

VARIATIONS OF AMPLITUDE VLF-SIGNALS CONNECTED WITH SEISMIC ACTIVITY

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1. Introduction

The problem of the forecast of earthquakes of various intensity totals decades, but till now remains unsolved. The complexity is, that it is required to predict event, which obviously has individual peculiarities, and there is the large number of this peculiarities and they are beforehand unknown. There exist sudden earthquakes, i.e. such, which do not find out self during preparation no one of registered parameters but they are extremely rare. In general the whole complex perturbations in a zone of preparation, occurring as in earthly cruts and in earthly environmental space precede the earthquake. It is possible to predict the earthquakes by two methods: the allocation of a harbinger in geophysical parameters of a spreading surface directly in the field of formation of the center of earthquake, and remote method, based on research and allocation of the special attributes in a signal, the radioline of which passes above region of preparation of earthquake, caused by changes of electromagnetic parameters of an environment. Such remote research of parameters of an environment allows to receive the additional information on physical mechanisms of harbingers of earthquakes and the decision of the given problem is directly connected to development of the forecast of temporary intervals between the beginning of preparation and moment of the earthquake. One of directions of a remote method of search of seismo ionospheric effects is the Earth - ionosphere the radiograph waveguide by Very Low Frequency waves (VLF). On records of amplitude VLF- signals, the radioline of which passes close or above region of seismoactivity as before to and after strong earthquake the abnormal variations of various intensity are observed. The concepts of the missing of the target and false alarm are closely connected with a question on reliability of experimental data. By virtue of geology-geophysical peculiarities of region of a preparation zone, the degree of activization of tectonic activity, the latitude of observation points, the condition geomagnetic and solar perturbation and etc. the character of display of prediction perturbations can vary in rather wide limits. In this case the proofs of reliability of connection of registered perturbations can be base on a statistical material with allocation of the most general regularities or on presence of the special attributes in a signal, inherent to given process only at the account of a geophysical conditions as a whole.

2. The analyze of experimental data

On base of the measuring-receiving of complex continuous monitoring of a level of an electromagnetic background in a range of frequencies from 0.01 Hz to 30 MHz developed in Siberian physical - technical institute we carry out the analysis of dynamics of behavior of radiosignals of low-frequency radiostations with the purpose of allocation of component, caused by seismoactive processes in region, located near to a considered radioline, and specification of general attributes of harbingers of earthquakes on abnormal display in signals from a received material. In the given work the analysis of variations of amplitude of VLF-signals of low-frequency navigating radiostation "Omega (Tsusima - Tomsk, extent about 4000 kms) from February 20 to August 31, 1997 is resulted. The used VLF-line covers only small seismoactive part of the Earth (coordinate of stations Tomsk 56°30' N 85° 02' E and Tsusima 34° 36' N 129° 27' E) and therefore the region around a radioline which makes 3500 kms from a radioline was chosen for the analysis of received experimental data. During researched period in analyzed region 610 events with magnitude > 4.0 numbers have taken place.

The allocation of electromagnetic effects on records of amplitude of VLF-signal connected with seismoactive events is a difficult problem, because there is the natural level of various electromagnetic fields of the Earth (quasistationary electrical field and etc.) and powerful artificial pulsing sources of radiation, creating a high and irregular level of a background. Nevertheless, in result of experimental observations and spent statistical processing of continuous records of amplitude of VLF-signal, it was possible to connect abnormal displays of amplitude of VLF-signal to processes of preparation of earthquakes in this region on temporary concurrence, and to allocate 3 possible recurrences of an image of a signal - harbinger: excess of a background level in 2,3 times (1); sharp burst and gradual recession up to a moment of earthquake, or after it (2); and quasiperiodical variations of various intensity (3). Rises and the sharp bursts of amplitude of VLF-signal are observed on the average from 3 minutes till 10 o'clock before earthquake ($M > 4.0$ numbers).

In statistical processing the records of continuous measurements of amplitude of VLF-signal and the catalogue of data on earthquakes (time, coordinate, magnitude and depth) for this researched period were used as the initial information. In processings for each daily record of amplitude (realization) the sliding "reference" day and root-mean-square deviation is defined. First, each realization was standardized, i.e. it was resulted to zero average and dispersion of one. Further, current "researched" day was compared with "reference" one and as soon as the difference between them exceeded of a level 2σ , time (t_{pert}) was accordingly defined. Automatically t_{pert} was compared with the time of nearest earthquake from the catalogue. An interval, being between the given temporary interval, is required time of a harbinger of earthquake. The realized program analysis has prove, that the chosen kinds abnormal variation of amplitude of VLF-signal during experimental observation are connected with seismic events. Examples of abnormal variations of amplitude on daily records of VLF-signal for February 21 (a) and on April 17 (b) 97 years are shown on fig.1.

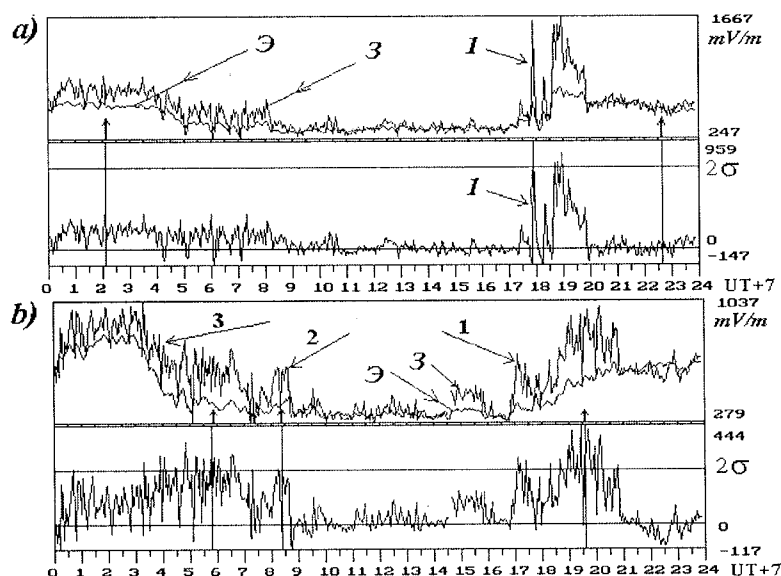


Fig.1 Examples of daily record of amplitude VLF- signal and its processing for February 21 (a) and on April 17 (b)

Where the vertical arrows on a timeline specify moment of a beginning earthquakes, and the inclined arrows with a figure (1,2,3) mean a kind of image-harbinger of signal. On fig. (a1, 61) there is example of record of amplitude of VLF-signal (the arrows with figure 1), (a2, 62) - example of processing of this record (the arrows with figure 3).

The realized analysis of observation of image - harbinger of signal on records of amplitude of VLF-signal has shown, that quantity of fixation of that makes about 65 % from total of events in this region.

We have tried to define the dependences of display of an image - harbinger on the characteristics of earthquakes and geoleogeophysical conditions. The realized quantitative analysis of processed data (record of amplitude of VLF-signal for researched period) has shown, that in result of process of preparation of earthquakes the temporary interval between the beginning of observation of image - harbinger (t_{pert}) and the moment of earthquake (t_{quak}) ($t = t_{quak} - t_{pert}$) is more then **15 hours** both for earthquakes with depth more than **150 km**, which have taken place on distance from researched VLF- radioline more than **1500 km**, and for earthquakes with magnitude there are more than **6 numbers**, which have taken place up to **1500 km** from VLF-radiolines. This dependence of temporary interval of image - harbinger of earthquake on distance, depth and magnitude of earthquakes is shown on a Fig. 2.

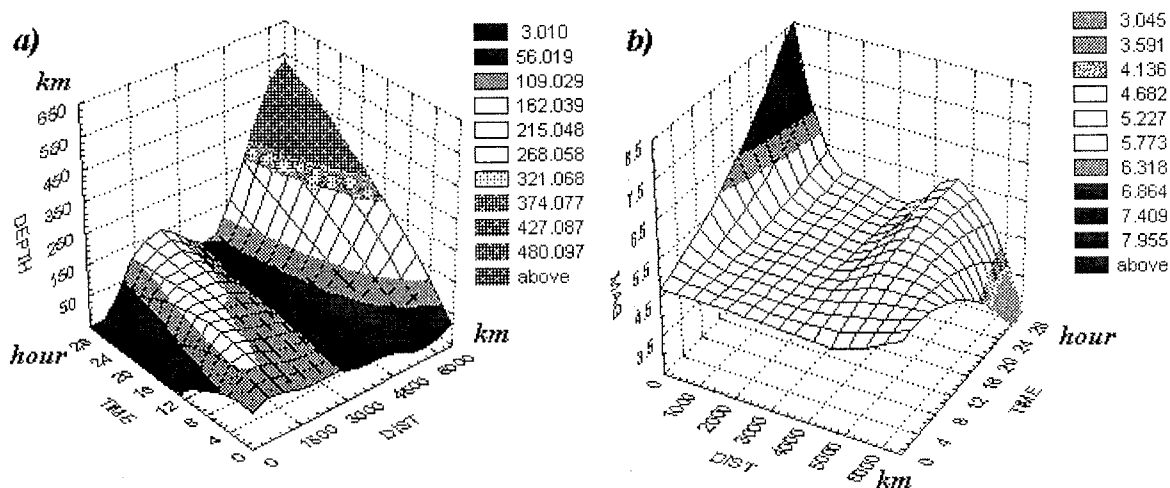


Fig. 2 The dependence of temporary interval of image-harbinger of earthquake on distance, depth (a) and magnitude (b)

For earthquakes the observation of image - harbinger with an average temporary interval till 10 o'clock does not depend on depth of epicenter of earthquake and its magnitude.

The quantity of earthquakes, for which harbingers were observed is 2-4 times more, than quantity of earthquakes for which harbingers were not observed. The dependence of quantity of observations and unobservations of image - harbinger of earthquake on depth and its magnitude of earthquake is shown on Fig.3.

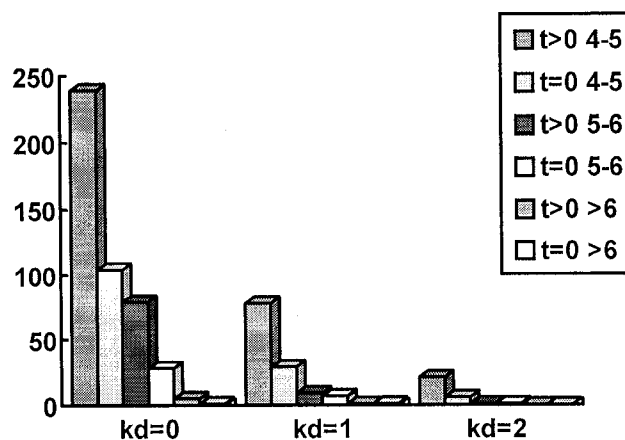


Fig.3 The dependence of quantity of observations ($t > 0$) and unobservations ($t = 0$) of image-harbinger of earthquake on depth ($kd=0$, $kd=1$, $kd=2$) and magnitude (4-5, 5-6, >6 numbers) earthquake.

Where all earthquakes which have taken place in researched area and in researched period was separated into groups on following characteristics: on depth, the magnitude and the observation or not of image-harbinger. On depth this is earthquakes separated on 3 type:

- of surface depth which from 0 to 70 kms — $kd = 0$;
- of intermediate depth from 70 to 300 kms — $kd = 1$;
- of deep-focus depth from 300 kms — $kd = 2$.

On magnitude this is earthquakes separated on 3 type: *4-5 numbers*, *5-6*, *more than 6 numbers*. And on earthquakes for which image - harbinger is observed ($t > 0$) and for which it is not observed ($t = 0$).

The observations of image - harbinger of earthquake on records of amplitude of VLF-signal does not depend on geologicophysical parameters such as Ap, W and $F_{10.7}$

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