APPLICATION OF MICROSEISMIC FOCUS ENERGY ON ASSESSMENT OF ROCK BURST IN UNDERGROUND COAL MINE

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https://doi.org/10.15017/1470568

出版情報：九州大学，2014，博士（工学），課程博士
バージョン：
権利関係：全文ファイル公表済
From a mining perspective, rock bursts are one of the most destructive geologic hazards with their potential for damage to working faces and roadways, which may impact safety, productivity and operational costs. Unfortunately, current technology cannot predict when a rock burst will occur. One way that rock bursts can be predicted is through identifying areas of high rock burst potential by the microseismic monitoring technique, which captures microcracking activity in underground mining panels. By obtaining the precise origin time, location and magnitude of microseismic events, mitigation and prevention of rock burst hazards can be appropriately managed. However, determining those three elements, especially the magnitude of energy release, is not easy. Many available methods, such as the reference sphere method, are not adequately accurate for indicating focus energy. From these backgrounds, in order to improve the accuracy of rock burst management, the author developed the new correction method for determining a precise value of microseismic focus energy and proposed the new assessment method for rock burst hazards by using the extracted parameters.

Chapter 1: This chapter describes the conceptual framework of the research including the problem statement, which stressed microseism and rock burst hazards in China, and the research objective and approach. A brief explanation of the microseismic and rock burst mechanism and the application of microseismic monitoring on rock burst management are also given.

Chapter 2: This chapter briefly describes three fundamental theories adopted in this research, consisting of microseismic focus energy calculation used in the reference sphere method, wavelet packet transform (WPT) in the denoising process and wave energy quantification, wave energy attenuation in rock masses and the characterizing parameter: energy attenuation coefficient (EAC).

Chapter 3: This chapter describes an advanced denoising process for primitive microseismic waves using the WPT technique. Denoising is a desirable step in wave processing to improve the quality of subsequent processes, and is obviously paramount when considering the study location, the Xingcun coal mine, which consists of complex folds, faults and nonlinear mechanical rock properties creating problems regarding noise. Moreover, the microseismic wave is also associated with noise induced by a geomagnetic field, electric discharge, and machinery operation. This chapter also describes the experimental set up concerning monitoring the seismograph to receive appropriate data by considering the microseismic focus. In this study, the wavelet packet basis function and specialty in Daubechies, Symlets and Coiflets families...
were elaborated. In order to specify the determination of the optimal wavelet basis, a wave group was randomly selected from the database and applied as the analysis object. It is found that the noise effect depends strongly on geological conditions; compared to the waves monitored in deep rock, waves monitored in alluvium have a higher distortion. Upon this finding, the data of alluvium was discarded from the database. The case study focused mainly on the data recorded in deep rock. On account of the analysis, results show that function 'sym5' from the Symlets family is the optimal wavelet packet basis suitable for microseismic wave denoising by WPT. The denoising process produced less noise waveform and accurate arrival time.

Chapter 4: This chapter describes transient characteristics of wave energy attenuation in deep rocks. The energy attenuation behavior of microseismic wave in deep rocks is closely related to the rock properties and structure. Therefore, a mechanism of wave energy attenuation is too complicated to be illuminated merely by an individual model or formula. In this study, a total of 158 wave groups have been screened and used as analysis objects. All waves have been treated in accordance with the discussion in Chapter 3. It was found that the spherical radiant energy of a microseismic event in deep rocks dissipates exponentially. High-energy wave components mostly concentrate in low frequency domains, which are generally less than 50 Hz. The energy-fitting inversion successfully reveals the microseismic focus energy and the EAC magnitude, and is an innovative method with a high dependence on waveform integrity, repositioning accuracy and the denoising process’s reliability. With a little error (less than 8%), energy accuracy corrected by this method is more reliable. The microseismic EAC magnitude indicates the distinct viscoelastic attribute of a rock medium, and the average level in the targeted coal mine is $3.144 \times 10^{-3}$ km$^{-1}$.

Chapter 5: This chapter proposes an overall assessment method for rock burst hazards in mining fields upon statistical distribution of corrected microseismic focus energy and a regional prediction method for rock bursts upon spatial distribution of microseismic EAC, respectively. For the former, a significant amount of dataset obtained from a long-term large-scale microseismicity observation in the targeted coal mine was used as the statistical sample and formatted by uniform criteria. A distribution-free hypothesis test was applied to determine the probable pattern of the data sample. Energy characteristics of abnormal microseismic events and the commonality with rock burst events were discussed. Hazardous microseismic outliers were identified. The microseismic energy gradient was determined, and the weighted energy eigenvalue was created to balance the hazard assessment. For the latter, a 3D distribution of the microseismic sample was structured. Microseismic EAC discretization in the corresponding individual path was processed based on two essential assumptions: the isotropous rock medium and straight wave path. A separate rock region endowed with a distinct EAC magnitude was precisely recognized via a matrix interpolation algorithm. Key findings show that anomalous critical values used for identifying microseismic outliers and the weighted energy eigenvalue of a continually increasing energy gradient play positive roles in evaluating the hazard level of rock bursts. The microseismic EAC magnitude in a spatial domain is practicable for implementation into the regional prediction of rock burst hazards in deep mining circumstances, and a lower EAC level implies a higher rock burst probability. These two methods are objective and effective, and introduce new insight into the hazard assessment and prediction of rock bursts.

Chapter 6: Main conclusions abstracted from the discussion are briefly summarized.