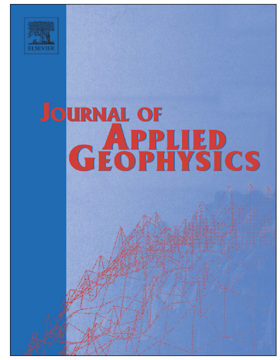

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The spatial-temporal evolution law of microseismic activities in the failure process of deep rock masses

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Abstract: Under high stress and blasting disturbance, the failure of deep rock masses is a complex, dynamic evolutionary process. To reveal the relation between macroscopic failure of deep rock masses and spatial-temporal evolution law of micro-cracking within, the initiation, extension, and connection of micro-cracks under blasting disturbance and the deformation and failure mechanism of deep rock masses were studied. The investigation was carried out using the microseismic (MS) monitoring system established in the deep mining area of Ashele Copper Mine (Xinjiang Uygur Autonomous Region, China). The results showed that the failure of the deep rock masses is a dynamic process accompanied with stress release and stress adjustment. It is not only related to the blasting-based mining, but also associated with zones of stress concentration formed due to the mining. In that space, the concentrated area in the cloud chart for the distribution of MS event density before failure of the rocks shows the basically same pattern with the damaged rocks obtained through scanning of mined-out areas, which indicates that the cloud chart can be used to determine potential risk areas of rocks in the spatial domain. In the time domain, relevant parameters of MS events presented different changes before the failure of the rocks: the energy index decreased while the cumulative apparent volume gradually increased, the magnitude distribution of microseismic events decreased rapidly, and the fractal dimension decreased at first and then remained stable. This demonstrates that the different changes in relevant MS parameters allow researchers to predict the failure time of the rocks. By analysing the dynamic evolution process of the failure of the deep rock masses, areas at potential risk can be predicted spatially and temporally. The result provides guidance for those involved in the safe production and management of underground engineering and establishes a theoretical basis for the study on the stability of deep rock masses.

Keywords: Microseismic monitoring; Rock mass stability; Apparent volume; b value; Fractal dimension

1 Introduction

With rapid economic development, China has reached an important development phase characterised by fast industrialisation and urbanisation, and therefore has a growing demand for non-ferrous metal resources. At the same time, the resource consumption is reaching an unprecedented peak. As shallow mineral resources are exhausted, the development and utilisation of deep resources has become the norm in the mining industry, however, the stability of deep rock masses also pose a grave threat to the environment and mining safety. Owing to deep mining being performed in a complex mechanical environment, mining disturbance is likely to cause the concentration of *in situ* stress, thus inducing the dislocation, deformation, and failure of strata. Mining and blasting can generate severe disturbance in deep rock masses and therefore very likely to trigger ground pressure hazards such as rockbursts, which threaten the safety of underground personnel and equipment. Therefore, the stability of deep rock masses is always a technical bottleneck restricting the safe, high-efficiency, sustainable development of deep mineral resources(Ma et al., 2012). Traditional methods for studying the stability of deep rock masses include field measurements, statistical methods, numerical simulation, and so on(Kaiser et al., 2001; Singh, 2002; Swift and Reddish, 2005). The failure of deep rock masses is generally assessed by analysing factors including the lithology of rocks, geological structure, ground pressure, and stress concentration in the surrounding rocks(Luo et al., 2016; Lv and Lv, 2011; Zhang et al., 2017). Hu and Kemeny (Hu and Kemeny, 1994) studied the mechanical effects acting between deep rock masses and filling bodies using fracture mechanics, and concluded that filling provides