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Spatio-temporal Characteristics of Acoustic Emission during the Deformation of Rock Samples with Typical Fault Pattern

Jiang Haikun (1,2) Ma Shengli (2) Zhang Liu (2)

(1) Earthquake Administration of Shandong Province, Jinan, China (Jianghaikun@sohu.com)

(2) State key Laboratory of Earthquake Dynamics, Beijing, China

1. Introduction

Four physical models with typical fault pattern have been designed and the sample were made from torpedo granite, with size of 300mm×300mm×50mm. Based on the accurate locations of AE (Acoustic Emission), the spatial-temporal characteristics of microfracture during rock deformation have been studied statistically through the biaxial compressional experiments.

In our experiments, axial and lateral stresses were loaded simultaneously to 5 MPa at a constant loading rate of 0.001 mm/s firstly, and then the lateral stress was kept constantly and the sample was deformed at an axial loading rate of 0.0005 mm/s, the average strain rate was about 1.67×10^{-6}/s. To reduce the friction between the sample and the loading steel blocks, the roller blocks were put between the sample and the lateral piston, the axial loading block was greased by lubricant of MoS_2. AE waveforms were recorded by a 16-channel AE monitoring system with 8-bit resolution at a sampling frequency of 5 MHz and with a sampling length of 1024 points. The intensity of AE was defined and calculated by the acoustic emission magnitude M_{AE}(Jiang, 2002). AE events, each of them at least has more than 5 clear P-phases, has been located. The results of the numerical test based on the actual experimental condition show that the locating errors, for more than 97% AE events, are smaller than diameter of transducers. Location algorithm used in this paper and the numerical tests see from reference (Jiang, 1999).

2. Spatio Temporal Characteristics of Acoustic Emission During the Deformation

of Rock Samples with Typical Fault Pattern

(1) For compressional and tensional jog models, the results show that the pre-existing structure can significantly influence the images of AE spatial distribution. With increasing of differential stress, AE events firstly cluster around the two ends of pre-existing faults inside the jog and then along the line joining the two ends. The biggish AE events often occur around one end repeatedly. The images of AE clusters indicate the direction of the crack propagation, which is perpendicular and parallel to the direction of axial stress for extensional and compressional jogs respectively. The weaken process before the instability is remarkable, and one of the typical precursors for the instability is that the cumulative frequency of AE events increases exponentially. Results also show that the features of AE sequences are strongly affected by the mechanical state. The high loading ratio corresponds to the high release rate of strain energy and low b values. Due to their lower failure strength, the broken area is sensitive to tiny variations of differential stress. Therefore, it offers a potential explanation for the phenomena of "sensitive site?.

(2) For collinear fault with a connected area model, due to the influence of strong locked area, it reveals a clear evolvement of "seismic gaps" around the connected area before the 98% of peak strength. The gaps gradually develop in time and constringe in space. Comparing with the elastic stage, the main area of AE activity migrated from active wall to the passive wall during the weaken stage. The frequency of larger AE events, as well as the AE releasing strain energy increased obviously during the weaken stage. AER reached the highest value at the moment before the fracture of connected area.

(3) In theoretic studies on earthquake mechanism, the concepts of "barrier", "strong area" (Mogi, 1977; Jones and Molnar, 1979; Brune, 1979; Kanamori, 1981), "strong body" (Mei, 1995)or "strong locked area" (Guo and Qing, 1991)are often used to explain the asymmetric seismic activity. Usually, it has been thought that the fracture of a barrier or stick-slip of a fault will lead to a strong earthquake. Because the strength of barrier rock (gabbro) is higher than that of the confining rock (torpedo granite. JIAO Mingruo, 2002) in our worksčňthe physical model of the regular fault containing a hard barrier can be conceptually simulated as the barrier or strong area inside the fault surface concerning the earthquake pregnancy. For this model, due to complex action between the hanging wall and lower wall, as well as the barrier, alternate AE activities in different regions become the most remarkable feature during the deformation process. The pre-condition for instability of this model is that the barrier should be failed firstly with the increase of the loading. The AE distribution features are very different before and after the barrier failure. The cumulated AE frequency also increases exponentially before the instability. During the rock weaken stage, there are only a few

AE events distribute in barrier and surrounding area. Abrupt instability happens under such a relative quiescent background.

3. Changes of b value

The changes of b value for four models show the typical changing pattern of ?decreasing tendentiously→returning quickly? before the instability. The decrease of b values occurs in the process of stress increasing and sometime goes down to the weakening stage, and the quick increase of b values appears in a short time just before the instability. The comparative analysis shows that the b values for different pre-setting tectonic patterns have some obvious differences, that is larger than b value variation caused by increase of the differential stress. The regional differences of$b$ value interrelated to different tectonics are remarkable for some extent.

Key words: Acoustic Emission, compressional and tensional jog , collinear fault with a connected area, regular fault with a hard barrier, differential stress, biaxial compressional experiment

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