EMSEV 2012
Gotemba Kogen Resort, Gotemba, Japan
October 1–4, 2012
Abstract 3-05

Multi-parameters monitoring of electromagnetic earthquake precursors in frequency range 0.1 Hz – 1 MHz in the area of Bishkek

Multi-parameters EM monitoring

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Investigations of electromagnetic (EM) earthquake precursors and development of the multi-parameters monitoring technology in frequency range 0.1 Hz – 1 MHz is carried out in the area of Bishkek (Kyrgyzstan). As the basis for the technology development we use reliable, authentically determined earthquakes precursors, which have been registered by various groups in different regions of the world, with realization the network's monitoring using properly installed multipurpose instruments and integrated data interpretation.

The developed technology includes the registration of such EM precursors, as variations of apparent resistivity (ρ_a), electrotelluric anomalies, electromagnetic emission and ionosphere disturbances. In the investigations of these precursors last years is marked the significant progress [1,2], and the obtained results are taken into account at the development of the multi-parameters EM monitoring technology.

Two types of equipment we use for the EM monitoring. The audiomagnetotelluric system ACF-4M [3] is used for measuremets in frequency range 0.1-1000 Hz. The equipment includes two horizontal induction coil sensors for magnetic field components H_x and H_y measurements, two electric lines for electric field components E_x and E_y measurements and a four channel recorder with 24-bit ADC. The radiomagnetotelluric system RMT-F [4] is intended for field electromagnetic investigations with remote radio transmitters and naural EM fields measurements in frequency range 1-1000 kHz. The equipment includes three induction coil sensors for magnetic field components H_x, H_y and H_z measurements, two electric lines for electric field components E_x and E_y measurements and the five channel recorder with 16-bit ADC. Both types of equipment and developed software tools ensure time series measurements of EM field components, robust data processing, spectral parameters calculations, apparent resistivity and impedance phase determination. The integrated multi-parameters monitoring of the considered precursors is carried out simultaneously and obtaining of informative parameters is differed only by methods of measured time series data processing.

For successful registration of such EM earthquakes precursors, as variations of apparent resistivity (ρ_a), electrotelluric anomalies and electromagnetic emission it is necessary to solve a problem of tensosensitive zones selection for the installation of the measuring equipment. An approach connected with the analysis of territory geological features and field experimental investigations is used at the selection of these zones. Realization of audiomagnetotelluric (AMT) soundings permits us to estimate rocks properties and degree of sites heterogeneity, where the installation of the measuring equipment is supposed. The experience of works on the study of ρ_a variations shows, that the tensosensitive zones are characterized by a non-uniform structure and are composed by rocks of the increased resistivity with threshold moisture content [5]. Also the performance of short-term sessions of monitoring at preliminary selected sites helps us to estimate possibilities of tidal effects registration in ρ_a variations [5] and electromagnetic emission anomalies. The changes of the rocks stress-strain state under influence of the earth tidal deformations and during preparation of earthquakes are similar, so observation of tidal effects allows us to estimate the site tensosensitivity and to study regularities of investigated parameters changes before seismic events.

Examples of tensosensitive zones selection in the area of Bishkek is shown in Fig. 1. Behaviors of AMT curves of apparent resistivity and impedance phase for azimuths 0 degrees (ρ_{a2}, φ_{z2}) and 90 degrees (ρ_{a1}, φ_{z1}) indicate of the Tash Bashat site heterogeneity and high rocks resistivity, and of the Uch Emchek site homogeneity and lower rocks resistivity. Data of short-term sessions of the AMT monitoring in comparison with the vertical component dH of tidal deformation show noticeable ρ_a changes at the Tash Bashat tensosensitive site and absence of changes at the Uch Emchek one with low tensosensitivity.

For ρ_a variations monitoring in tensosensitive zones we apply the AMT method with the sufficiently large investigation depth for decreasing of seasonal and daily factors influence, temperature changes and other weather conditions. The audio frequency range from the first Schumann resonance (7-8 Hz) up to 300-400 Hz is the most appropriate one for the ρ_a variations monitoring using natural electromagnetic field measurements. In this frequency range natural electromagnetic fields are quite stable for reliable data obtaining in any time of day and season (Fig. 2) with accuracy 0.5 % for apparent resistivity and 0.5 degrees for impedance phase. We can see the good coincidence of sounding curves in frequency range 7-40 Hz, and significant their scattering in frequency range 1-7 Hz. The remote reference technique can improve the low frequency data quality, but in an insufficient degree for monitoring aims.

Deep soundings using fields of the magnetotelluric frequency range for the study of large depths (5-20 km) where the earthquake focuses are usually located are the less promising for earthquake prediction. Rocks resistivity variations in zones of focuses can reach large values but these zones are local, deep-seated and usually located not optimally concerning to positions of monitoring stations. These variations

are usually not appeared in the ρ_a monitoring data.

For electromagnetic emission study the narrow-band registration of electric and magnetic fields at the preliminary selected frequencies is usually applied. We use the wide-band registration of time-series of electric and magnetic fields in frequency range from 0.1 Hz up to 1 MHz for improvement of the monitoring information value and the reliability of earthquake precursors detection. Also the registration of electrotelluric field variations for frequencies less than 1 Hz (the VAN method) is carried out.

An example of a magnetosphere disturbance reflection in the dynamic spectrum of magnetic field measured with the ACF-4M system is shown in Fig.3. EM emission anomalies before earthquakes could have the similar view. For detection of earthquake precursors it is necessary to have networks monitoring which will allow us to discriminate other signals (magnetosphere disturbance, industrial noise etc.).

Last time the study of ionosphere earthquake precursors from observations of amplitude and phase parameters of remote radio transmitter's signals is fulfilled [2]. Additional information about the ionosphere state can be obtained from Schumann resonance observations in frequency range 8-45 Hz [6]. The realized in the developed technology combined observations of the radio wave propagations features in the radio frequency range and the Schumann resonances of natural electromagnetic field in the audio frequency range allow us to increase the reliability of the ionosphere earthquake precursors registration.

This work was supported by a research grant of Saint Petersburg State University and the ISTC Project KR-1828.

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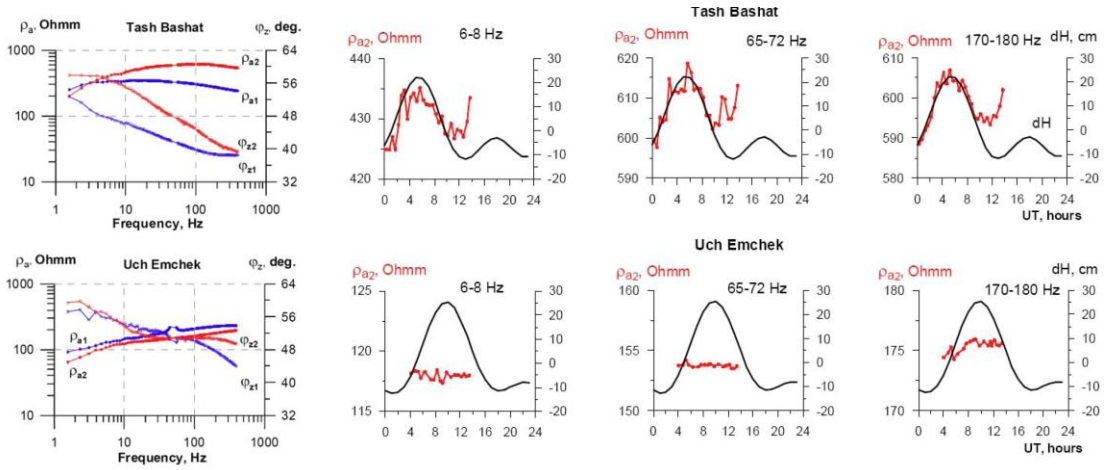

Fig. 1: AMT sounding curves (at the left) and monitoring results (at the right) at the sites Tash Bashat and Uch Emchek (the area of Bishkek).

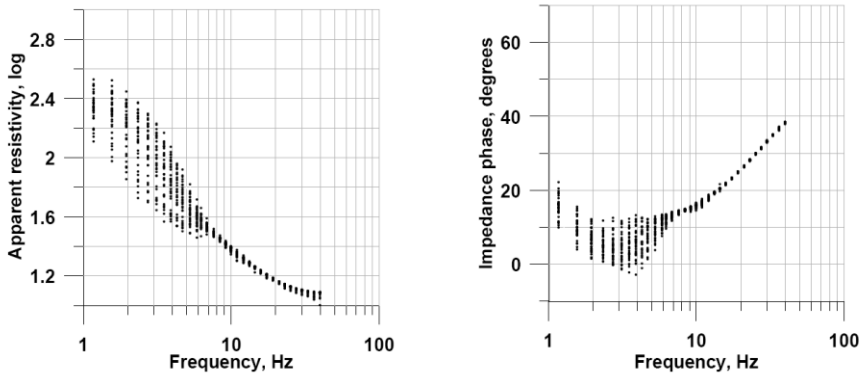

Fig. 2: AMT sounding curves in frequency range 1-400 Hz from 34 one-hour measurements.

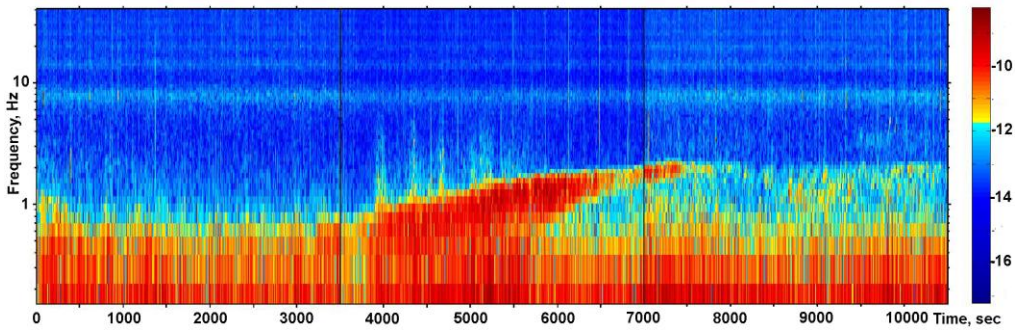

Fig. 3: An example of magnetosphere disturbance anomaly in the magnetic field dynamic spectrum of the value lg S_{HH} in frequency range 5-20 Hz.