# Statistical Regularities of a Main Crack Formation in Rocks. Acoustic Emission and X-ray Microtomography

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The peculiarities of the formation of a main crack in the Westerly granite samples under quasistatic uniaxial compression without any lateral upthrust have been studied using the data of acoustic emission (AE) and X-ray computer microtomography (CT). We have tested two sample series. The first series contained the specially fabricated cylindrical samples with plane nonparallel edges (non-parallelness was $\approx 0.5°$); the second series were standard cylindrical samples with plane-parallel edges. The absence of the edge parallelness allows us to apply a pronounced shear stress component during a uniaxial quasi-static compression. In the second series, the load was removed a short time before the sample macroscopic fracture occured; while the acoustic emission still being recorded. This loading algorithm allowed to study the process of stress relaxation in a material with a developed defect subsystem.

Multifractal analysis was applied for research of intervals between sequential AE-signals in the time series. Series were divided into partially intersected sequences, consisting of 1024 elements. Singularity spectrum was evaluated for each sequence. Two main system parameters – Hurst coefficient and spectrum width were computed and plotted as functions of time. One should notice that while approaching the destruction time, the Hurst coefficient become larger while the spectrum width lower. Based on these facts, it was concluded that fractal self-organization occured before the material destruction, i.e. the process nature changed from more complicated multifractal to more simple monofractal one.

We carried out a detailed analysis of the energy distribution functional form of the AE-signals. In all the experiments, using the method of successive approximations, we succeeded in the determination of the critical time, after which the energy distribution becomes a power-law one, while before this time moment, the energy distribution is described by the exponential function.

In all the experiments samples conserved their integrity, which allowed us to carry out the tomographic study. Based on the analysis of the tomographic slices we constructed the three dimensional model of the defect structure. In samples with nonparallel edges, one plane crack has been formed; parallel to the sample axis and disposed near its edge, which was caused by the fact that the sample edges were nonparallel. This indicated a predominantly shear character of the crack formation.

The three-dimensional area of microcracks localization (main crack origin) in samples of second series has a more complex shape and is inclined with respect to the sample axis at some angle. It is important to note that in both these cases defects formed only in the vicinity of the main crack; no defects were detected in other parts of the samples. Therefore, no disperse accumulation of defect observed beyond the crack area.

In this work the analysis of the energy distributions of the acoustic emission signals allowed us to separate principally different stage of the main crack extension , despite the spatially localized character of defect accumulation revealed by X-ray microtomography. This fact demonstrates the universality of the approach used and the regularities revealed.

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