Monitoring of mine tremor-induced stress response in coal seam

Du Taotao

中国煤科 CCTEG

Dept. of Tiandi Science & Technology co. Ltd

Coal Mining Branch, China Coal Research Institute

Xuzhou, China June 23,2019

◻ China Coal Technology & Engineering Group Corp(CCTEG)

China Coal Technology & Engineering Group Corp (here-in-after referred to as **CCTEG**) has been established for more than 50 years and directly managed by the State-owned Assets Supervision and Administration Commission of the State Council. Under CCTEG, there are 19 wholly-owned subsidiaries and one high-tech listed company, respectively located in more than 10 big cities in China like Beijing, Shanghai, Xian and Chongqing, etc.

outline

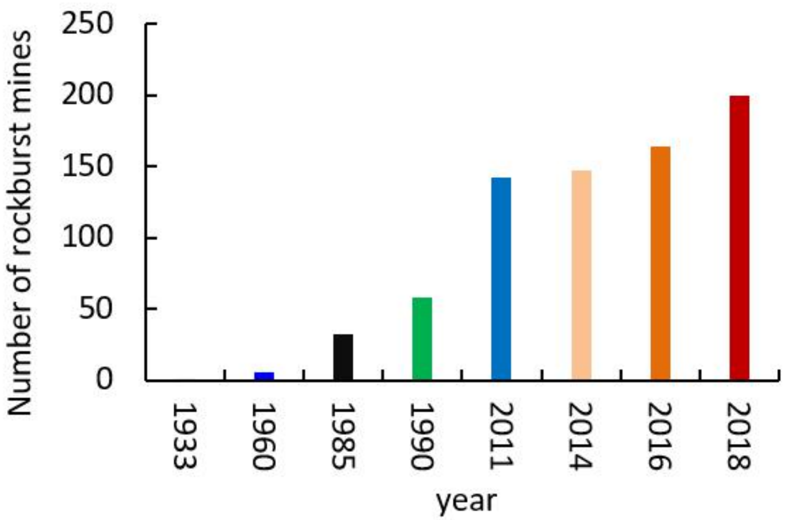
1 Introduction

2 Monitoring mine tremor-induced stress response

3 Conclusion

1 Introduction

- **In China, The number of rock burst coal mines had increased from 32 in 1985 to more than 200 in 2018.**



- **The frequency, intensity and area of rock burst disaster in coal mine are increasing year by year.**
- **In recent years, there have been many casualties caused by rock burst.**

1 Introduction

☐ More and more rock burst induced by mine tremor

table1

Name of Coal Mine	date	Magnitude or energy	induced rockburst
Mu chengjian coal mine	2005	M_L=1.8	Yes
Nan Tun coal mine	2007	M_L=2.8	Yes
Bao Dian coal mine	2013	M_L=1-4	No
Xin Zhouyao coal mine	2014-2015	M_L=3.4-4.3	Yes
Kuan Gou coal mine	2018	$E=10^5$-10^6J	Yes

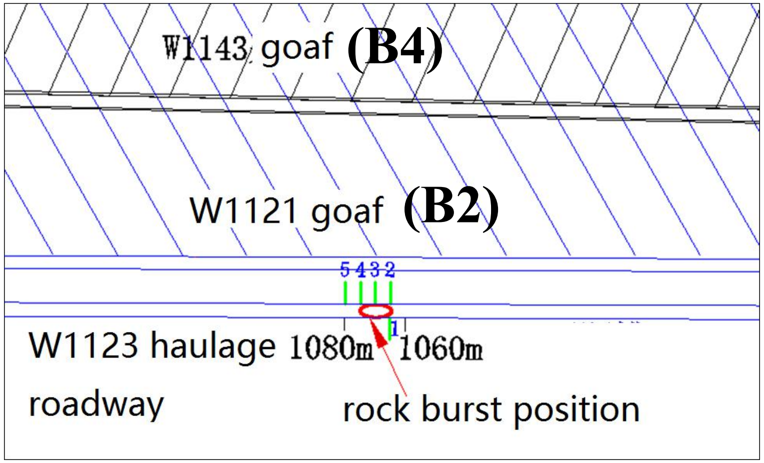
- **A large number of studies have been carried out by scholars at home and abroad on the mechanism of mining tremor.**
- **But, Less attention is paid to the stress response process induced by mine tremor.**

☐ Coal mine dynamic load monitoring is the bottleneck restricting the quantitative research on the process analysis of rock burst induced by mine tremor and the occurrence of rock burst.

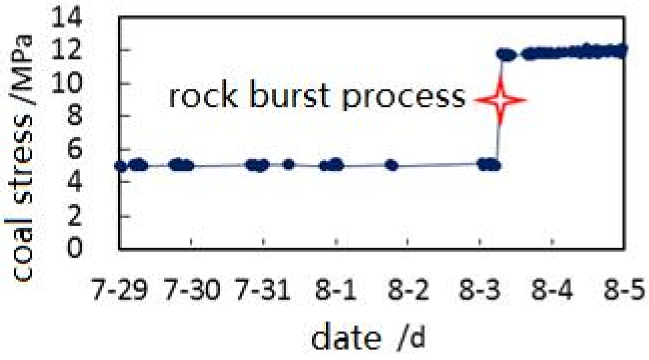
1 Introduction

□ Case of mine tremor response in traditional stress monitoring

- **In Kuanggou Coal Mine, At present, the B4 coal seam has been mined and the B2 coal seam is being mined. W1123 haulage roadway was excavated to the area of 1060-1080m. The dynamic effect was significantly enhanced.**



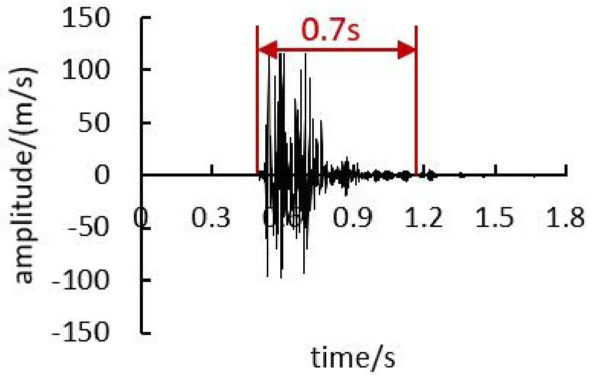
- **In view of this abnormal phenomenon, the traditional coal seam stress senors was installed on both sides of the 1060-1080m area for monitoring. Weak rock burst occurred in the area during installation, which resulted in deformation of roadway floor heave. However, traditional stress monitoring only monitored the results, but could not effectively reflect its process.**



1 Introduction

Main difficulties

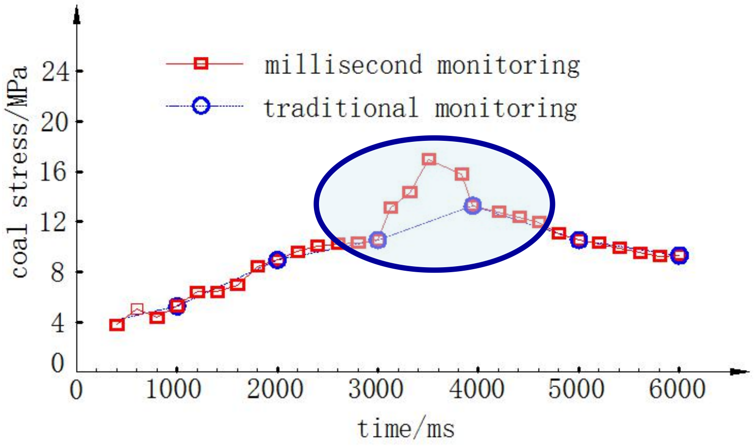
- The duration of mine tremor is short, and the traditional stress sampling frequency can not meet the timely capture of mine tremor.



Solutions

- A millisecond sampling frequency stress sensor was designed and field monitoring was carried out.

- Compared with the traditional rock burst stress monitoring system, the millisecond stress response monitoring system can realize millisecond acquisition and recording, and can effectively record the process of rock burst disasters.



outline

1 Introduction

2 Monitoring mine tremor-induced stress response

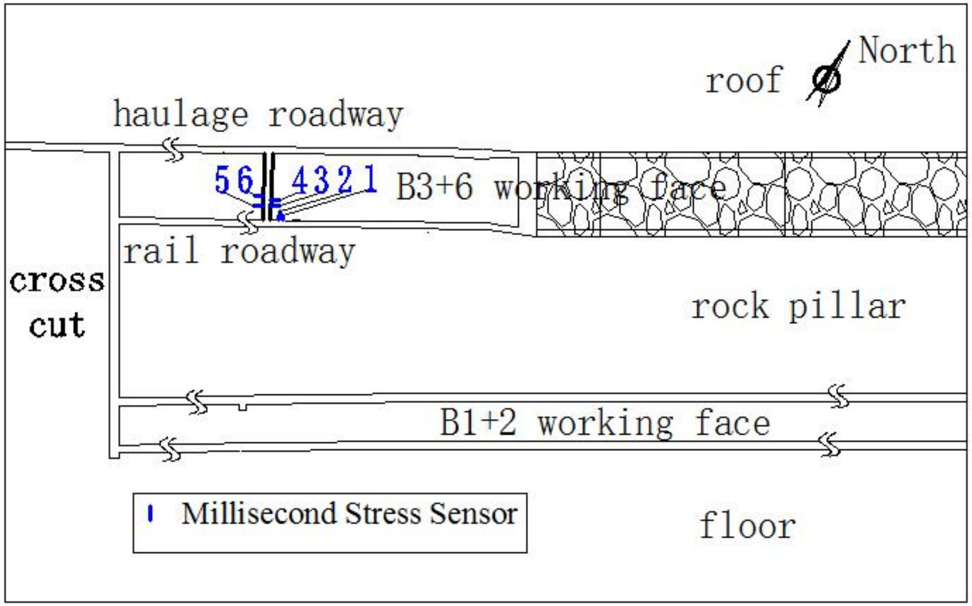
3 Conclusion

2 Monitoring mine tremor-induced stress response

□ millisecond stress sensor monitoring scheme

- **Wudong Coal Mine has two working faces, B1 + 2 working face and B3 + 6 working face, the working face length is 37m and 49m respectively, with an average coal seam inclination of 88° .**

- **The average thickness of rock pillars between the two working faces is 80m**
- **The fully mechanized top coal caving with horizontal slicing is adopted.**
- **Six millisecond stress sensors were installed to monitor the stress response process of coal seam.**



□ Case I of monitoring results

- On October 24, 2015, rock burst occurred in B3 rail roadway, causing severe deformation of the two U-shaped steels within 62 meters in front of the working face.
- Microseismic monitoring showed that the seismic source distance stress sensor was 175m, earthquake magnitude of mine tremor was 2.1.
- The macroscopic behavior caused by mine tremor was the deformation of U-shaped steel and plate falling off. So how did the coal seam stress change?

Bottom distortion of U-shaped steel

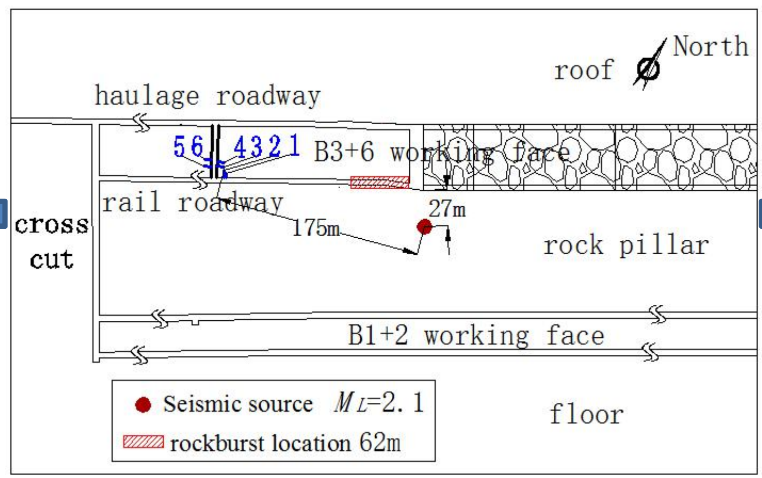


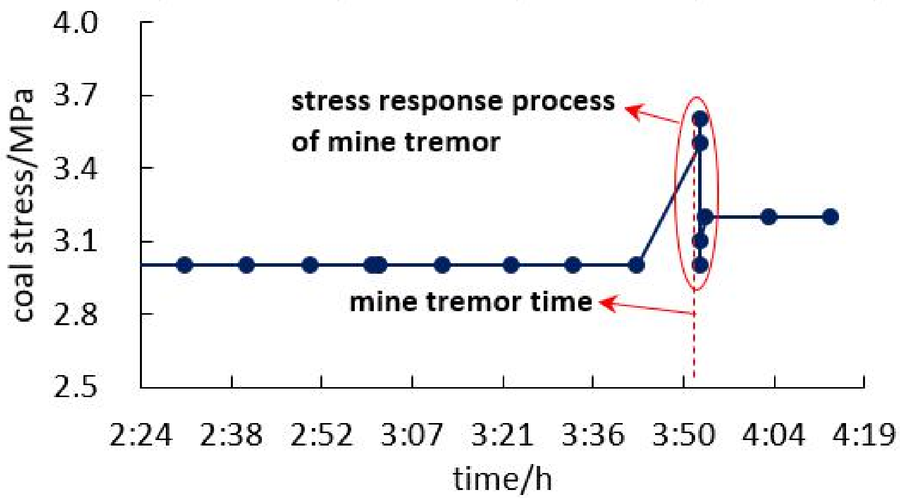
Plate falling off

2 Monitoring mine tremor-induced stress response

◻ Monitoring results of stress response

In many cases, it is difficult to distinguish the rock burst caused by the mine tremor or mine tremor induced by rock burst.

- **Microseismic monitoring showed that mine tremor occurring time was 03:53:25 513 ms**
- **Monitoring by millisecond stress sensor shows that the stress response time of coal seam was 03:53:32 187ms**



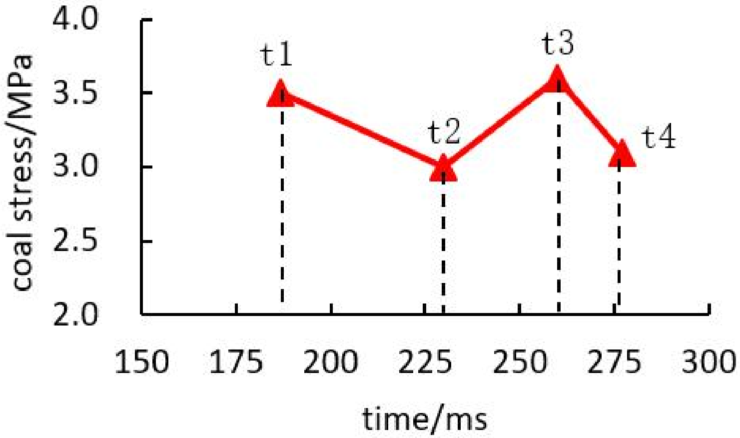
Through microseismic and coal stress response process monitoring, the effect of the mine tremor was revealed based on the occurrence time and changes of the two.

2 Monitoring mine tremor-induced stress response

□ mine tremor-induced stress response process

① Mine tremor propagation process: The seismic source distance was about 175 m from the millisecond stress sensor, the time range of tremor propagation was 35-117ms.

② Mine tremor loading process. Before the stress response of the coal seam, it lasted 6674ms, and the propagation time ranged from 35-117ms. The loading time of the coal body was 6557-6639ms, which caused the coal body stress to increase from 3MPa to 3.5MPa.

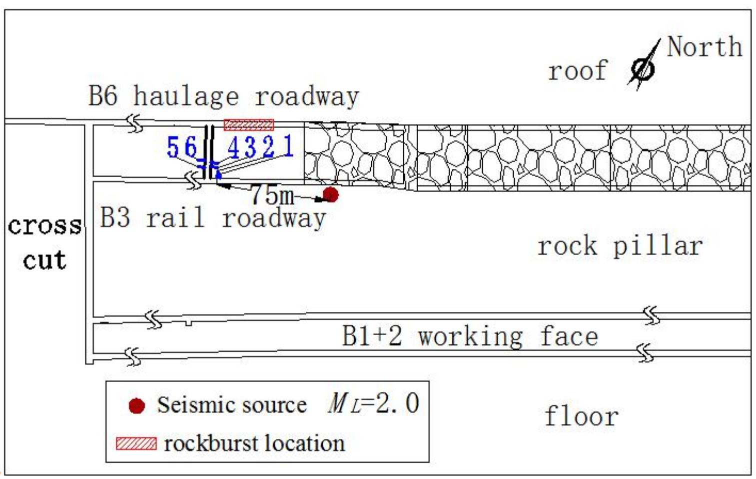


③ The mine tremor-induced stress response was a process of "decrease-rise". The stress response process not only reflected the result of coal stress response caused by mine tremor, but also revealed the stress value in the process of rapid change of coal stress.

2 Monitoring mine tremor-induced stress response

□ Case II of monitoring results

- On December 12， 2015, mine tremor occurred in B6 haulage roadway , the mine tremor causes the ground to shake and the sound of coal “bump” was louder in the working face.
- Microseismic monitoring showed that the seismic source distance stress sensor was 75m, earthquake magnitude of mine tremor was 2.0.
- The macroscopic behavior caused by mine tremor were serious deformation of B6 haulage roadway, and the roof subsidence reached 400 mm. New ground collapse reached 3m, and obvious cracks appeared in front of the working face.



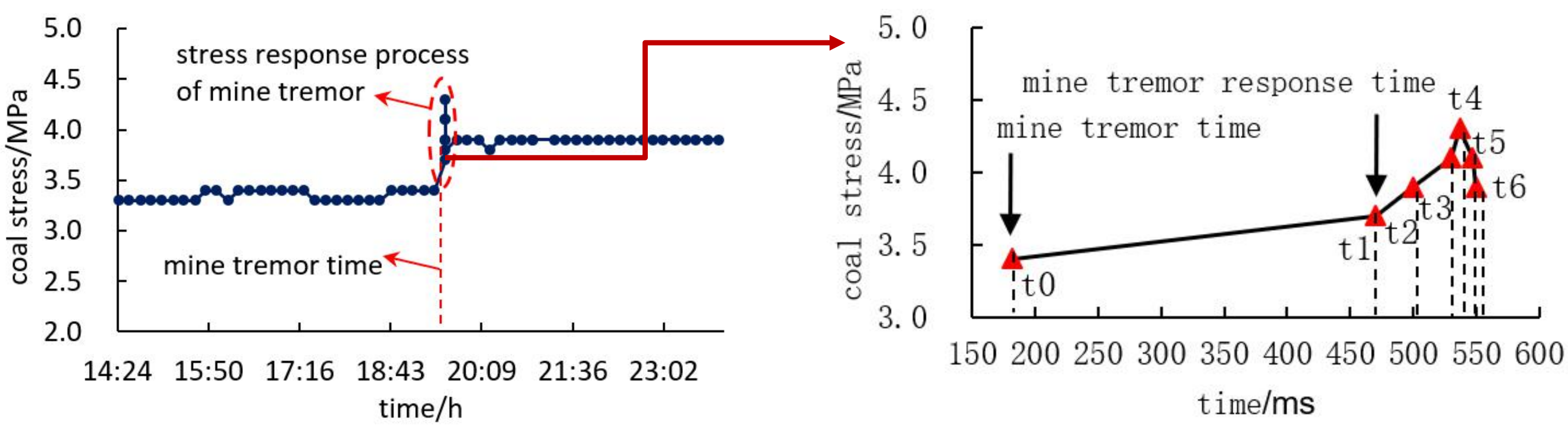
2 Monitoring mine tremor-induced stress response

□ mine tremor-induced stress response process

① The seismic source distance was about 75 m from the millisecond stress sensor, the time range of tremor propagation was **15-50ms**.

② The time from loading coal to initial response was 318-353 ms. The stress of coal increases from 3.4 to 3.7 MPa.

③ The mine tremor-induced stress response was a process of "decrease-rise". The maximum fluctuation of coal stress is 0.9 MPa, and the increment of coal stress before and after mine tremor is 0.5 MPa.



2 Monitoring mine tremor-induced stress response

☐ Characteristics

- **Time response characteristics**

  The response time of mine tremor includes the time of vibration propagation and the time of loading. The time of vibration propagation was usually tens of milliseconds, and the time of loading of mine tremor was usually hundreds to thousands of milliseconds.

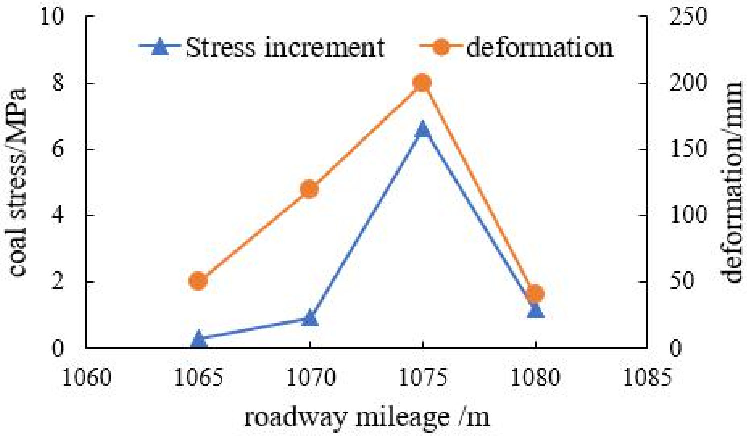
- **Stress response characteristics**

  The response characteristics of the coal seam in the response area were increased and decreased, indicating that the mine tremor changed the stress state of the coal seam sharply.

2 Monitoring mine tremor-induced stress response

□ The relation of mine tremor-induced stress response to rock burst

- **There was a certain correlation between stress response increment and impact appearance. The larger the stress response increment was, the larger the floor heave was.**



- **From the characteristics of stress response and rockburst appearance, it was easy to cause more serious damage in the area where the stress increment of mining face changed greatly.**

2 Monitoring mine tremor-induced stress response

□ Significance of coal stress response process monitoring

- **Quantitative determination of dynamic load in critical conditions of rockburst occurrence can be further studied.**

The critical stress of rock burst is quantitatively described by monitoring the dynamic and static load.

$$\sigma_j + \boxed{\sigma_d} \geq \sigma_{b\min}$$

$\boldsymbol{\sigma_j}$ **---static load of coal seam**

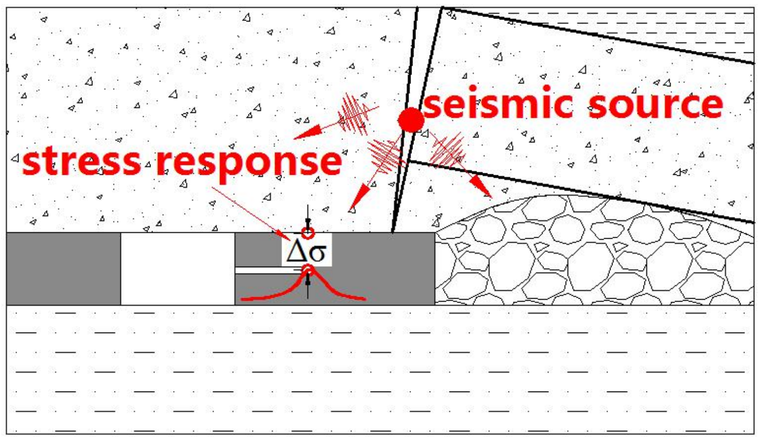
$\boldsymbol{\sigma_d}$ **---dynamic load of coal seam**

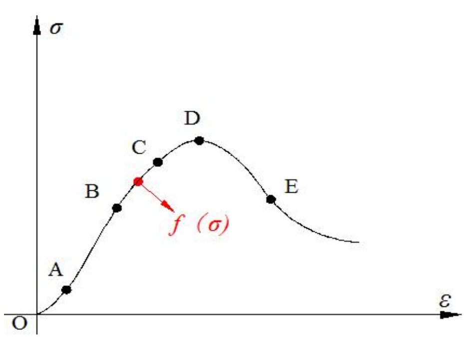
$\sigma_{b\min}$ **---Critical stress of rock burst**

Dynamic load monitoring and quantification has always been a difficult problem.

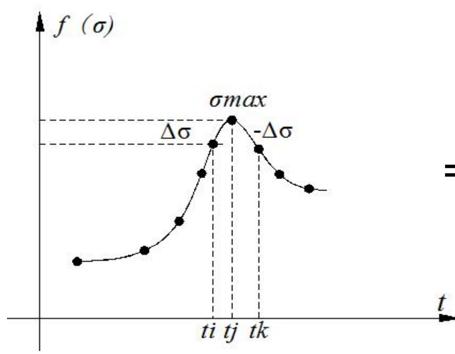
□ Significance of coal stress response process monitoring

- Through monitoring the stress response process of coal seam, real-time evaluation of the stress level and state is significance for monitoring and early warning and effect test.





+



$= f(\sigma) + \Delta\sigma$ ⇒

- the stress level
- early warning
- effect test

outline

1 Introduction

2 Monitoring mine tremor-induced stress response

3 Conclusion

3 Conclusion

- The millisecond stress monitoring system of rock burst was applied to effectively capture the stress response process of mine tremor.
- The time response characteristics and stress response characteristics of the mine tremor-induced stress response were obtained through monitoring.
- It plays an important role in quantitative research of rock burst, but a lot of practical research is needed.

THE END

THANK YOU FOR ATTENTION