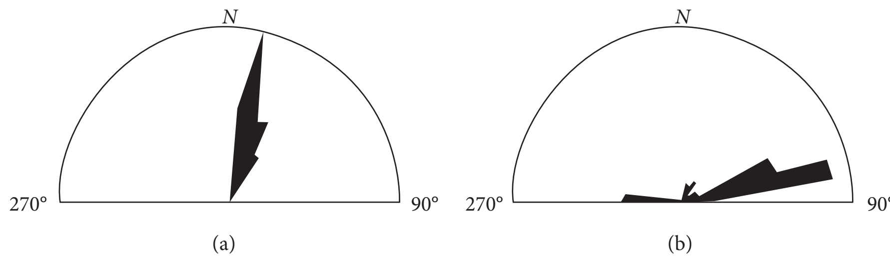


Figure 10: Rosette diagrams of fault strikes in the Qianqiu and Changcun mine. (a) Qianqiu mine. (b) Changcun mine.

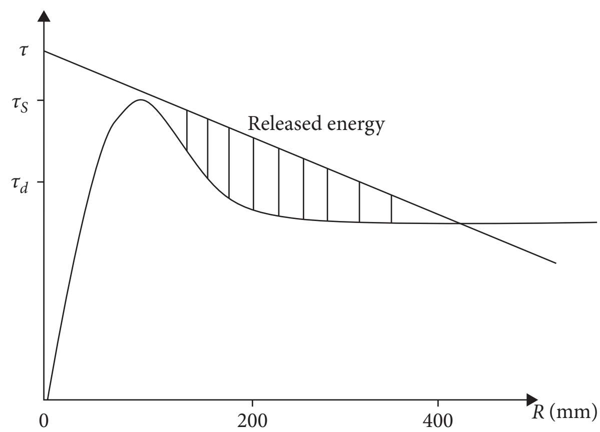


Figure 11: Schematic diagram of energy released by a fault slip [26].

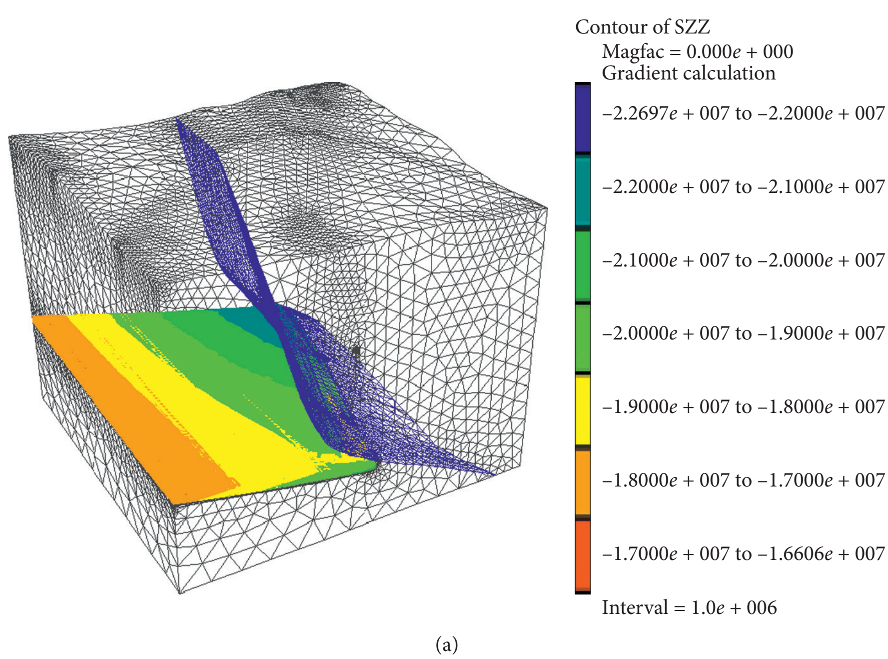
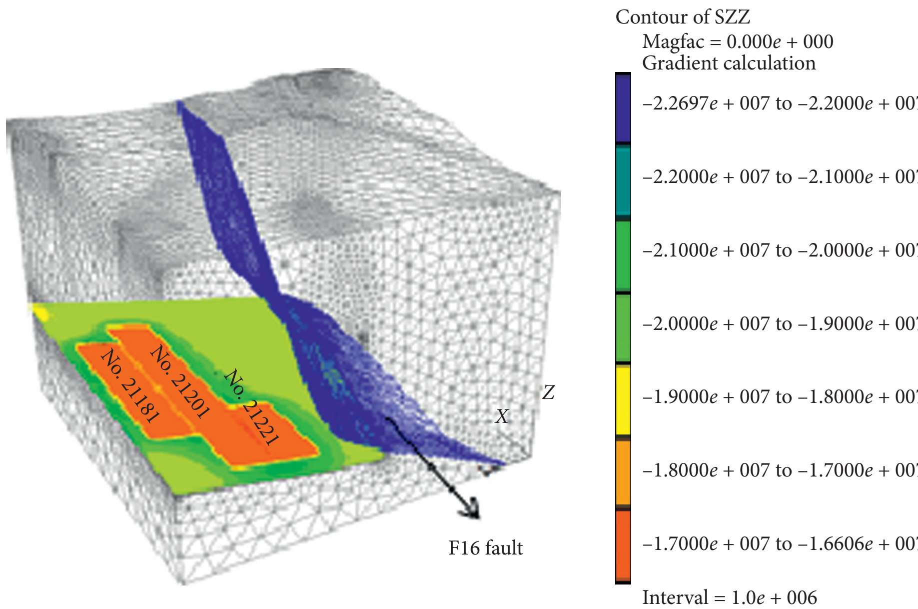
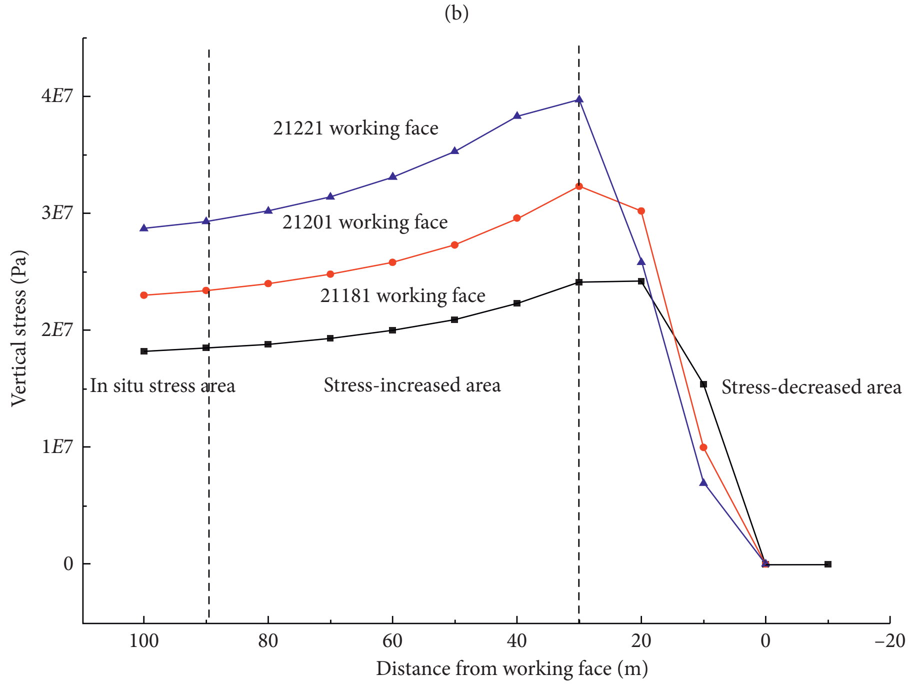


Figure 12: Continued.



(b)



(c)

Figure 12: Variation of vertical stress in coal seam. (a) Vertical stress before mining, (b) vertical stress during mining, and (c) stress variation curves in each working face.

The stress in the coal seam is not homogeneously distributed in the coal seam. The vertical stress varies from 18 to 22 MPa, and the horizontal stress varies from 20 to 26 MPa. During mining, stress concentration is formed in the front and side of the coal wall. With the increase of mining space, the stress concentration increases gradually, and the coal seam in the fault area is in a state of high stress. When mining 21221 working face, the vertical stress rises to 28.7 MPa, and the peak stress is 39.2 MPa. It has been tested in a laboratory that the average strength of No. 2 coal seam is 22.47 MPa. The vertical stress has exceeded the uniaxial compressive strength of the coal seam. Under the condition of deep mining, the stress of coal increases, which increases the static load to induce rock burst.

To further analyze the fault slip characteristics in deep mining conditions, a similar physical model was constructed based on the No. 21 mining and geological conditions, as illustrated in Figure 13.

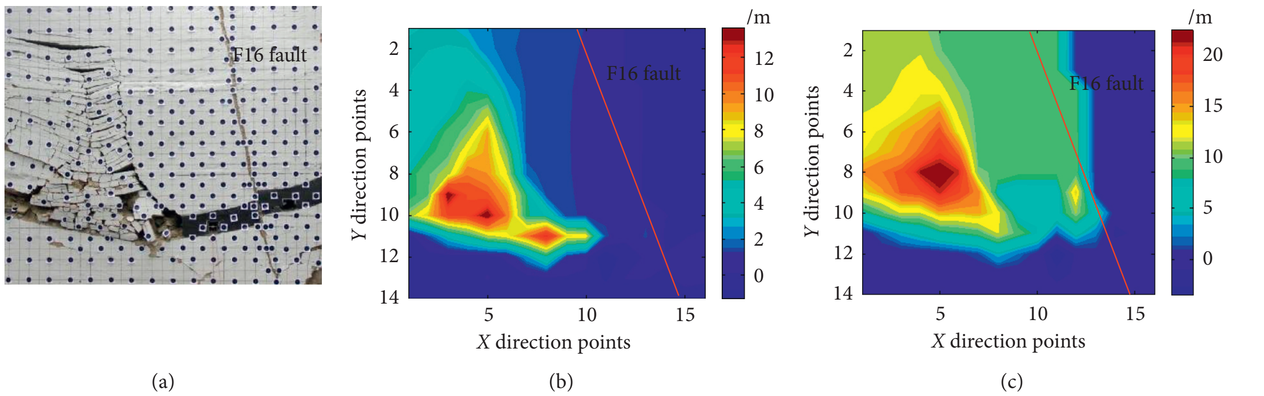


Figure 13: Comparison of displacement changes before and after fault slip. (a) Similar simulation model, (b) before fault slip, and (c) after fault slip.

By using digital speckle monitoring technology, the variation law of the overburden displacement field in the mining process is obtained. It can be seen that, with the increase of mining space and the decrease of the distance from the fault, the disturbance effect of mining on the fault becomes more obvious, the possibility of fault slip increases, the fault slip breaks the equilibrium state of the strata, and the displacement of the overlying strata mutates, which provides an external dynamic load for the occurrence of rock burst. The process of fault sliding and instability observed by similar simulation experiments shows that the rock activation movement caused by mining disturbance is not the whole activation of rock mass on both sides of the fault. Different positions along the fault have different slippage. The slippage of the lower part is larger than that in the middle and upper part. It is easy to induce rock burst when the superposition of the static and dynamic load exceeds the ultimate strength of coal, so rock burst occurs frequently in the actual mining process.

When the coal seam is mined, the surrounding rock stress redistributes, the maximum principal stress trace deflects obviously, and the mining stress distribution of surrounding rock is shown in Figure 14.

The mining stress in the surrounding rocks can be divided into two types. (1) High compressive stress area: the stress arch angle is in front of the working surface. It can increase the vertical stress exerted on the coal seam, the plastic failure of the coal body under compression, and the stress transfers to the deep part of the coal wall. Generally, the influence range of the compressive stress area is small; in this area, the brittle strain failure will also occur violently due to the mechanical properties of the coal seam. (2) High shear stress area: the shear stress of surrounding rock increases due to stress deflection, and when there are structural planes such as faults and primary joints in surrounding rock, the shear slip fracture is easy to occur under the action of high shear stress. Fault slip and dislocation occur before rock burst. Under the influence of mining, the sudden dislocation of fault leads to a mine earthquake, which spreads to the mining space (working face, roadway) and superposition with static load; it can easily induce rock bursts. The reason why rock bursts occur less in

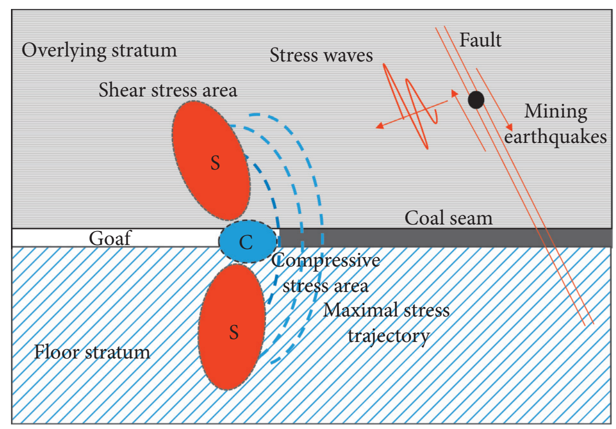


Figure 14: Schematic diagram of mining stress distribution.

the working face and more in roadway is related to the distribution of surrounding rock stress. Generally, the shear strength of rock is 10%–40% of the compressive strength, and the area distribution of high shear stress is larger than that of high compressive stress. In addition, the working face is the concentrated place of production, the hydraulic support is used to support the roof and coal wall, and the support strength is high (0.5–2 MPa); while the roadway range is long, different rock conditions and geological structures will be encountered in the process of roadway excavation, and rock bursts easily occur at the weak support of roadway. Normally, the floor is usually not supported.

6. Conclusions

Through case study and theoretical analysis, the mechanism of rock burst near fault in deep mining was studied. The main conclusions drawn from this study are summarized below:

(1) The frequency and intensity of rock bursts during deep mining near the F16 fault in Yima coalfield have significantly increased over the years, and 84% of total cases have occurred shallower than 600 m, while 93% of all cases have occurred within 1,000 m of F16 fault.

(2) Rock bursts often occur in areas with high stress concentrations, especially in the roadway. The released energy ranges from 1.1×10^4 to 3.5×10^8 J, and the resultant damage distance can extend 60–500 m. The main failure form of roadway is floor heave, accompanied by side heave and roof subsidence.

(3) The mechanism of rock burst formation is related to the distribution of mining stress. In deep mining near faults, coal seam stress increases, and mining activities have a prominent effect on disturbing the fault. Under the combined influence of static and dynamic loads, rock bursts are easily induced. In addition, the occurrence and mechanical characteristics of faults can affect rock burst occurrences.

(4) The major factors of rock bursts are mining factors, geological factors, and stress. Therefore, it is often necessary to assess the risk of rock bursts by using numerical simulations before mining. The investigation of rock burst cases in this study provides basic data for constructing and verifying numerical simulations.

Data Availability

The data used for conducting classifications are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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