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Electromagnetic Manifestation of Earthquakes

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Abstract. In a joint analysis of the results of recording the electrical component of the natural electromagnetic field of the Earth and the catalog of earthquakes in Kamchatka in 2013, unipolar pulses of constant amplitude associated with earthquakes were identified, whose activity is closely correlated with the energy of the electromagnetic field. For the explanation, a hypothesis about the cooperative character of these impulses is proposed.

1 Introduction

In this paper the data for year of 2013 regarding seismic activity (represented by the Kamchatka branch of the geophysical service of the Russian Academy of Sciences), and the signal of the vertical electric component of the electromagnetic field of the ELF-VLF range (registered at the Karymshin observation station of the IKIR FEB RAS) we compared.

2 Data analysis

During the visual analysis of the waveforms of the initial data in the time vicinity of the earthquake moment, attention was drawn to the presence of unipolar pulses accompanying earthquakes. The range of these pulses is ten times higher than the background value, while its shape remains unchanged. The pulse duration is about 0.4 milliseconds (Figure 1).

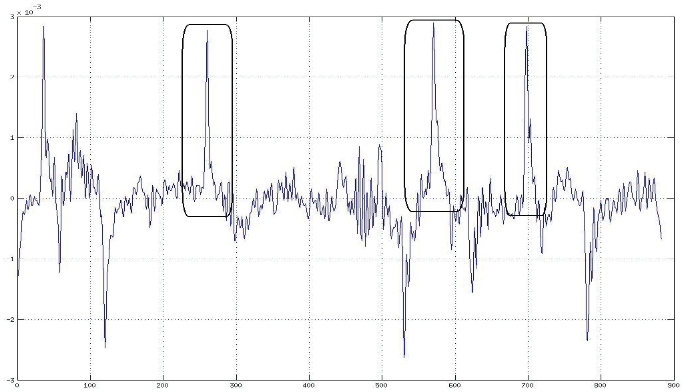

Fig. 1. Unipolar pulses of electromagnetic radiation appearing near the time of the earthquake. Electrical component. Unipolar impulses are singled out.

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For the subsequent analysis of the mentioned phenomenon, a consistent filtering of the original data was carried out using the reference sample obtained by averaging the anomaly value (Fig 2). Stable anomaly of the electric component of the electromagnetic field, which appears near the moment of the main earthquake push. Above is the individual anomaly. Below is the anomaly is averaged by 50 individual implementations.

The Figure 3 shows the results of signal processing using as an example the earthquakes of 2031/02/28 14:00.

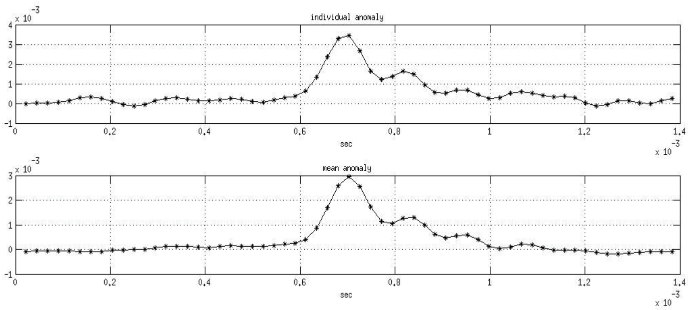

Fig.2. Initial data and processing results. 1 - initial signal. 2 - signal subjected to optimal filtration. 3 - rms value of the original signal. 4 - dispersion of original signal. The moment of the earthquake is marked by the arrow.

3. Pulse properties

Analysis of these graphs shows that

At the time of the earthquake, the activity (the number of pulses per unit time) of unipolar pulses corresponds to the background level

- The activity of unipolar pulses reaches its maximum 2-4 hours before and after the earthquake
- The activity of unipolar pulses is extremely closely correlated with the moments of maximum intensity values
- The amplitudes of different unipolar pulses are the same.

4. Model of deformation process

As is known, the process of deformation of a solid body by its conversion character has two extreme forms - an evolutionary one, at which a continuous change in the body is observed, and a catastrophic one, in which the structure of the body changes abruptly. The process of evolutionary deformation is accompanied by the birth and elimination of structures that impede the evolutionary process of deformation (stoppers) formed from stronger structural heterogeneities by piling up these heterogeneities with the formation of impassable formation. These stoppers can be eliminated in two ways: either as a result of thermal diffusion, or when disrupted by the accumulated stress. If the rate of birth of stoppers is lower than the rate of their annihilation, then evolutionary aseismic development of deformation occurs. The equality of birth and annihilation rates corresponds to the bifurcation region, where intermittency of the evolutionary and catastrophic forms is observed. At a birth rate greater than the rate of annihilation leads to the deformation process occurring with an increasing number of stoppers, an increase in the stress to the

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threshold of fragile breaking's of the rock, the subsequent disruption of the stoppers, relaxation of the stresses, and a transition to a new equilibrium state. In such case, the process is catastrophic and accompanied by seismic manifestations.

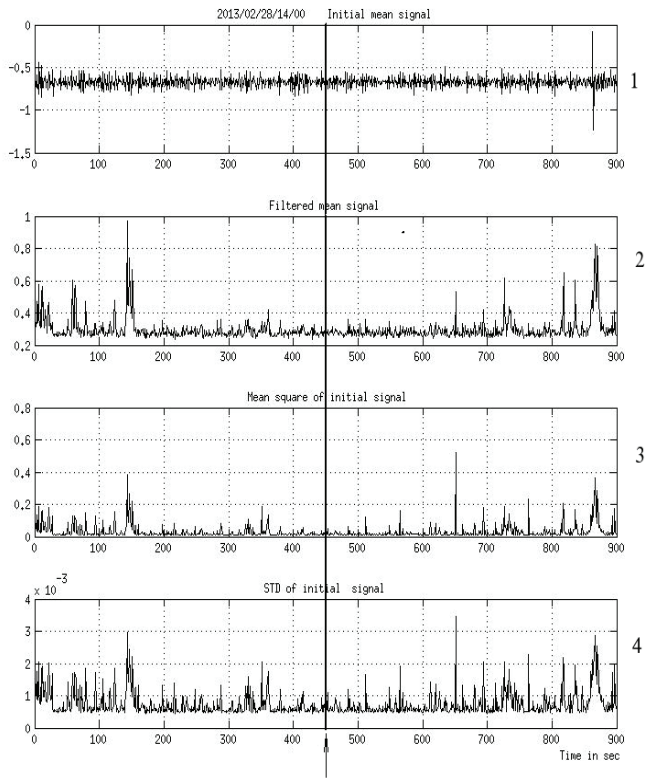

Fig.3. Initial data and processing results. 1 - the initial signal. 2 - signal subjected to optimal filtration. 3 - the rms value of the original signal. 4 - dispersion of original signal. The moment of earthquake is marked by the arrow.

The presence of deformational electromagnetic transformation mechanisms inherent in the rock leads to the existence of electromagnetic satellites of seismic/acoustic perturbations of the earth's crust [1- 3]. Since charges of different signs have different mobility and interact differently with stoppers, during the formation of a stopper electric charges of the same sign are being accumulated, and therefore charges of different signs are being separated. Simultaneously with the accumulation of charge, the environment is polarized to compensate for the excess charge, and a compensating cloud with a core of accumulated charges is being formed. With the subsequent disruption of the stopper, the cloud breaks, during which the total dipole moment increases many times. The rate of growth of the dipole moment is determined by the velocity of the substance motion during the stopper detachment. After the relaxation of mechanical stresses, relaxation of the dipole moment arises.

According to our measurements, the leading edge has a duration of $\Delta t \sim 10^{-4}$ sec, which is determined by the rate of mechanical separation of the charge and the limiting frequency of the transmission of the antenna amplifier (about 10 kHz). At the same time, it is a characteristic time of formation of polarized cracks. If to assume that the rate of formation of such objects is approximately equal to the rate of crack development (according to Griffiths ~ 0.4 speed of sound, and the sound of velocity in the rock about ~ 3000m / s), then the characteristic size of this radiating object (crack) is some $l \approx \Delta t \times 0.4c \approx 0.1$m. That is enough small size.

Trailing edge of the pulse is much longer, at about 3×10^{-4} sec. It is determined by the characteristic relaxation time of the resulting dipole moment and the electrophysical properties of the rock: $\tau = \epsilon \rho$.

6. Discussion and conclusions

The analysis of these facts leads to the following questions:

How to ensure a large amplitude of radiation by a small generating object (and, consequently, a small volume of energy accumulating environment)?

How the nearly constant amplitude of these pulses can be explained?

The only consistent explanation, in our opinion, lies in attraction of the cooperative interaction mechanism of the emitters in the active rock environment (the optical analogue is Dicke's superradiance). Conditions for the cooperative radiation arise when the critical excitation energy density is reached at the wave stress front. In this case, the characteristic volume of the radiation, and, consequently, the amplitude of the emitted pulse is determined by the coherence radius, which is quite a constant value. This radius has the size of a kilometer scale. In the immediate vicinity of the instant of the earthquake (minutes), there are no conditions for the emergence of cooperative radiation.

References

1. Uvarov V., Geophysical Journal, **38,** 6, p.180-185, (2016)

2. Gulielmi A., Physics of the Earth, 3, p. 3-16. (2006)

3. Gulielmi A., Physics of the Earth, 5, p. 65-70. (1994)