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Analysis on rock burst danger when fully-mechanized caving coal face passed fault with deep mining ☆

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ABSTRACT

When fully-mechanized caving face passed fault, rock burst accidence easily occurred. The SOS microseism monitoring system was applied to monitor the microseismic activities all time occurred in the coal and rock mass near the fault area. Variation features of microseismic energy releasing and microseismic frequency were analyzed. Numerical simulation method was used to research the abutment stress distribution when coal face passed fault, which was compared with microseism occurrence rules. When the coal face approached to fault, the abutment stress increases gradually, so the high stress would accumulate near the fault region. When the coal face left fault, the abutment stress decreased. The SOS microseism monitoring results showed that microseismic activity in the fault area had a high instability. When the coal face neared to the fault, total energy value and frequency released by the microseism steadily increased. The maximum energy peak value also had the tendency to rapidly increase. Before the strong shock occurred, there was a period of weak seismic activity. The weak seismic activity showed energy accumulation for strong shock, which can be used to forecast the danger of rock burst.

1. Introduction

The equipment will be damaged, and people will be injured when rock burst occurs, which is one of the biggest disasters to mine safety. With the expansion of mining and tunneling, the condition of mining face will be complex, the mining activity in the coal pillar and adjacent to coal pillar is inescapability. During the mining progress in deep coal seam, influenced by the fault structure, the mine pressure appears very violently around the excavation face, the sound of mine quake becomes larger, and the number of mine quake becomes more and more. Research on the rock burst occurrence rule under the complex geological structure is very necessary to safety production.

The domestic and oversea scholars (Su and Li, 2008; Lu et al., 2008; Li et al., 2008a,b,c; Lu et al., 2007; Gou et al., 2007; Jiang et al., 2006; Dou and He, 2004; Song et al., 2004; Caim Kaiser and Martin, 2001; Meng et al., 2001; Huang and Gao, 2001; Pan et al., 1998) have studied the mechanism of fault activity inducing rock burst, and the microseismic law of rock burst portent. The slide destabilization characteristic of surrounding rock, the stress distribution and change rules, and rock burst occurrence mechanism were researched by the viewpoint of the fault upper wall and lower wall, coal seam roof and floor, and fault fractured zone and coal mechanics character in the relevant document. The research on rock burst danger of fully-mechanized caving coal face passed fault is relevantly less.

The No. 14310 coal face passing the No. NF6 fault in the Dongtan mine was acted as research object. The relevant mathematical model was used to research the rock burst mechanism induced by the activity of regional surrounding rock. Microseismic law of coal face passed fault was explored, which can guide the forecast and prevention of rock burst.

2. Microseismic activity monitoring and change rules in fault region when coal face excavated

2.1. Change rules of microseismic hypocenter

The Polish SOS microseismic monitoring system was used in the Dongtan mine, and the microseismic activity was monitored and

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located in real time. The change of microseismic hypocenter position and energy was recorded when the coal face passed the No. NF6 fault. The monitoring result about concentrative and violent distribution of microseismic hypocenter was analyzed.

Illustrated as Fig. 1, all kinds of the points showed microseismic hypocenter position, the different shapes showed different microseismic grades, and the black short line showed the excavation position of coal face. According to the monitoring result, the microseismic hypocenter changed along with the excavation progress. In the vertical section, the hypocenter changed obviously. When the coal face was far from the fault, the excavation was little influence on fault activity, and the microseismic hypocenter mainly distributed in the front of coal face and on the goaf.

In July 26, 2010, the distance of coal face far from fault was 62 m, the mine pressure emergence near coal face enhanced, the times of microseismic occurrence increased obviously, but the microseismic grade was small. At this time, microseismic began to appear near fault, which showed the fault activity was influenced by the coal face excavation (see Fig. 1a).

Along with coal face excavation, microseismic activity was more and more obvious, hypocenter point concentrated on the hard rock seams above the main roof and near the fault (see Fig. 1c and d). In August 25, 2010, the distance that coal face left fault was 80 m, microseismic occurrence was not influenced by fault, microseismic times reduced, microseismic position still began to distribute in the front and goaf of coal face. According to the microseismic monitoring result, there was rock burst danger in the region near the fault under the excavation disturbance.

2.2. Changes of microseismic total energy and microseismic times

According to the excavation progress, changes of microseismic total energy and microseismic times were drawn as Fig. 2 during the period of coal face passing the fault.

Since July 25, when the distance of coal face far from fault was above 60 m, microseismic times obviously increased. But microseismic total energy little changed, and microseismic grade was mainly small. After August 5, 6, high energy microseismic began to appear, energy changed violently, which presented two rules: Firstly, microseismic energy undulated on a special level, but the amplitude difference between maximum energy and minimum energy was big. Secondly, before strong shock occurred, the frequency and grade of microseismic activity had the decrease tendency. After strong shock occurred, microseismic usually turned to low energy shock. So the low energy shock showed the tendency of energy accumulation for strong shock occurrence. After August 24, the changes of microseismic energy were not influenced by the fault structure.

3. Mine pressure emergency near the fault under the influence of excavation

3.1. Numerical simulation model

The mining depth was above 600 m, so the uniformly distribution load acted on the upper boundary of model was 12.86 MPa (Zhu et al., 2007). X direct displacement of model left and right was 0, and X direct displacement and Y displacement of model bottom was 0 (see Fig. 3). Material constitutive relation was Mohr–Coulomb. The rock seam properties (see Table 1) referred to the No. 49 geological borehole of the No. 14310 coal face in Dongtan mine. The fault mechanics property was referred to the relevant document (Zhou et al., 2006; Wang et al., 2003; Li et al., 2008a,b, c).

3.2. Fault influence on abutment stress

The coal face excavated from fault lower wall to fault upper wall, when the different distance between coal face and fault

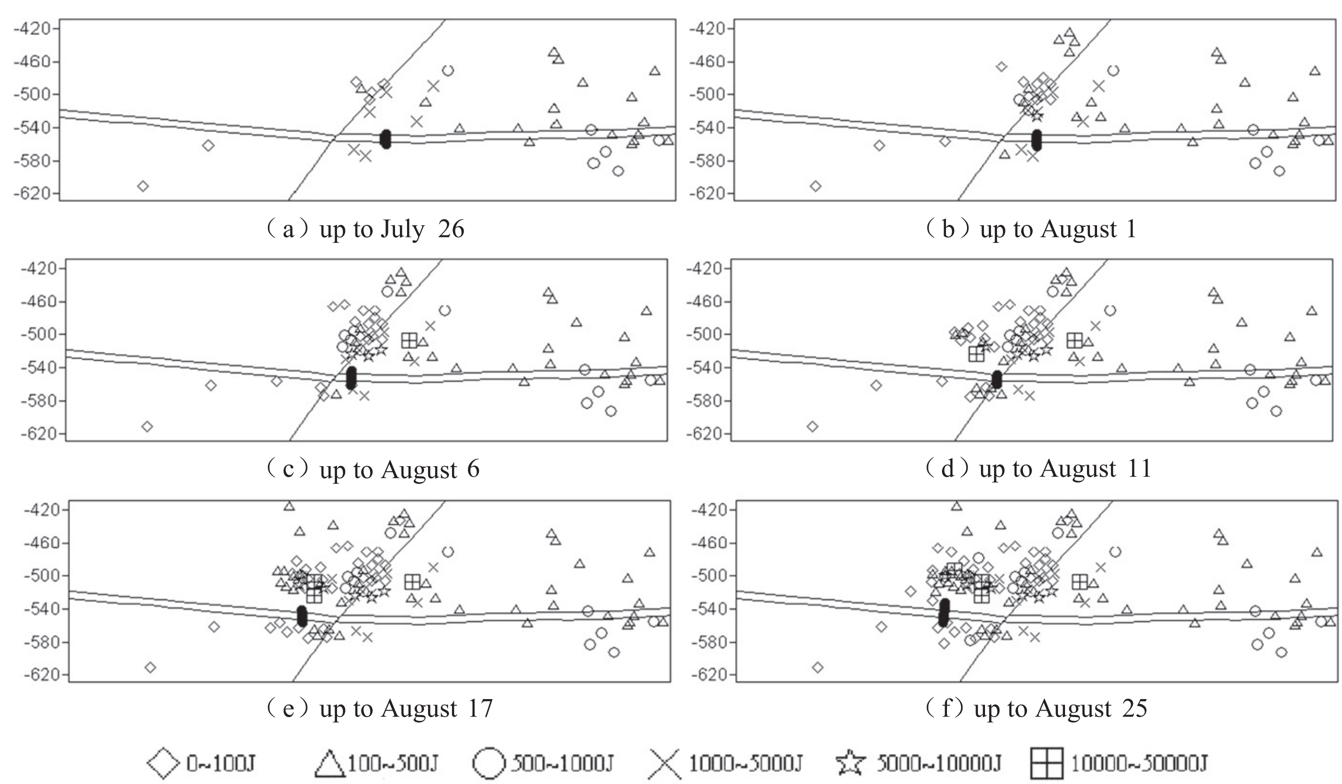

Fig. 1. Distribution change of microseismic hypocenter along with coal face excavation in vertical section.

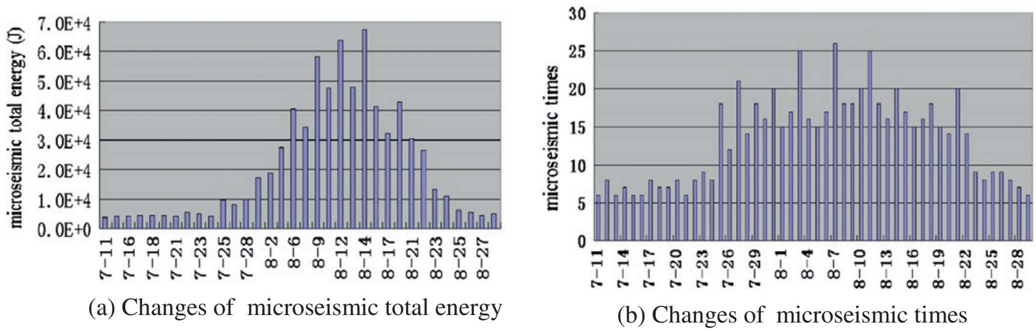

Fig. 2. Changes histogram of microseismic energy and times during the coal face passing fault.

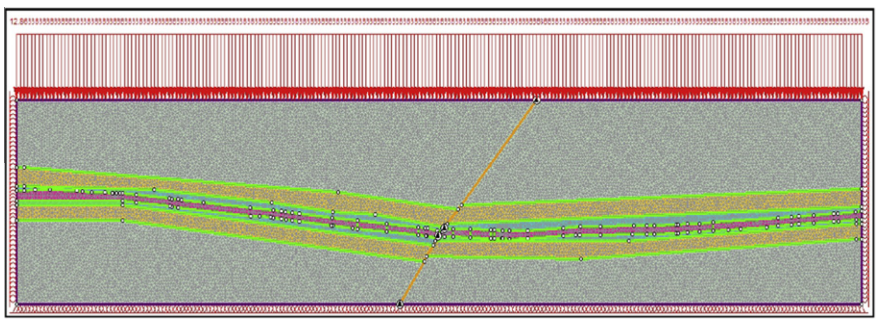

Fig. 3. Numerical simulation model.

Table 1
Rock seam properties of model.

Rock seam	Sandstone	Medium grained sandstone	Siltstone	Coal seam
Density (kg m^{-3})	2600	2400	2640	1400
Elastic modulus (GPa)	16	13.2	13.1	1.5
Poisson ratio	0.25	0.23	0.18	0.32
Compress strength (MPa)	80	100	69.7	19.6
Cohesion (MPa)	5	12.8	3	1.1
Angle of internal friction	32	30	32.1	25

respectively were 80 m, 65 m, 40 m, 20 m, −5 m, −30 m, −70 m, −100 m, the different abutment stresses distribution was illustrated as Fig. 4, and the peak value of different abutment stresses was listed in Table 2.

When the distance between coal face and fault was 80 m and 65 m, the two curve of abutment stress ahead of coal face were basically superposition, so fault influence on abutment stress was very small. Numerical simulation results showed that in the coal body ahead of coal face, stress peak value reached to 53.37 MPa, stress concentration factor reached to 3.42, the distance of stress peak value far from coal wall of coal face was 24.2 m, and the stress

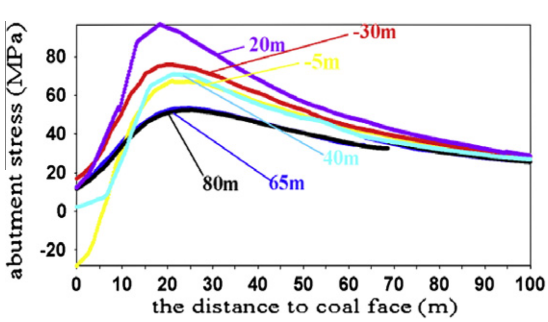

Fig. 4. Distribution of abutment stress.

Table 2
Peak value of abutment stress.

Distance far from fault (m)	Peak value of stress (MPa)	Stress concentration factor (K)
80	52.32	3.35
65	53.37	3.42
40	70.84	4.54
20	90.21	5.78
−5	68.37	4.38
−30	74.81	4.79
−50	52.03	3.34
−80	51.21	3.28

influence scope was above 50 m. On-situ observation results indicated that the distance of stress peak value far from coal wall of coal face was more than 2–3.5 times of excavation coal height, the stress influence scope was 40–60 m, and stress concentration factor was 2.5–3 (Qian and Shi, 2003). The above two research results were similar, which explained that numerical simulation model was reasonable.

Along with the coal face approached to fault, the fault influence on abutment stress enhanced, and the stress peak value gradually increased. When the distance between coal face and fault was 40 m, stress peak value reached to 70.84 MPa, stress concentration factor reached to 4.54, the distance of stress peak value far from coal wall of coal face was 25.2 m. When the distance between coal face and fault was 20 m, stress peak value rapidly reached to 90.21 MPa, stress concentration factor reached to 5.78, the distance of stress peak value far from coal wall of coal face was 20.12 m. After the coal face left fault, the stress in the coal body gradually decreased, for example, the distance of coal face left fault was 30 m, stress peak value decreased to 74.81 MPa, and when the distance was 50 m, peak value was 52.03 MPa, which was similar to normal excavation.

Fig. 5 illustrated distribution nephogram of abutment stress when there were different distances between coal face and fault. When the distance of coal face approached fault was 15 m, there

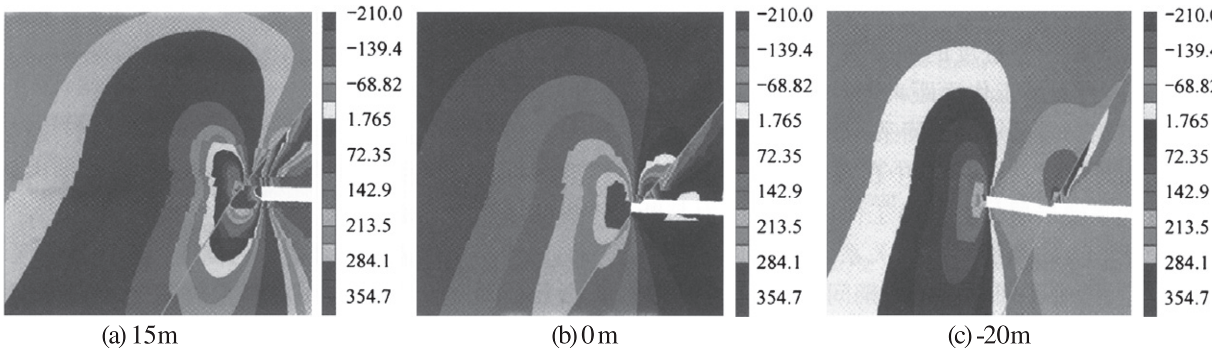

Fig. 5. Distribution nephogram of abutment stress with different distances between coal face and fault.

was obviously stress concentration (see Fig. 5a) near the fault. When the distance of coal face left fault was 20 m (see Fig. 5c), rock seams near the fault were mostly destroyed, so the stress was little.

4. Conclusions

(1) When the fully-mechanized caving coal face with deep mining and big excavation height passed fault, several strong shocks occurred, which indicated that the great scope of rock and coal seams fractured and destroyed under the action of abutment stress and fault tectonic stress, there was rock burst danger near the fault region.
(2) Microseismic activity had obviously rule. When the coal face excavated normally, microseismic energy undulated on a special level. On the special conditions, before strong shock occurred, the frequency and grade of microseismic activity had the decrease tendency. After strong shock occurred, microseismic usually turned to low energy shock. So the low energy shock showed the tendency of energy accumulation for strong shock occurrence.
(3) When coal face approached to fault, the abutment stress on the front of coal face obviously increased, so the rock burst danger near the fault was bigger.
(4) Under the influence of coal face excavation, fault had the possibility of instability and slippage, which was because in the fault region, microseismic intensity obviously increased, and most of microseismics occurred in the roof of coal seam. These rules can be used to forecast rock burst danger.

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