The Study of Precursors of Failure Under Biaxial Compression

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Summary – The process of failure preparation in model material has been studied. To constrain the deformation and fractures to a certain zone within the sample the biaxial compression tests have been chosen. During the deformation the cross-like zone, consisting of a great number of small cracks, appeared followed by the development of macrofracture in the central part of the specimen. The strong minimums in velocity of ultrasonic waves, changes of strain rate, and self-electric potential reliably pointed to the approaching moment of failure.

At the Institute of Physics of the Earth, a programme of laboratory investigations is being carried out to examine the basic laws of the fracturing process for application to the physics of earthquakes. The programme includes investigation of the development of single fractures, interaction of fractures, and formation of macrofractures. Measurements are conducted under different states of stress and with different materials (Vinogradov et al. [1]; Schamina et al. [2]; Volarovich et al. [3]). In this paper we consider only one series of experiments made by the author with Z. J. Stakhovskaja and A. V. Kolzov.

To constrain the deformation and fractures to a certain zone within the sample we used the biaxial compression tests. The experimental arrangement consisted of a massive frame and piston. The specimen was tightly adjusted to the mandrel so that under vertical loading in one horizontal direction, displacement was held at zero, leading to the development of stress in this direction. Two faces of the specimen were free. This method of loading, together with friction on the confined faces of the specimen, leads to a complex stress state. Plexiglass was used as a model material, the transparency of the plexiglass permitting the interior of the sample to be observed during an experiment. The specimens had the shape of a parallelepiped and dimensions of $40 \times 40 \times 30$ mm. The tests were conducted under slow loading and lasted from one to two hours in order to prolong all the processes going on within the specimen and to permit termination of the test at the first appearance of visible fractures. Before the experiment the constrained sides of the specimen were marked with a $0.5 \times 0.5$ cm$^2$ grid.

During the deformation two cross-like zones consisting of a great number of small cracks would appear followed by the development of a macrofracture in the central

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part of the specimen. In Fig. 1a one can see the photo of a partially fractured specimen. We noted that macrofracture appears inside the specimen which is, to a certain extent, analogous to processes in the earth. Figure 1b shows full failure of the specimen. From the displacement of grid lines the local deformation can be estimated. The force, total strain, and velocity of longitudinal ultrasonic waves along the axis of main loading were measured during the test. The self-electric potential was measured between an electrode fixed to one of the free faces of the specimen (Fig. 2) and the ground. Longitudinal mode ceramic transducers (ZTS-18), with a natural resonant frequency of approximately 760 KHz, were used for the ultrasonic measurements. Total deformation was registered with the help of deformometers in the form of rings with strain-gauges attached to them.

Figure 2 shows the results of one of the experiments. The loading of the specimen