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Abstract

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ELECTRO-SEISMIC EFFECT

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The seismo-electric effect of the second kind, discovered by A. G. Ivanov ([1]) and theoretically substantiated by Ya. I. Frenkel ([2]), manifests itself in soils and rocks when they contain dissociated ions of dissolved salts moving relative to the rigid framework of the rock. In essence, this effect is a geophysical manifestation of one of the known electrokinetic phenomena ([3]), the so-called streaming potential, or filtration potential. The author succeeded in reproducing the seismo-electric effect of the second kind under laboratory conditions ([4]). Electrokinetic phenomena reciprocal to the streaming potential are also known: electroosmosis or electrophoresis, consisting in the motion of a liquid, or of particles suspended in it, under the influence of an external electric field. It is natural to assume the existence of a geophysical effect reciprocal to the seismo-electric one: the occurrence of oscillatory deformation of a rock (containing in its pores a dissociated solution of metallic salts) when an alternating potential difference is applied to it.

Indeed, since in a rock the motion of dissociated ions under the influence of electric polarization can occur only in chaotically arranged capillary pores, some of them will inevitably collide with the molecules of the rigid framework of the rock, transferring part of their kinetic energy, i.e., exciting mechanical oscillatory motion of the framework.

The first experiment in the laboratory detection of the electro-seismic effect was performed on a shale rod that had previously been used to reproduce the seismo-electric effect of the second kind ([4]). The electrodes were two collars made of sheet brass, one of which was placed on the middle part of the rod, and the other on one of its ends. The shale, previously soaked for twenty-four hours in water and slightly dried to remove the moist film from the surface, was excited by an alternating voltage of audio frequency, the source of which was an audio generator with an output resistance of 10,000 ohms.

Bringing one end of the rod close to the ear, it was possible to notice that the rod sounded when the frequency of the exciting electrical oscillations coincided with one of its natural frequencies (about 2800 Hz and somewhat above 5000 Hz). Despite the great sharpness of the resonances, this sound was so weak that it could be heard only in a quiet room at a noise-interference level not exceeding 25–30 phons. Attempts to measure the intensity of the sound with an objective sound-level meter were not successful.* Nevertheless, the sound was quite clearly detected by ear, and its use—

* Standard sound-level meters with a piezoelectric microphone are suitable for measuring sound with a level not lower than 35 dB. The level of the sound radiated by the rod in our experiment was below the sensitivity threshold of the sound-level meter.

source—the rod—was clearly localized. At frequencies different from those indicated above, no sound was observed.

The experiment described could be regarded as proof of the real existence of the electro-seismic effect, if doubts about the absence of contact effects were eliminated. At the point of contact between the slate and the brass electrode, for example, the Johnsen—Rahbek effect ([5]), or some other contact effect, could have appeared, which might also have been the cause of the sound of the rod.

To verify the existence of the electro-seismic effect independently of contact phenomena, several other types of contacts were tried:

1) Plates of thick brass with a layer of crumpled tinfoil, tightened with bolts and providing a very tight mechanical contact.
2) Soldering of the conductors by means of a low-melting alloy (melting point about 60°) into recesses drilled in the rod.
3) A mercury contact in the same recesses.
4) A nonpolarizing contact made by means of a cotton plug impregnated with a solution of vitriol and connecting the end of the conductor with the rod (there was no direct contact of metal with the rod).

All these types of contacts were tested with an unchanged result: the sound of the rod at its natural frequencies did not cease; the numerical values of the frequencies remained quite stable.

Subsequently, the experiments were repeated with rods up to 250 mm long, cut from red building brick or cast from gypsum. These materials possess a rigid framework and relatively high porosity, which makes it possible easily and quickly to impregnate the rods with solutions of metallic salts, for which salts of silver (spent fixer or developer) and copper (copper vitriol) were used. The electro-seismic effect was noted in all cases when the rod had been impregnated and had not yet had time to dry completely, or when a previously impregnated and dried rod was moistened again. Dry rods and rods not impregnated with metal salts could not be excited. Excitation of the rods was carried out chiefly through nonpolarizing contacts. In the experiment with rods impregnated with a solution of copper vitriol and provided with nonpolarizing vitriol contacts, any contact phenomena were obviously absent, since the entire specimen was saturated only with ions of dissociated vitriol. Nevertheless, no specific features in the behavior of the rods in these experiments were observed.

In all the cases observed by us, the intensity of the sound of the rod was in direct dependence on the amplitude of the exciting voltage. However, the intensity of the sound increased with an increase in voltage only up to a certain limit (about 150 V). A further increase in voltage, up to 400 V, did not produce any substantial change in the intensity of the sound. At the same time, the electrical power dissipated in the rod increased with increasing voltage, as evidenced by the rise in the temperature of the rod. The causes of "saturation" in the electroseismic effect have so far remained unexplained.

It was suggested that the observed effect might be one of the manifestations of electrostriction ([6]), which is the mechanical deformation of a solid or liquid dielectric under the influence of an electric field. It is known that, in electrostriction, the deformation increases quadratically with the growth of the exciting voltage. Therefore, for example, the additional application of a constant polarizing voltage should have caused a considerable increase in the amplitude of the rod' s vibrations, sharply increasing the loudness of the sound. To test this, an experiment was carried out in which the rod was polarized by a constant voltage up to 600 V. The voltage supplied from the audio generator was varied within the limites-

···from 40-50 V to 100-120 V, i.e., it was certainly below the "saturation" threshold. When the polarizing constant voltage was switched on, no change in the level of the rod' s sound was observed. The increase in the electrical power dissipated in the rod, as in the preceding case, manifested itself in its heating, which grew with the increase in the polarizing voltage. The constancy of the rod' s sound in the experiment described is direct evidence of the absence of electrostriction.

The impossibility of exciting the effect in an unmoistened rod indicates that in our observations piezoelectric phenomena, observed in rocks by M. P. Volarovich and E. I. Parkhomenko ([7–9]), were also absent.

The observations described leave no doubt as to the existence of the electroseismic effect, which is a new, previously unknown geophysical effect, reciprocal to the seismo-electric effect of the second kind.

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Note: Figure translations are in progress. See original paper for figures.