ELECTROMAGNETIC EARTHQUAKE PRECURSORS MONITORING METHODOLOGY

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1. INTRODUCTION

Electromagnetic precursors of earthquakes seem to be the most often occurred and the best studied phenomena. There are many practical evidences of the electric and magnetic specific fluctuations occuring before the earthquakes. The most promising frequency band of their occurrence, according to the information published, is ULF-ELF range for short-term precursors and periods from hours to months for medium-term precursors. The common feature of all these fluctuations is their small amplitude what makes it difficult to extract them from the background noise – fluctuations, caused by the sources of other nature. Also this imposes special requirements on the sensitivity threshold and stability of the measuring devices - electrometers and magnetometers. By this, taking into account that the corresponding measurements are executed mostly in field conditions, both thermal and temporal stabilities of the measuring devices have to be as high as possible.

The aim of this work is to review the existing methods of the measurement of electric and magnetic fields oriented to the solution of the problem of short-term precursors extraction.

2. MAGNETIC MEASUREMENTS

The analysis of the existing data gives approximative values of ELF-ULF magnetic signals apparently connected with the seismic activity in the range from few nanotesla to some tens of picotesla. It is evident that all wide amount of types of magnetometers is restricted for this application to only four ones: flux-gate magnetometers (FGM), torsion magnetometers (TM), search-coil magnetometers (SCM) and SQUID magnetometers. The last magnetometer type, because of high price and practical impossibility to use such magnetometer for constant monitoring, is not taken into account here. Further the noise spectra of the three selected types of magnetometers – FGM, TM and SCM – will be studied both theoretically and experimentally.

The most important feature of the magnetic measurements is the huge dynamic band of the studied signal - more than 200 dB. Other peculiarity is the apparent nonsense of the magnetic measurements, when the device with the reduced relative error about 0.1% is used for the measurements of the values about 0.0001% from its full scale. It becomes clear that in such conditions the selection of parameters characterizing measurement precision has to be specially made.

3. ELECTRIC MEASUREMENTS

The noise level of magnetometers, as it was stated above, is mostly determined by the sensor parameters and construction. The electric measurements peculiarity is the direct contact of the sensor – electrode – with the medium in which the measurements are

executed. It immediately causes the well known phenomenon – formation of double layer along the electrode contact surface. That is why even ideally manufactured electrode will have potential drop across this layer, highly dependent on many electrophysical parameters. That is why not only electrodes manufacturing methodology but also the methodology of their use during the experimental study of the electric fields in the conductive media plays an important role for the decreasing of the electrometer noise.

The experimental study conducted at LCISR clearly stated that the lowest noise - within the adopted frequency domain for the measurements in the ground - have copper electrodes (Cu-Cu SO_4), if the methodology of their application is properly followed. This study showed that the potential difference of properly selected electrodes pair in laboratory conditions can change within ±20÷30 microvolts within one mouth of observations. Taking into account that the obtained in practice values of electric precursory signals (from hundreds microvolts to some millivolts) are considerably greater, such electrodes seem to solve the problem of their registration.

But unfortunately in field practice many other sources of noise and error appear. Accepting that most of investigators make proper installation of the electrodes in the soil, we shall analyse further only the methodological errors which give different ways of electrodes mutual placing and of their matching with measuring amplifiers.

CONCLUSION

The presented study allows to recommend an optimal set of measuring instrumentation and a corresponding methodology of its use for the monitoring of ELF-ULF electric and magnetic fields, oriented at the selection of seismic activity electromagnetic precursors.

For lower part of the frequency domain of interest FLUX GATE MAGNETOMETER appear to be the best choice in order to get minimally possible noise value.

But already starting from about 0.01 Hz and higher the SEARCH COIL MAGNETOMETER overcome any other possible type of the magnetometers as to the noise level. At higher frequency, say about 10 kHz, their noise can be as low as few femtotesla (10^{-15}T).

The Cu-$CuCO_4$ electrodes are preferable for the measurements of electric fields in the ground. The double 2-electrodes array is recommended for electrodes installation, especially if long-term study of long-period electric field fluctuation is executed.