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Laboratory modeling of seismoelectric effects in rock

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It is well known that deformation of rock by seismic waves is accompanied by a complex of various electromagnetic effects of different physical natures. These phenomena are widely used in exploration geophysics and well tests, besides that these effects are of great interest in forecasting catastrophic events, such as rock bursts in mining operations. For adequate interpretation of experimental results it is necessary to understand the physical nature of the seismoelectric effect. Despite of a considerable amount of performed investigations, no general model of the phenomenon has been developed yet. The known sources of electric signals in rock are electrokinetic phenomena, piezoelectric phenomena, triboelectricity, contact electrification, induction phenomena and the effect of charged edge dislocation oscillations. One of the urgent questions is studying the relationships between form and amplitude of the seismic pulse and the electric signal.

In this work an experimental investigation is presented of the process of electric signal origination in hard rock, which does not contain fluid in an explicit form. The constructed laboratory set-up allows to make experiments with compressional waves of a wide range of amplitudes and frequencies. It also allows to simulate both continuous media, and fractured rock. Marble, granite and a model material made of hyposulphite mixed with granite crumb were used in this research. Longitudinal waves of different intensities were initiated in the model by impacts of balls of different masses. The constructed one-dimensional model – the rod – provides conditions for formation and propagation of a plane wave as well as a noticeable delay of the arrival of the tension wave reflected from the free end of the rod. This permitted to sort out clearly the electric signals accompanying propagation of a longitudinal compressional wave and to find out the degree of correlation between the parameters of electric and mechanical signals. It is shown that a dry rock can be a source of highly mobile electronic charge carriers. It is also shown that there are two kinds of variations of the electric field. The source of the disturbance of the first sort is localized in the point of dynamic shot and is caused by origination of microcracks in the impact point. This kind of variations of electric field appears in the silica-base rocks. The form of this "instant" electric response is controlled mainly by the particle velocity in seismic wave, i.e. by the form of dynamic stress. Variations of electric field of the second sort have a coseismic character, i.e. the electric signal arises simultaneously with a seismic wave. It is shown that the intensity and the form of coseismic electric field variations are controlled by the form of acceleration or strain rate of the medium. This work was partially supported by RFBR grant № 09-05-00614-a.