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Complex investigation of ionosphere-lithosphere coupling for development of short-term prediction based on EM triggering phenomena

Overview of RFBR Project 11-05-12052-ofi_m

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At present there are no doubts that many seismic events are preceded by perturbations in ionosphere, which have been reported in many papers as possible precursors of strong earthquakes. A comprehensive overview of these activities is presented in [1]. Along with these phenomena it is well known that various external impacts on lithosphere influence seismicity [2]. Results of recent field/laboratory observations and theoretical analysis obtained in Russia within recent ten years show an evidence of artificial/natural electromagnetic earthquakes triggering phenomena and their implication for earthquake preparation and occurrence [3]. Based on these results it may be supposed that some of the reported pre-seismic atmospheric/ionospheric anomalies provide the triggering effect for earthquake occurrence. To clear the details of ionosphere-lithosphere coupling and a possibility of electromagnetic triggering of seismic events the special project #11-05-12052-ofi_m supported by Russian Foundation for Basic Research was launched last year in Russia directed to analyze the correlations between ionospheric electromagnetic perturbations and seismic activity and development of a model of earthquake electromagnetic triggering, which is a complex interdisciplinary problem at the junction of the ionospheric plasma physics, electrodynamics, geodynamics, and fracture mechanics of rock. Another goal of the project is an analysis of a possibility of short-term earthquake prediction based on electromagnetic triggering effects. The project is a continuation of interdisciplinary studies of ionospheric disturbances and triggering of deformation processes in the Earth crust by weak electromagnetic impacts.

Complex interdisciplinary research carried out in 2011 and directed to solving the problem of short-term earthquake prediction based on analysis of ionosphere-lithosphere relations incorporated development of theoretical models, gathering of geophysical data bases for numerical analysis, physical

simulation of behavior of models of rocks and fault zones under critical stressed-deformed state under weak electromagnetic and mechanical disturbances.

Theoretical model and algorithm of calculation of electromagnetic action of ionospheric disturbances on lithosphere were developed for the following numerical simulation of ionosphere-lithosphere relations and electromagnetic triggering of seismic events, as well as a simulation of complex triggering mechanism. Three possible source models are considered: 1) electric currents exited in ionosphere by movement of charged particles in magnetic static filed of the Earth (solar daily variations); 2) electric fields on the earth surface excited by solar daily variations in the Earth; 3) currents excited by high-power artificial sources (like pulsed MHD or ERGU-600 pulsed power systems). It was shown that for simulation of effects of generation of currents in the faults and cracks of rock massifs it is possible to limit the task to plain model of the Earth and ionosphere.

For estimation of interaction of ionosphere and lithosphere an algorithm of calculation of Hall, Pedersen, and longitudinal conductivities of ionosphere over any point of middle and low latitudes for any levels of solar and geomagnetic activities was developed and realized in the code, which based on the state-of-the-art knowledge of parameters of ionosphere, neutral atmosphere, and geomagnetic field.

An overview of general results of study of ionospheric precursors of earthquakes was carried out. Experimental data obtained by ground stations of vertical sounding of ionosphere located in seismically active regions of the Earth, as well as results of satellite radio-soundings were generalized and systematized. It was shown that one of the most sensitive parameter of ionospheric plasma to the processes of earthquake preparation is electron density in the maximum of F-layer NmF2 of ionosphere. Demonstrations of seismo-ionospheric perturbations in the F-layer have so specific nature that under quiet or moderate-perturbed helio-geomagnetic background they may be identified as seismo-ionospheric precursors of earthquakes with high level of probability. In this connection the data of regular monitoring of spatial-temporal distribution of electron concentration of ionosphere may provide sufficiently reliable information on precursors of catastrophic events and apply efficiently to the short-term earthquake prediction.

At present GPS technology is the most advanced diagnostic tool for detection of seismo-ionospheric precursors. It is noted that seismo-ionospheric effects may by partly (or completely) "masked" by effects connected with helio- and geomagnetic activity. Ionospheric storms are observed sufficiently frequent during earthquake and a few days before it that makes difficult a detection of seismogenic precursor in ionosphere. Nevertheless, the storms may be considered as a possible trigger of seismic events. For a study of possible influence of magnetic storms on seismicity a catalog of the strongest Japanese earthquakes (magnitude M over 6.0) was analyzed during a period of 2000 to 2005. It was shown that

50% of all strong earthquakes recorded in Japan within the mentioned period occurred during 0-3 days after commencement of the storms. In so doing, the general picture of spatial-temporal modification of ionosphere before earthquake often is a superposition of effects caused by ionospheric storm and ionospheric heterogeneities of seismogenic nature.

It is well known that telluric currents induced in lithosphere due to ionospheric perturbation depend on the Earth's conductivity. A data base of geoelectric properties of over 30 faults was gathered. It was shown that the faults may be classified as faults with conductive and resistive zones. Considering a selection of Bishkek geodynamic proving ground region as a basis territory for the project research the Issyk-Aktinsky fault was described in details, around which within recent years comprehensive electromagnetic surveys were carried out including magnetotelluric (MTS) and magneto-variation (MVS) soundings, as well as shallow soundings by transient process technique.

An analysis of possible mechanisms of electromagnetic and mechanical impact on deformation processes in the rocks under critical stressed-deformed state resulted in occurrence of seismic events was carried out, and physically based working hypotheses of mechanisms of electromagnetic triggering action on seismogenic fault were selected. For experimental verification of these hypotheses the laboratory spring-block facility was updated for simulation of behavior of fault zone under stressed-deformed condition and external weak mechanical and electromagnetic actions and a series of check-out experiments was carried out.

A theoretical model was developed and an analysis of a possibility of artificial electromagnetic triggering action on an area of future earthquake by generation of electromagnetic impulse of cumulative injection in ionosphere was carried out. Analytical estimations of characteristic amplitudes and frequencies of azimuth component of electric field on the earth surface depending on altitude of explosion and power of impulse of cumulative injection in ionosphere.

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