Geophysical Research Abstracts, Vol. 7, 03874, 2005
SRef-ID: 1607-7962/gra/EGU05-A-03874


# On the correlation between the Earth's crust electrical resistivity and earth's surface deformation on GPS data for seismoactive region of the Central Tien Shan.

V. Bragin (1), A. Fridman (1,2), A. Zubovich (1), G. Sobolev (3), E. Polyachenko (2), V. Zeigarnik (1), L. Bogomolov (1), V. Makarov (4), and G. Shchelochkov (1)

(1) Research Station of Russian Academy of Sciences in Bishkek, Kyrgyzstan

(2) Institute of Astronomy of Russian Academy of Sciences, Russia

(3) Shmidt Institute of Earth Physics of Russian Academy of Sciences, Russia

(4) Institute of Environmental Geosciences of Russian Academy of Sciences, Russia

(bragin@gdirc.ru / Fax: 996 312 611459)

## 1 Introduction

It is generally known and cannot be doubted that the problem of strong earthquake prediction is of great scientific and practical importance. The problem is considered to be a social public task. Due to many uncertainties, related to earthquakes, their successful prediction is rather rare.

Nevertheless, the opportunity of accurate prediction is so tempting, that even today many scientists proceed with investigations into given subjects. Recent decades are characterized by development of experimental and theoretical works in this line. Field experiments involve different geophysical and other methods. However, we still have no answer to the main question: "Is it possible to predict strong or disastrous earthquakes?"

According to the traditional point of view, earthquakes occur when the stress in crust, gradually accumulating, reaches the ultimate stress of mountain rocks. It may seem that the prediction will become feasible, if we could directly measure the level of stress in the earth's crust using any method. However, this is wrong. We hardly know, or we do not know at all, the structure of the cross-section in the territory being observed, we don't know the distribution of hardness of the crust, especially at the depths of the earthquake hypocenters. Due to the heterogeneous medium structure, the hardness of the crust, undoubtedly, varies in space.

It is more acceptable to investigate and record the very stage of the process, when we observe the beginning of active crack formation and/or reconfiguration of the system of microcracks in deformation field of the earth's crust.

The formation of cracks involves the process of essential changes in physical properties of component rocks, in particular such properties as density, porosity, water saturation (in the presence of fluids), specific electric resistivity etc. Taking this into account, it is possible to suggest two basic methods, which have sufficient intensity of investigations and which should directly react to the changes in the mentioned physical properties of the medium. The methods of deep electromagnetic monitoring (based on the powerful current sources), combined with seismic monitoring (based on vibrational or explosion sources), and the methods of studying the deformations of the earth's surface (particularly GPS) have great potential for the investigations into the features of mentioned processes.

Until now, the opportunities of artificially excited electromagnetic fields for the deep sounding of the earth's crust have been restrained by the absence of powerful sources of electrical energy. This problem was solved at Bishkek (Kyrgyzstan) geodynamic proving ground with the advent of powerful MGD plants followed by cheap powerful electropulse systems with power-supply from industrial electrical networks. The electropulse system, presently used at Scientific station RAS, allows to receive the information on changes in electrical properties of the earth's crust in a range of depths from the first kms up to 25 kms in the area of more than 10000 $km^2$.

## Correlation between the results of deep measurements of the Earth's crust electric resistivity and movements of the Earth's surface on GPS data

Prima facie, such relationship looks rather strange. Indeed, using GPS it is possible to determine spatial displacement of any given system of points on the earth's surface, while the measurements of electric resistivity are made starting from the first kilometers up to 25 kms. On the other hand, we have revealed the relationship between spatial distribution of computed (by GPS data) speed of deformations and degree of seismic activity. According to seismological observations in the Central Tien Shan, the degree of seismic activity is determined by the earthquakes right up to the depths of 25 kms. Similar relationship is observed between the changes in electrical resistivity of mountain rocks and seismic activity. At this point, the change in electrical resistivity is determined by regional and local deformation processes and, as a rule, such changes anticipate seismic events. Such relationship becomes clear if we consider that electrical resistivity of mountain rocks in any direction is determined by the density of conducting channels (microcracks and capillaries), filled with fluids in the same direction. Here, the force acting in the north - south direction (for example) compresses all cracks having orientation close to the west – east direction. The conducting liquid is squeezed out of these cracks and, being incompressible, it passes over to other cracks that have orientation close to the north - south direction. The latter cracks become wider and, so, the conductivity increases (i.e. the resistance decreases) in the north - east direction.

To compare the results of measurements of temporary variations of the earth's crust electrical resistivity $\rho$(t) and deformations of the earth's surface D(t) (GPS observations) we chose two continuously functioning stations of electromagnetic observations. The criterion for choosing these stations was the close location of GPS sites. At these stations we watched over the changes in components of electrical resistance in two crosscut directions (east - west and north - south). At GPS sites we measured the displacement in the same crosscut directions.

These works revealed the correlation between variations of displacement of points on the earth's surface and variations of electrical resistivity at the given depth from a surface point. Thus, having measurements of function D (t, $x_0$, $y_0$) by GPS methods, it is possible to get an idea about the change in function r (t, $x_0$, $y_0$, z), received by electromagnetic methods (where $x_0$, $y_0$ are the coordinates of a surface fixed point, z - vertical coordinate) and vice versa.

According to the analysis of coefficients of time series correlation, we have proved that around the faults, close to observation sites, the most of cracks have orientation close to the orientation of the fault line.

## Appearance of anisotropy of electrical properties of the Earth's crust in the periods of regional seismic activation.

According to the detailed analysis of data on electromagnetic observations of changes in components of electrical resistivity at Bishkek geodynamic proving ground, we have revealed the appearance of anisotropy of electrical properties of mountain rocks during the activation of seismic process. In general, we can assume that specific resistance, as well as the stress field, has a tensorial nature. Variation phases of apparent specific resistance are determined by the geometry of sounding configuration (azimuth of receiving dipoles) regarding the directions of main deformation axes and, accordingly, the directions of rock fracturing at observation site. By investigating the anisotropy of electrical resistivity, we can make some conclusions about the direction of force action and orientation of conducting cracks in the investigated medium.

The detailed works at multidipole azimuthal sounding configurations have revealed the sharp differentiation of anisotropy ellipses in depth. This fact can be explained by the geological concept of tectonic fibering of the earth's crust. In dynamic sense, every layer of the earth's crust has its own deformation process, which proceed under the different principles. Thus, the direction of forces and orientation of conducting cracks are different in different layers.