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The development of a complex acoustic deformation method to fix reliable precursors of rock failure under uniaxial compression

The investigation of the generality of failure of brittle rock samples was carried out in the Laboratory of Geodynamics of the Far Eastern Federal University, Vladivostok, Russia. In the course of testing, the complex acoustic deformation method was used performed by the servocontrol loading machine MTS-816. As a result, established were the regularities of the appearance and development of dissipative mesocracks structures in rock samples under uniaxial compression. The deformation of greatly stressed rock samples was connected with the properties of the acoustic emission radiation of the sample. It enabled one to determine the system of reliable precursors of failure of rock samples both long-term and short-term ones. The system of the precursors represents all stages of the appearance and development of

System of reliable precursors of failure involving long-term and middle-term was established. This system of precursors reflects the stages of formation and development of dissipative mesodefect structures in high stressed rock samples.

*Key words: r*ock sample, deformation, acoustic emission, precursors, complex method.

Introduction

Achievement of put goal of detection reliable precursors of rock samples failure needs a realization of complex experimental researches [3]. It is direct to research of regularities of source of failure forming in rock samples under uniaxial compression and changes regularities of deformations of lateral surface of rock samples which associates with source of failure forming [1].

Laboratory experimental researches should be carried out by complex acoustic-emission and deformation methods. It lets relate deformation anomalous and source of failure forming in rock samples under pre-failure load.

Preparation of experimental studies

Complex deformation and acoustic-emission method have to be carried out with some special necessities.

The minimum number of acoustic emission sensors should be four. And the record of signals should be provided at all stages of the development of source of failure [2]. Fixing the position of acoustic emission events should be done with an error less than 1 mm.

The number of strain gages fixed on the sample must be at least four for each type of deformation. They are placed evenly around the perimeter in the average height of the side surface of the sample without overlapping each other.

The strain gages should be placed at a minimum distance of 5 mm from the planes created for place of AE sensors to prevent distortion of the sensor readings.

Synchronization of readings of acoustic emission and deformation should be carried out on one computer on the testimony of a system timer for maximum synchronization accuracy with the accuracy of clock cycles of the central processor unit. If this is technically impossible, it is necessary to synchronize the system time of both systems on the same local server time synchronization that gives acceptable accuracy within 50 milliseconds.

The research to identify reliable precursors of the destruction was carried out on cylindrical specimens. The ratio of height to diameter was made h/d=2 [2].

Developed a complex method of deformation and AE researches was used for test cylindrical samples of rhyolite with a diameter of 64 mm and a height of 128 mm. Layout of sensors for complex researches is presented in Fig. 1.

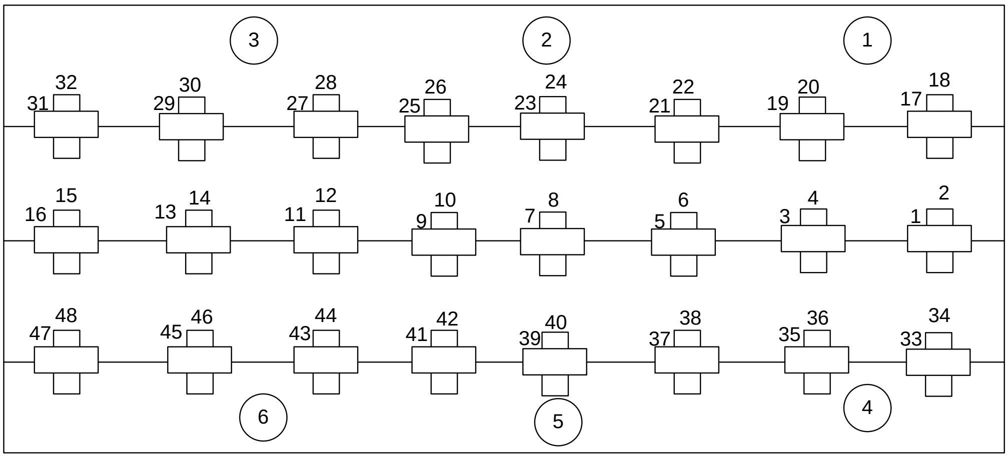

Fig. 1. Layout of sensors

The process of sample preparation for the test involves grinding the faceplates, marking positions for the fixing of sensors. Further, the side surface of the sample is degreased, strain gauges are glued in accordance with the selected scheme of their placement, AE sensors are mounted (Fig. 2).

Fig. 2. Rock sample prepared for test

Testing of rock samples by complex deformation-AE method was carried out in the Laboratory of Geodynamics of the Engineering School, Far Eastern Federal University, Vladivostok. Loading was performed by servo-hydraulic test machine MTS-816 (Fig. 3).

Results of test

Below the results of measurement of parameters of AE sample No. 23 tested by complex method are presented. Data on changes in the rate of acoustic emission radiation and the average amplitude of AE signals are presented in Fig. 4 and Fig. 5.

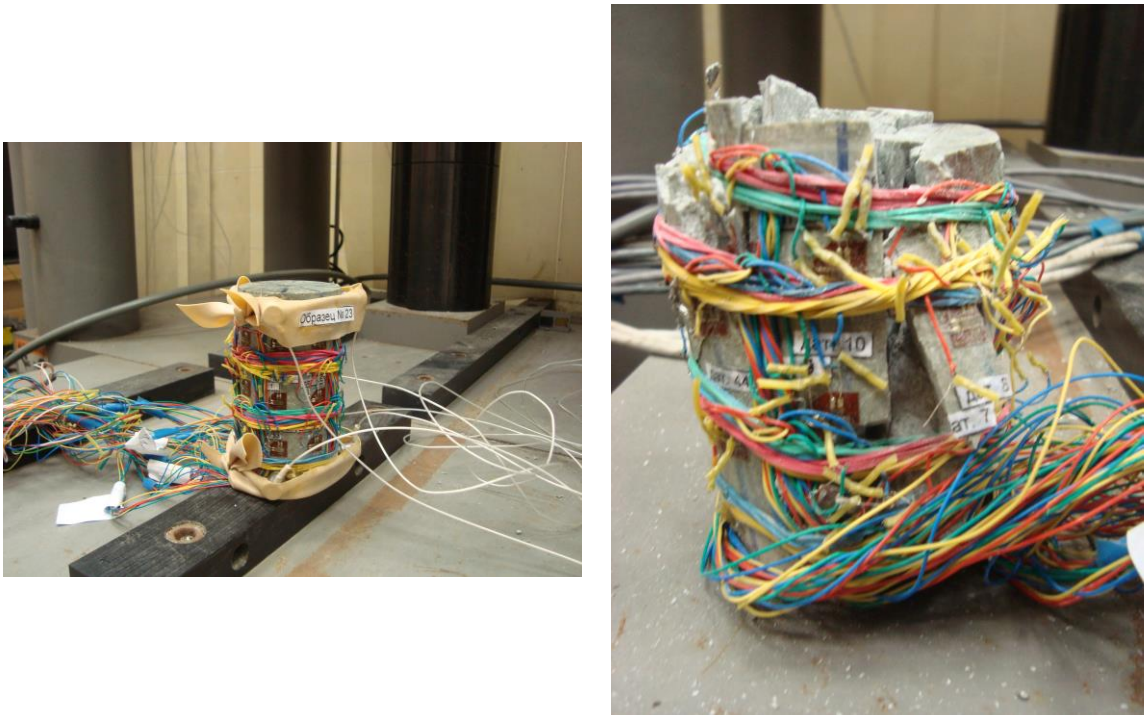

Fig. 3. Rock sample N 23 before and after test

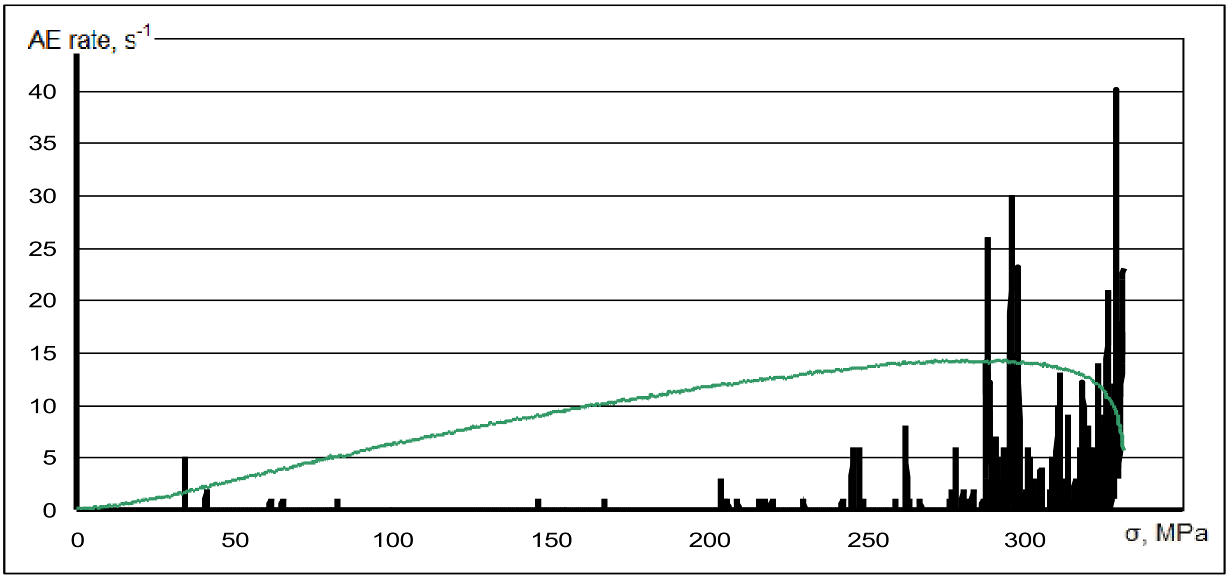

Fig. 4. Change of AE events rate during loading, sample N 23

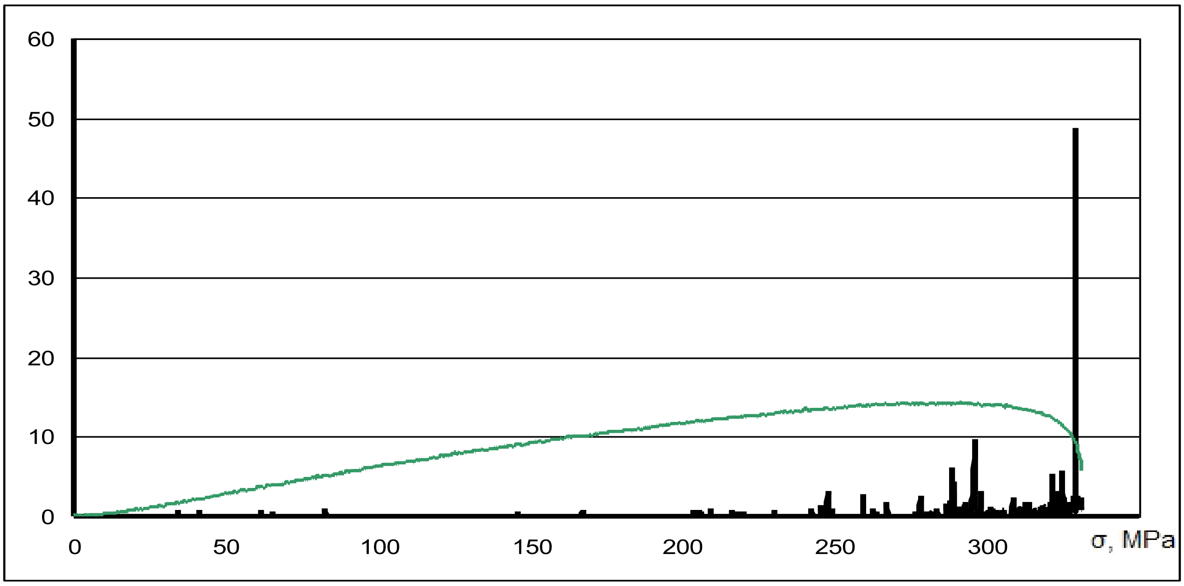

Fig. 5. Change of average amplitude of AE events during loading, sample N 23

Deformation curves of linear deformations for the central part of the specimen are shown in Fig. 6. It is seen that flattening of the curves is observed with decreasing the modules deformations in 1,5–3 times at pre-failure stage of loading. There is a reverse linear deformations in other areas.

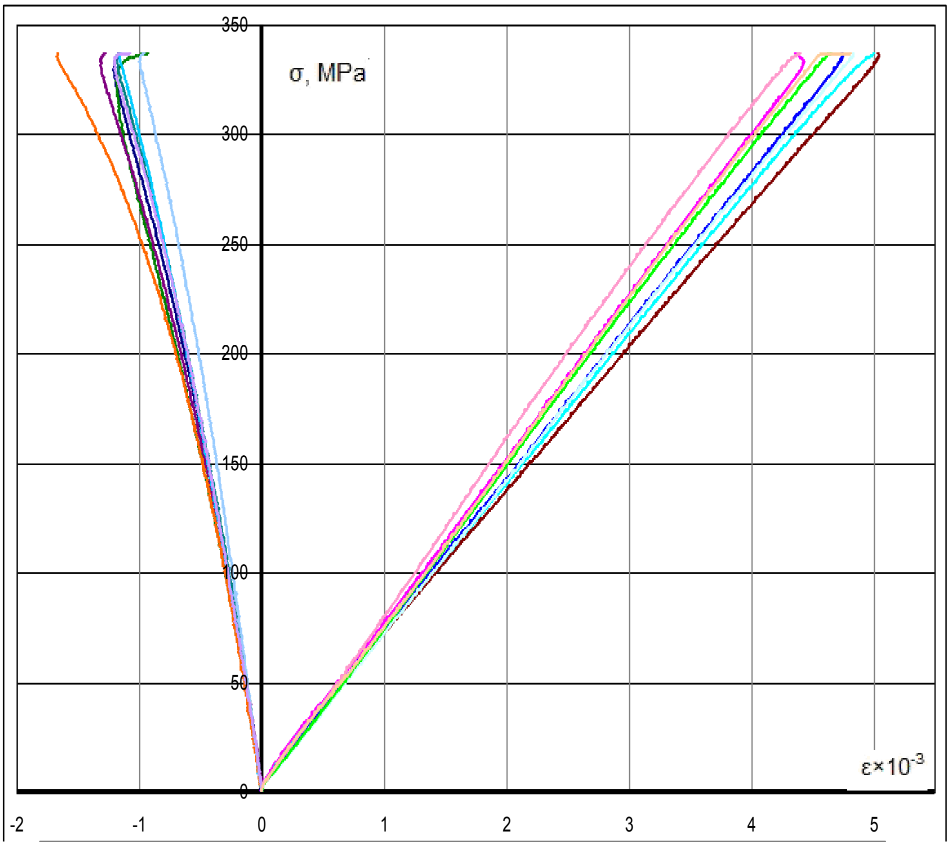

Fig. 6. Regularities of rock samples deformation: linear deformations, central part of sample N 23

Further analysis shows that zones with different deformation characteristics formed in the sample. Fig. 7 shows a typical linear deformations in the area of maximum thinning.

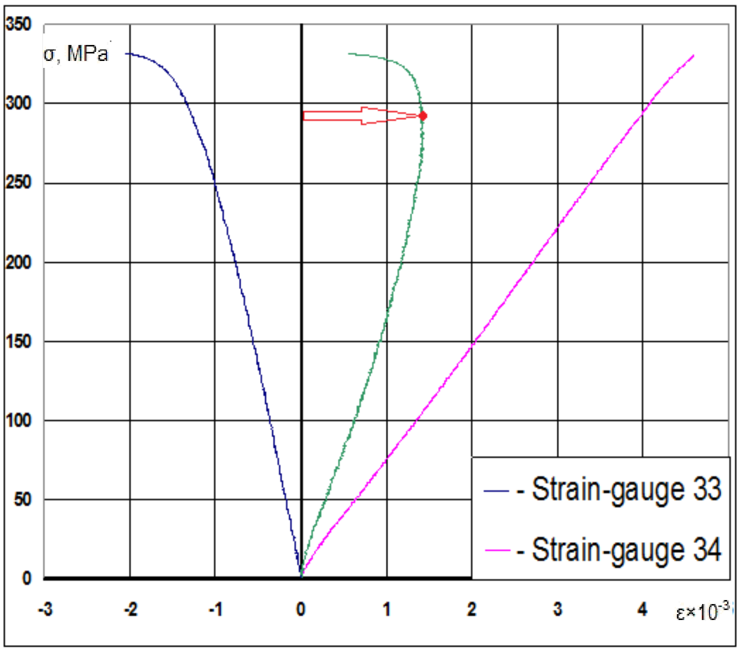

Fig. 7. Area of maximum thinning, linear deformations at pre-failure stage of loading

This area at pre-failure stage of loading is characterized by an increase of the transverse and longitudinal deformations. The curve of volumetric strain becomes U-shaped. Such behavior testifies to the intense increase in this area of the sample.

At the same time the formation of areas of compression with reverse linear deformations in the direction of the loading axis relative to the area of decompression are observed. This region is characterized by a reverse longitudinal and transverse deformations, in this case negative increment of longitudinal deformations exceed the negative of the transverse strain increment (Fig. 8). We denote this type of deformation as a reversible deformation of the first type. Such anomalous nature of the deformation due to the influence of the decompression zone, located under the zone of reversible deformation of the first type, which leads to the formation of the compression region in a direction along the axis of loading.

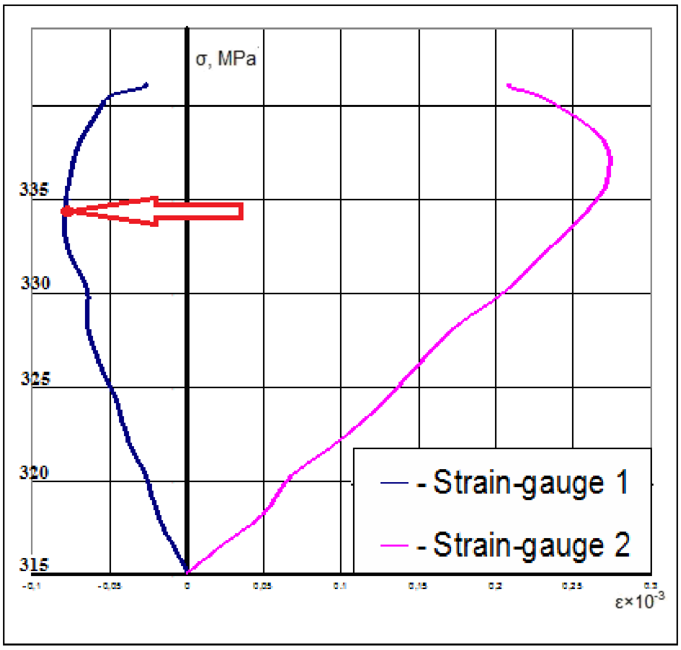

Fig. 8. Area of reversible deformation of the first type at pre-failure stage of loading

At the same time another area is formed in the neighboring area of decompression. This zone is characterized by negative increments of longitudinal and transverse deformations. But in this case module increment of transverse strain exceeds the modulus of the increment of the longitudinal deformation (Fig. 9).

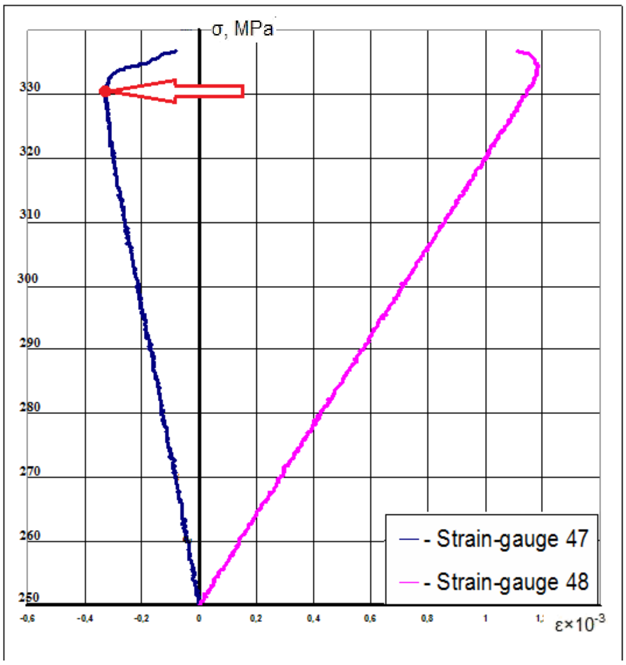

Fig. 9. Area of reversible deformation of the second type at pre-failure stage of loading

This type of deformation is observed in the vicinity of the decompression region perpendicular to the loading axis. We denote this type of deformation as a reversible deformation of the second type. This deformation indicates the direct impact zone of decompression on the anomalous behavior of rock in a nearby field. The increase of volume in the area of decompression causes compression in the neighboring regions, perpendicular to the loading axis.

Precursors of failure

Based on the data presented above, it becomes possible to compose the system reliable precursors of rock samples failure under uniaxial compression. To determine precursors requires the use of both acoustic and deformation data. As a long-term precursor is taken increase the intensity of AE rate, the simultaneous increase of the average amplitude of the recorded signals and the simultaneous achievement of the threshold of dilatancy in the areas of maximum decompression (Fig. 10).

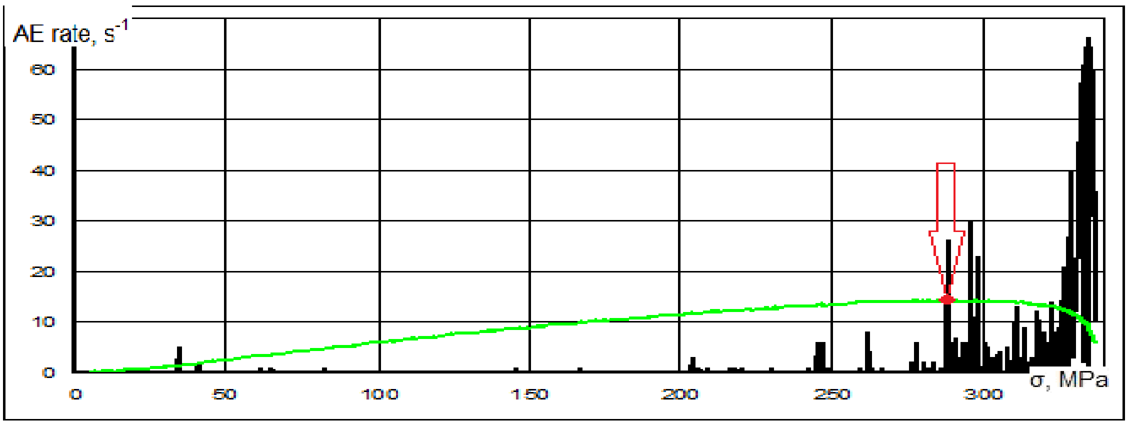

Fig. 10. Long-term precursor: change of AE rate, AE average amplitude is coinciding with the threshold of dilatancy

As a middle-term precursor is taken the moment of reverse of the linear deformations in the areas immediately adjacent to the areas of greatest decompression and a simultaneous increase of AE rate that excess AE rate recorded during long-term precursor (Fig. 11).

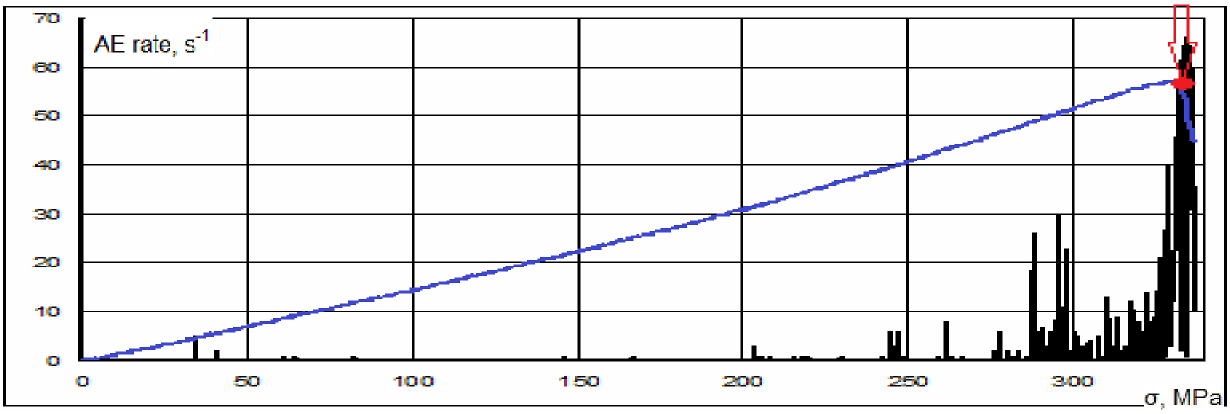

Fig. 11. Middle-term precursor: increase of AE rate is coinciding with reverse of linear deformations

Also research show the period of zero increase of deformations while load is growing accuracy before failure. It may indicate the moment of stable macrocrack forming and may be used as a short-term precursor.

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Механизмы разрушения горных пород / Rock Failure Mechanism

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Разработка комплексного акустико-деформационного метода фиксации надежных предвестников разрушения образцов горных пород при одноосном сжатии

Исследование закономерностей разрушения образцов горных пород проводились в лаборатории геодинамики Дальневосточного федерального университета (Владивосток). Испытания проводились комплексным акустико-деформационным методом на сервоуправляемой испытательной машине MTS-816. В результате комплексных исследований были установлены закономерности формирования и развития диссипативных мезотрещинных структур в образцах горных пород в предразрушающей стадии нагружения при одноосном сжатии. Картина деформирования сильно сжатых образцов горных пород была связана с характеристиками акустико-эмиссионого излучения образца. В результате определена система надёжных предвестников разрушения образцов горных пород, включающая долго- и среднесрочный предвестники. Данная система предвестников отражает стадии формирования и развития диссипативных мезотрещинных структур в сильнонапряжённых образцах горных пород

Ключевые слова: образец горной пород, деформирование, акустическая эмиссия, предвестники разрушения, комплексных метод.

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