SCALING LAWS OF DAMAGE-FAILURE TRANSITION IN ROCKS: FROM LABORATORY TESTS TO EARTHQUAKES

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1. General

Empirical observations showed that the earthquake events can be linked with dynamics of triggered slips at the top layer of the Earth crust on a wide range of spatial and temporal scales. These phenomena are characterized by the interaction of different mechanisms related to crack nucleation and propagation along numerous faults with pronounced friction properties of fault interfaces. The threshold character of earthquake events occurs due the complexity of phenomena that have the features of self-organized criticality in the defect ensembles of different scales and can be analyzed under laboratory tests for damage-failure transitions in rocks. Statistical mechanics of mesodefects and statistically based phenomenology allowed the consideration of dynamics of slip-block systems in the presence of noise for the interpretation of scaling laws in seismicity – the Gutenberg-Richter, Omori, Bath laws and the links of scaling laws in seismicity with new type of critical phenomena – structural-scaling transition.

The explanation of the self-criticality nature of seismic events (pre-shocks, main-shocks and aftershocks) is related to the self-similarity of scenario of damage-failure transition due to the subjection to dynamics of mesodefect collective modes. It was shown that the evolution of characteristic types of collective modes (triggering waves and dissipative blow-up structures) reflect different scenario of the spinodal decomposition for qualitative different metastability of thermodynamic potential under transition of critical value of structural-scaling parameter. Since the problem concerning the representative volume for the study of scaling laws related to the earthquakes is one of the key questions the laboratory compression tests for the rocks combined with the analysis of acoustic emission data were performed.

The laboratory compression tests for gypsum and carnallite blocks combined with the acoustic emission data recording was realized and the correspondence of acoustic emission sequences to the Gutenberg and Omori laws was found.

2. Experimental conditions

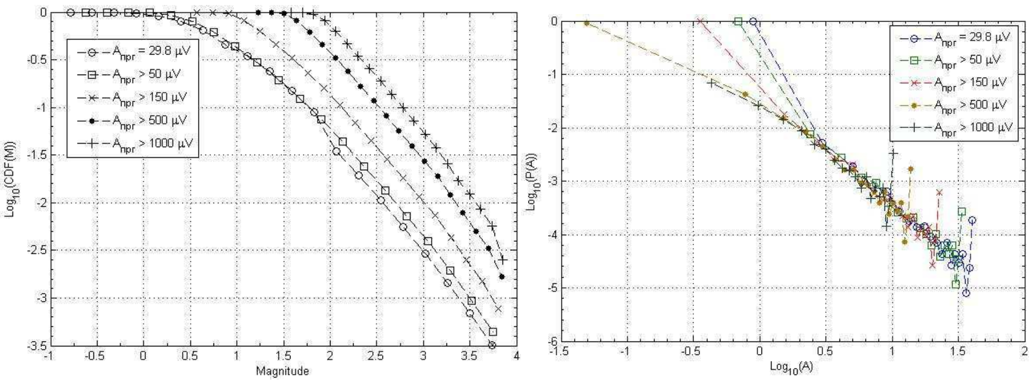
Experimental study of scaling laws under damage-failure transition in salt rocks (Verchnekamskoe potash deposit) and gypsum rocks (the Novomoskovsk deposit) was carried in laboratory conditions. The cube specimens had characteristic sizes about 60 mm. The acoustic sequences in loaded salt rocks (silvinite, carnallite) and gypsum rocks were recorded under quasi-static uni-axial compression tests for relaxation and creep at room temperature using electromechanical testing machine Zwick 250. Vallen Amsy 5 system was used for the registration of acoustic emission signals using high-frequency VS2MP (350-2000 кГц) and low-frequency AE104A (50-400 KHz) gauges.

Sequences of acoustic events (AE) in laboratory test were identified as the sequences of seismic events under earthquakes. The magnitude was determined as amplitude of AE signal divided by its duration.

3. Experimental results

The correspondence of acoustic events in the laboratory test to the scaling laws under earthquakes was found according to the Gutenberg - Richter law for all investigated rocks in the frequency range 50-2000 kHz. Fig. 1.a represents the distribution of AE magnitudes under carnallite relaxation. The exponent value for different thresholds of recording equals 1.2. Fig.1.b reflects the data for AE amplitudes that is linear. Similar distributions were obtained for creep conditions.

The AE sequences during rock relaxation were considered as aftershock events. The distribution of AE obeys Omori law with exponent equals one.



a) b)

Fig.1. Gutenberg - Richter's law at 50-400 кHz spectral range under relaxation of carnallite. The curves correspond to different thresholds of recording (a). AE amplitude distribution for different thresholds of recording (b)

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