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Hierarchical properties of AE amplitude spectrum of rock fracture

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The principal point in the hierarchical description of a system is the possibility of selecting discrete subsystems in it which are called levels, or ranks of the system [1]. A certain set of properties and parameters which permits one to consider the given subsystem separately enough is meant by rank. The independence of ranks is not absolute; there is an interaction between them that is asymmetric. This manifests the fact that a change of a parameter at an upper rank j may lead to a significant change of a state at lower ranks j-n (n = 1, 2...), while the effect of lower ranks on upper ones is much less. The asymmetric character of the dependence between the ranks results in their certain ordering, which makes this system hierarchic. Let us note two important properties of nature multilevel systems. The division of a given system into ranks is ambiguous and depends on the way of description and analysis aims. There is always overlapping between ranks.

Beginning from studies [2] which were the base of the notions on rocks as discrete multilevel environments, the studies of corresponding properties of a material and processes originating at its deforming have been rapidly developed. At present, there are convincing confirmations of the self-similarity in the arrangement of the structure of rocks and the processes proceeding under the action of mechanical loading in space and in time [3, 4, 5] In particular, this is why the studies of the regularities of fracture of rocks under laboratory conditions with further extrapolation onto large scales appear to be of current concern.

Within the framework of the present study the experimentally confirmed similarity principle is of importance, since it allows the natural formalization of the determination of the hierarchy level or rank to be done with respect to the destruction processes

of rocks. By the rank of fracture we mean the range of the change of space-time, energetic and other parameters of the process whose regularities are similarly translated onto other scales. The similarity principle manifests most generally in empirical dependencies of space-time parameters of the process on the energy released at the fracture [6], which permits considering it as a universal scale for the determination of levels to be found. The present study follows the researches of the regularities of the variation of acoustic emission (AE) [7] recorded upon the fracture of granite samples under laboratory conditions. It tries to formulate the hierarchical model of rock fracture.

Time variations of the of function probability density (Pa) of amplitudes of AE signals detected during deformation of granite have been studied [8]. The time evolution of amplitude spectra has characteristic points associated with qualitatively different spatial-temporal stages of fracture which point to a multilevel nature of the process. The amplitude ranges corresponding to definite ranks of defect formation have been found. The indication of the boundaries of these ranges is the constancy of Pa magnitudes. An antiphase variation in the probability density of amplitudes corresponding to neighbouring ranks of the process has been revealed. A pronounced correlation between these pairs of amplitudes throughout the deformation process in the sample points to the interaction between relevant defects.

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