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FORECASTING OF EARTHQUAKES: THE REASONS OF FAILURES AND THE NEW PHILOSOPHY

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Resume

There has been produced the review of the views at the possibilities of forecasting the earthquakes. There were considered the new technologies of earthquakes forecasting.

Conclusions of the author: The main reason of low efficiency of short-term earthquakes forecasting is the wrong interpretation of physical mechanisms of forming the earthquakes harbingers and the displacement of local and long-range harbingers. Overwhelming majority of stable and high-quality harbingers of earthquakes reflects the reaction of the measuring parameters on passing the tectonic waves from strong earthquakes sources, distanced from the registering instruments for more than 1000 km.

Introduction

During the whole history of humanity the people have been trying to learn about possible natural cataclysms beforehand. It is mentioned in ancient historical sources, legends, myths and in religious writings. For this purpose they used all accessible for them opportunities in accordance with their level of knowledge and philosophy. They tried to use astronomical phenomena and they associated the natural cataclysms with them. For example, ancient people take the solar eclipses, approaches of the Mars to the Earth, appearance of spots on the Sun, unusual behavior of animals and unusual phenomena in atmosphere as special signs of approaching of the catastrophe.

How far have the modern scientists gone from their predecessors? If we try to make parallels, we'll see that the modern science with more interest studies the influence of planets of solar system, solar activity and other cosmic factors on seismicity and volcanism. Meanwhile, for short-term forecasting the earthquakes are also used (as earlier) the different harbingers of earthquakes. The main difference is in explanations of the mechanism of connection between the observed harbingers and the process of preparation of the earthquake. Another main difference is the application of modern recording equipment, which use high tech. In other respects "philosophy" of forecasting the earthquakes practically hasn't been changed.

The scientific researches, aimed at creation of effective technology of forecasting the earthquakes were financed about 100 years in many developed countries of the world. Disappointment of public officers and wide mass of the population because of absence of serious achievements in this sphere can be understood. Seismologists, who forecast the earthquakes and spent milliards of dollars in the whole world, found themselves in difficult and delicate situation. Most of them were looking for justifications of their scientific failures, and gladly found them during international scientific meeting which was called in London on 7-8 November 1996 on the subject of interrelation of earthquakes with other phenomena in order to forecast them. Transactions of this meeting were published in Geophysical Journal International, vol. 131, pgs 413 to 533, 1997.

During this authoritative forum the famous seismologist Dr. Robert J. Geller declared the impossibility in principle of forecasting the earthquakes. His main idea is that the process of preparation of the earthquake source has a big probability of randomness and influence of many external factors. That is why he considers this process as a maximally approximate to chaotic processes. Many further articles and speeches of Dr. Robert Geller were the continuation of his idea about impossibility of forecasting the earthquakes. This idea is reflected in his basic statement: "Research in the sphere of forecasting the earthquakes have been carrying out more than 100 years without evident success. The results of researches didn't allow to receive the great achievements. The extensive researching was not able to find reliable harbingers. Our theoretic work supposes, that break displacement is nonlinear process, which is very sensitive to unknown details of structure of the Earth in bulk, and not only in immediate proximity to the epicenter. The reliable accordance of alarms about unavoidable strong earthquakes is inefficient and impossible" /9/.

What did Dr. Robert Geller achieve with his critical statements?

Firstly, he gave a perfect opportunity to the hands of "seismologists-pessimists" to "scientifically" avow their failures.

Secondly, he slowed down the development of science in the sphere of earthquake forecasting more than ten years, as after his speeches "the epidemic of mass pessimism and scepticism" had come in the sphere of earthquake forecasting.

Thirdly, he divided seismologists in two enemy camps – the adversaries of earthquake forecasting and the adherents of earthquake forecasting.

The followers of Robert Geller published and publish now the articles which "prove" the impossibility in principle of earthquake forecasting /10, 12-15/.

As Robert Geller thinks "Modern theories of earthquakes consider that they (earthquakes, author's notes) are critical or self-organizing critical phenomena, which means the system which is kept on the border of chaos, with integral random element and the dynamics of avalanche, with strong sensibility to weak variations of stress."

Does Robert Geller really believe that a part of "chaos" in the process of display of all earthquake harbingers increases a part of strict regularity?

The matter is that the mistake in choosing the physical model brings to the mistake of all further mathematic models. Everything depends on correctness of the choice of "system of coordinates" or "reference frame". If your physical model is inside the system of coordinates where the physical processes are changed together with the system of coordinates, you will never "see" these processes. In order to see these processes you have to exit this system of coordinates and go to another system of coordinates. This conclusion proceeds from the postulate of special relativity theory. We advise Dr. R. Geller and other critics not to forget this postulate of special relativity theory.

We don't want to say that Dr. Robert Geller and his followers are not right at all. Our assertion is that these statements are true only for one type of earthquake harbingers – local harbingers. But the point of view of Dr. Robert Geller and his followers isn't kept for long-range earthquake harbingers, which we'll talk about below. Meanwhile, we also want to draw attention to the works with optimistic viewpoints of the problems of earthquake forecasting /17-21/.

Fortunately, during the last years there was traced the serious "impulse" in the problem of earthquake forecasting, and these new researches allow to better understand the physical origin of earthquake harbingers and the reasons of failures of their forecasting.

1. Registration of different harbingers in big distances from epicenters.

Now there is known more than 300 harbingers of earthquakes of different character and origin.

During the last years a number of scientists published the results of researches, indicative of possibility of registration of harbingers of strong earthquakes in the distance of more than 5000 km, and in some cases more than 10 000 km /1-4, 6-7,11, 21-24/.

Seismic-gravitational harbingers

So, as a result of researches, carried out by the department of physics of the Earth of Petersburg's State University, seismic-gravimetric complex in Petersburg has registered the long-term tensile deformation (vertically) with duration of 12 days and nights, which forestalled the cycle of strong earthquakes of December 2004, including the strongest earthquake on the north of Sumatra island on 26.01.2004, which caused the catastrophic tsunami. Before each strong earthquake there were registered the deformations of less continuation (1-2 days and nights), which were observed earlier too. There was also noted the increasing of intensity of seismic-gravitational fluctuations, which accompany these deformations, the beginning of which always advanced the moment of breaks of strong earthquakes for 1-4 days and nights. At that, the first estimates of speed and length of waves. Low-speed waves (speed from 0.35 to 0.68 km/sec) of seismic origin had waves from 1520 to 7310 km. As a result of analysis of the received data the scientists came to the conclusion that the observed fluctuations are connected with the deformational processes, which are taking place inside the continent with the complex block-hierarchical structure /3/.

Tideless variations of gravity

So, from 2002 the Scientific-Research Institute of forecasting and studying the earthquakes (Baku) has been carried out the continuous measurement of tideless variations of gravity in the station "Binagadi", which is located in Absheron peninsula in 24 km from Baku. The measurements were carried out simultaneously by four high-precision quartz gravimeters of KB an KC types /21/.

As a result of measurements and interpretation of the received data, there were found out the gravitational signals in variations of gravity, which preceded the strong earthquakes, the epicenters of which are in big distances (in the radius of two thousand to tens of thousands km) from the registered stations. In the process of interpretations of results of researches there were deducted the gravitational effects from lunar and solar tides. As it is known, the solar tides cause the variations of gravity which do not exceed 0,1 mGal, and the amplitude of lunar variations is about 0,2 mGal.

Changes of tideless variations of gravity were registered before strong earthquakes in Indonesia, Pakistan, Japan, Taiwan, India, the Philippines, Iran.

Statistic data show that the gravitational signals were registered more than in 85% cases, on the average, 8-15 days before strong earthquakes /21/.

Geochemical harbingers

In series of works (A.A. Hasanov, R.A. Keramova, 2006) there was noted the change of geochemical composition of fluids on the registering stations of the Republican Centre of Seismologic Service of Azerbaijan, before catastrophic earthquakes (M_{LH} = 8.9) in Indonesia on 26.12.2004 in the distance of about 6000 km from the epicenter of the earthquake /1/. In the works of A.A.Gasanov and R.A.Keramova are considered the facts of change of hydro-geo-chemical mode in the registering points of Azerbaijan before strong ($M_{LH} \geq 6.0$), deep-focus ($h \geq 100$ km) earthquakes, the sources of which are within Hindu Kush seismic zone of Alpine-Himalayan tectonic belt of the Earth, in spite of the fact of remoteness of these sources from the objects of observations (Δ=2000÷5000 km) /1,11/.

Seismic-hydro-geological harbingers

Studying of seismic-hydro-geological harbingers of earthquakes allowed to determine the presence of connection of changes of the level of ground waters in the region of Kamchatka peninsula with strong earthquakes, more than 8000 km distanced from the measurements point /3/.

Seismic harbingers

In a series of works /4.6/ was determined that before strong earthquakes, on a seismic stations, situated in the distance of more than 3000 km from the epicenters, there was displayed the synchronization of micro-seismic noise.

The authors of researches (G.A.Sobolev and others, 2007; Lyubushkin, 2008) offer to use this effect as a harbinger during forecasting the strong earthquakes. It was determined that in big remoteness from epicenters of strong earthquakes the seismic stations registered the synchronic fluctuations of micro-seismic noise with the periods of 1-3 hours a few days before the tremor.

Low-frequency three-dimensional variations of gravitational field

During the last years there began the researches of earthquake harbingers, which were based on discovery in 2003 of unknown earlier the effect of low-frequency three-dimensional changes of gravitational field before strong earthquakes in big distances from their sources, at times increasing 10 000 km (E.N.Khalilov, 2003) /7, 22, 24/.

These signals are registered with the help of unusual physical instrument – "Torsion three-component detector of low-frequency gravitational variations" which was called by the author as station ATROPATENA. The station ATROPATENA uses the physical principle never applied before. The method of measuring and the instrument itself are patented in PCT, Geneva (E.N.Khalilov, Method for recording the low-frequency gravity waves and device for the measurement thereof. Patent of PCT. WO 2005/003818 A1., Geneva, 13.01.2005) /23/.

The station ATROPATENA uninterruptedly registers in three mutually-perpendicular directions the influence of changes of gravitational fields of geological origin on interaction of masses in "Cavendish balance" and on tideless variations of gravity. So, simultaneously was received the answer to one of the most actual questions of fundamental physics about reasons of variations of "gravitational constant", registered by different scientists at different time in many countries of the world.

From 2007 there were officially given many forecasts of strong earthquakes for Special Region of Indonesia – Yogyakarta and to Pakistan Academy of Science, and to the Center of Studying the Earthquakes of Pakistan, with which the Scientific Research Institute at Institute of Earthquakes has bilateral memoranda about cooperation.

Classification of the considered "long-range" harbingers

So, the carried out brief review allowed to mark out a few harbingers of earthquakes, which appear in big distances between registering points and epicenters of earthquakes:

- Seismic-gravitational anomalies /2/;
- Tideless variations of gravity /21/;
- Changes of hydro-geo-chemical mode /1,11/;
- Changes of the level of ground waters /3/;
- Synchronization of micro-seismic noise /4, 6/.
- Long-period three-dimensional variations of gravitational field /7/.

We didn't review some other harbingers, which also display in big remoteness from epicenters of strong earthquakes (variations of different parameters of ionosphere, electromagnetic noise disturbances, electric, magnetic and other harbingers).

2. What and how did the seismologists forecast heretofore?

Philosophy of short-term forecasting of earthquakes hasn't undergone essential changes during the whole history of its presence. The basis of all technologies of short-term forecasting the earthquakes is to create the network of stations, which register the changes of geophysical, geochemical, hydro-geological and other parameters of geological medium before strong earthquakes near potential sources of possible earthquakes. It is considered that the more the stations and the closer they are to the potential earthquake source, the higher the probability of successful forecasting.

Meanwhile, in practice it was much more complicated. In spite of the increasing of the number of stations in immediate vicinity from potential sources, the probability of authenticity of short-term forecasts hasn't gone over the level of 70-75%.

As it was shown in the brief review, before strong earthquakes there take place the changes of geological medium in big distances from the sources of future earthquakes. What is the physical mechanism of these changes?

In the works /7/ the authors come to conclusion that the main reason of long-period three-dimensional variations of gravitational field are tectonic waves, which are generated by the earthquakes source in the process of its preparation.

3. About possible influence of tectonic waves on different properties of geological medium

General information

Bases of the concept of tectonic waves were laid in the mathematical model of V.Elsasser in accordance with which the redistribution of compressive forces, averaged on cross-section of elastic lithosphere, are compensated with the tangential forces, which arise under horizontal shift of lithosphere along the viscous asthenosphere (Elsasser W., 1969). Afterwards, this model was used for quantitative assessment of aftershock activity transfer (Kasahara K., 1985; Baranov B.V., 1980).

Afterwards, the model of Elsasser was supplemented by J. Rice with the effect of viscous-elastic reaction of asthenosphere on horizontal shifts of lithosphere. He also took into account the real two-dimensionality of the process (Rice J.R., 1982). Theoretical analysis of propagation of waves of seismic activity in lithosphere was given in the works of F.Lehner and other researchers (Lehner F.K., Li V.C., Rice J.R., 1981). The effect of bend of lithosphere on liquid lithospheric base found its reflection in the works of Nadai A. and Artushkov E.V. (Nadai A., 1969; Artushkov E.V., 1979). Afterwards, in the works of Nikolayevskiy N.V., Karakin A.V. and Lobkovskiy L.I. was made an attempt to develop the two-dimensional theory of waves of bend – compression of lithosphere on viscous asthenosphere (Karakin A.V., Lobkovskiy L.I., 1984).

V.V.Rujich put forward hypothesis according to which (Institute of the Earth's crust, Irkutsk, oral report, 1998), each earthquake is accompanied with generation of condensational waves with extremely low velocity of propagation (V< 0.1 m/sec). V.V.Rujich gave them the name – slow deformation waves (SDW). This hypothesis well corresponds to the contrast deformation anomaly, fixed by Stepanov I.I. on 27 June 1998, 26 days after Shipun earthquake of 1 June (which is consisted of 3 contrast single impulses with amplitudes of 92, 140 and 43 conventional units and intervals between them about 7 hours). It allows to assess the speed of velocity

propagation of SDW about 0.05 m/sec. In the high background of cubic strains in the day of perceptible earthquakes 1,5 - 24 hours before the event there are observed the unit impulse signals, which 2-3 and more times exceed the noise. For example, on 1 June 1988 there were registered 2 such signals with amplitudes of 38 conventional units for a day and night and 41 conventional units 1,5 hours before the event. And on 27.08.2000 before weaker event there were also noted 2 impulse signals: 68 conventional units 6,5 hours and 40 units 3,5, hours before the earthquake at the background of about 20 units. It allows to suppose that such kind of impulse signals in the high background can act the role of short-term harbingers before strong seismic events.

More extensive analysis of researches devoted to tectonic waves with a lot of references to original sources has been cited in the works /7,24/.

What way can the tectonic waves influence on changes of different parameters of natural environment?

Gravitational harbingers of earthquakes.

In Fig. 1 is schematically shown the model of tectonic wave generation by the earthquake source and their successive passage under the stations ATROPATENA–AZ (Azerbaijan) and ATROPATENA-PK (Pakistan).

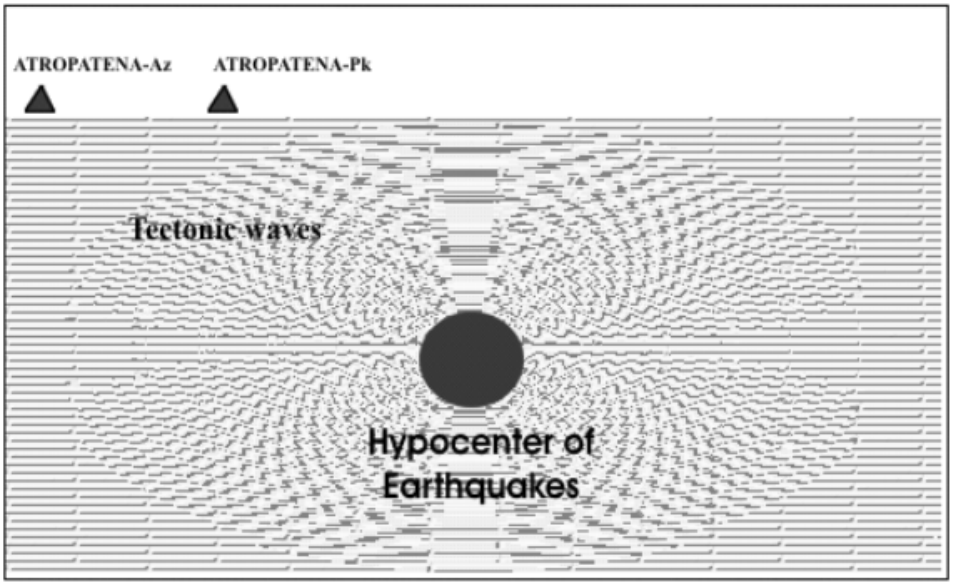

Fig.1. Schematic model of tectonic wave generation by the earthquake source.

In accordance with many researches and the rated models of different authors, the tectonic wave, similarly to the seismic one, has condensational and transverse components. In Fig.1 is shown the model of possible mechanism of tectonic wave propagation by the earthquake source, which is not spherical one.

The condensational tectonic wave propagation causes the alternate changes of rock density in a big stratum of lithosphere, along the direction of wave movement, Fig.2. Successive compression and expansion of lithosphere in the field of the passing condensational wave causes the alternating increasing and decreasing the mass of rocks under the registering stations. Therefore, the stations ATROPATENA register the alternate changes of gravity acceleration, as it is shown in the model, Fig. 2.

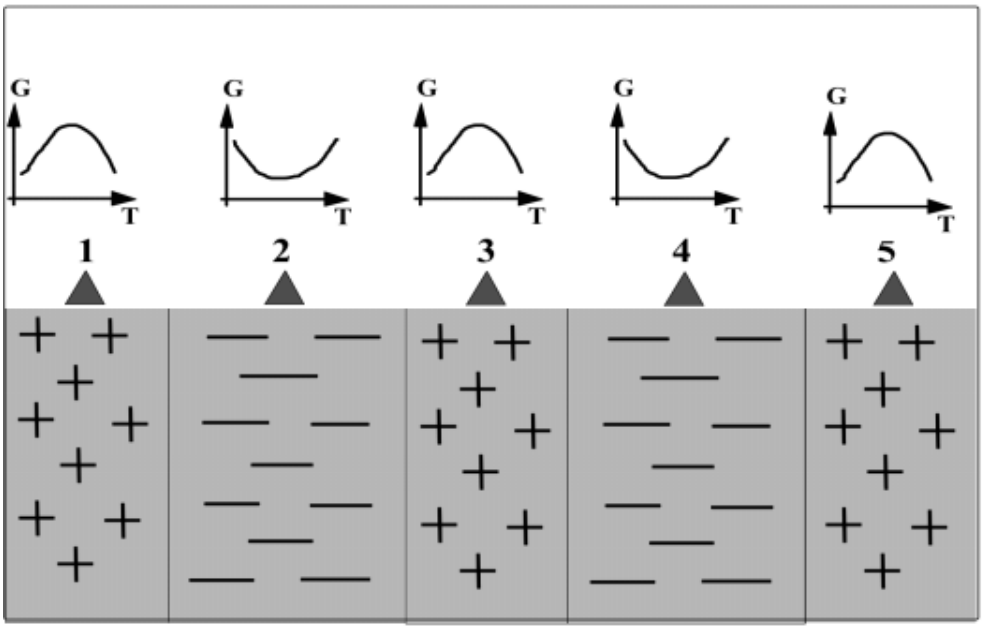

Fig.2. Model of influence of condensational tectonic wave on alternate changes of rock density and the corresponding variations of gravity.
1-5 - the registering stations ATROPATENA.

Movement of transverse tectonic wave causes the alternate changes of the density of rocks in a big stratum of lithosphere, perpendicularly to the direction of wave propagation, Fig.3. The successive alternate compression and expansion of lithosphere in the field of the passing transverse wave, causes the alternating increase and decrease of the mass of rocks from different sides from the registering stations. Therefore, the stations ATROPATENA register the alternate changes of the gravitational field in two mutually perpendicular horizontal directions, as it is shown in the model, Fig.3.

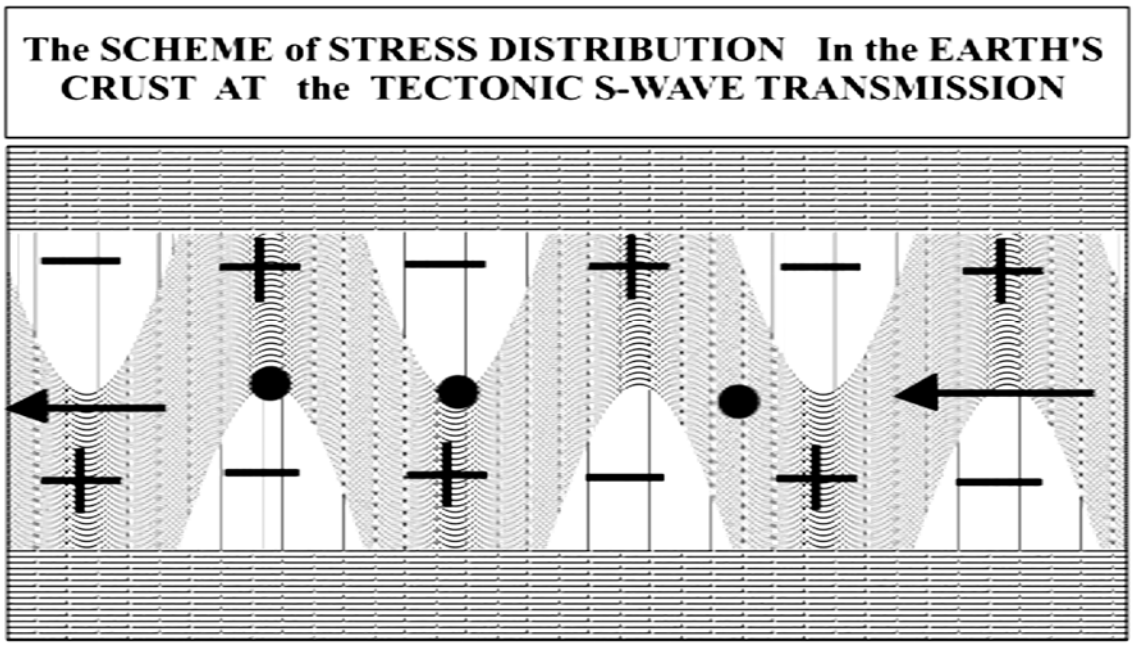

Fig.3. Model of influence of the transverse tectonic wave on variations of changing of the density of rocks in horizontal direction.

In Fig.4 as an example there is shown the gravitogram which was recorded by the station of earthquake forecasting ATROPATENA-AZ before strong earthquakes in the province of Sichuan (China) in May 2008.

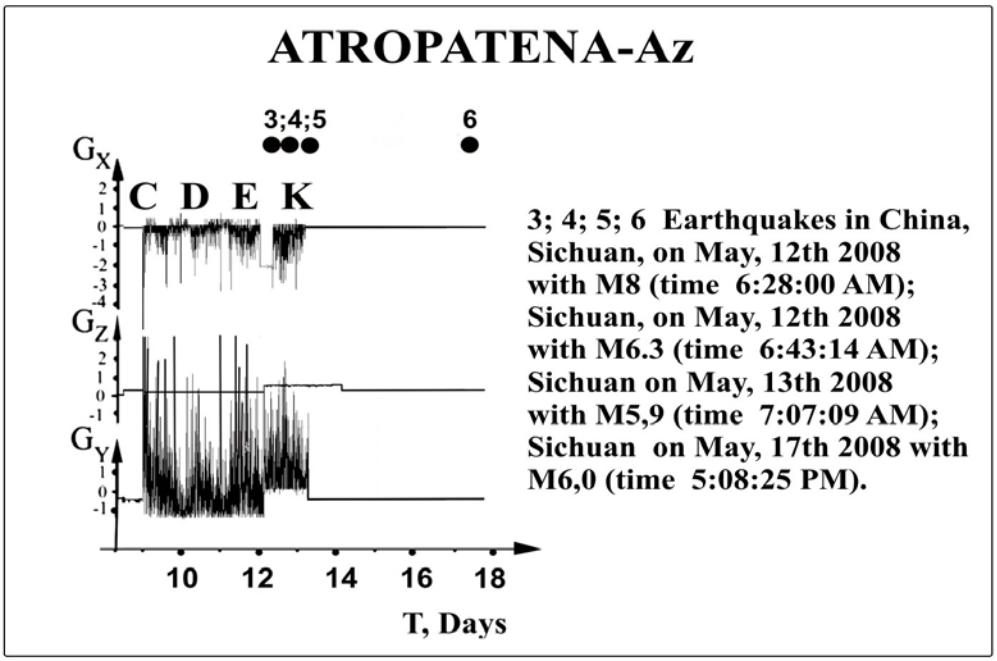

Fig.4. The registered anomalies of the gravitational field by the station ATROPATENA-AZ (Baku) before strong earthquakes in the province of Sichuan, China in May 2008.

Thereby, the physical mechanism of influence of tectonic waves on gravitational field of the Earth, to our opinion, is logically convincingly substantiated. This mechanism can explain all existing harbingers of earthquakes of gravitational character: long-period three-dimensional variations of gravitational field, tideless variations of gravity, seismic-gravitational effects, variations of gravitational gradient, etc.

Meanwhile, there is also the logical explanation of the mechanism of influence of tectonic waves on geochemical characteristics of geological medium, including hydro-geochemical, gas-geo-chemical ones and others.

Geo-chemical harbingers of earthquakes

In the work of I.I. Stepanov (I.I.Stepanov, 2002) were given very important, to our opinion, results of researches on monitoring of volume deformations with the help of geochemical deformometer in the region of Avachin bay /5/. The concept, taken as a principle of deformometer, is based on the discovery of I.I.Stepanov the special condition of atoms of some chemically inert elements, which are able to be in the volume of crystal lattices of minerals, similar in some relations with the ideal gas, and therefore, called “quasi-gaseous” one. According to the opinion of I.I.Stepanov, such substances are able to play the role of sensitive indicator of quantity of deformations of crystal lattices of minerals. During decreasing of the volume of lattices, the partial pressure of this “quasi-gas” inside it is increased. So far as this process in first approximation can be considered as adiabatic, a part of atoms gains additional energy and gets the possibility to overcome the potential barrier which exists on the borders of partition: lattice - open environment. If the system “mineral – the surrounding atmosphere” is the closed loop, then the equilibrium position inside it will vary to increasing of concentration of steams of this substance in the gas over the mineral. This state is reversible, and during increasing of the volume of crystal lattice of the mineral, the “extruded” from it atoms come

back to the mineral. So, uninterruptedly measuring the content of atoms of this element in the gas over the mineral, one may judge of degree of mineral deformation. At sufficiently low detection limit of measuring device, registration of small deformations, about 10^{-6} or less, becomes possible.

Thereby, the applied by I.I.Stepanov /5/ method of measuring the volume deformations of geological medium with the help of geochemical deformometer, uses the principle which can be also displayed in natural geological medium during passing the tectonic waves.

As it is known, the rocks and minerals have the structural anisotropy, and consequently, they are differently compressed, depending on the direction of compression. Under this feature, there is observed the peculiar selectivity of geochemical indicators of the medium (liquid or gaseous), depending on the direction, under which the tectonic wave passes through the rocks.

Similarly there can occur the changing of concentration radon on the zones of deep breaks under the influence of the passing tectonic wave.

Hydro-geological harbingers of earthquakes

Changes of the level of under waters during passing of tectonic wave are also logically may be explained by the process of extrusion of water at compression of pores of rocks (increasing of level of groundwater) and draw of water into the pores at increasing of their volume under influence of tensile strains (decreasing of level of groundwater).

Seismic and acoustic harbingers of earthquakes

As it is known, the seismic characteristics of medium directly depend on its density, particularly, velocity of seismic wave propagation, the refraction index and absorption coefficient, spectral characteristic, etc.

Thereby, the alternate change of density of big rock mass under the influence of the passing tectonic wave brings to periodic changes of its seismic properties that cause the modulation of micro-seismic noise and the so-called “synchronization of micro-seismic noise” by the tectonic wave.

Anisotropy of rocks putting down the layers of lithosphere brings to the fact that the tectonic waves which pass at different angles to seismic stations, differently synchronize (modulate) the micro-seismic noise. It means that there is the selectivity on the direction (asymmetry of directional diagram) of kinematic and dynamic parameters of micro-seismic noise, modulated under the influence of tectonic waves /25/.

Similarly is substantiated the display of acoustic, particularly, ultrasound and infrasound harbingers of earthquakes.

Electric, magnetic, electromagnetic, optical and other harbingers of earthquakes

Alternate changes of stress condition of geological medium under influence of tectonic wave should bring to display of other known harbingers of earthquakes too. As it is known, the change of level of underwater and density of rocks brings to change of electric properties of rocks that displays as electric harbingers of earthquakes (changes of electrical resistance of rocks).

On the other hand, change of density of rocks brings to change of their magnetic properties (changes of density and other characteristics of magnetic field).

Besides, under the influence of alternate deformations, quartz-containing rocks (piezocrystals) can display the piezoelectric effect and, as a consequence, stipulate the appearance of static electricity in huge stratum. It, in its turn, can influence on ionization of lower layer of atmosphere above the projection of the front of tectonic wave on the surface of the Earth.

4. Main reasons of inefficiency of classical methods of earthquake forecasting

The results of our researches and discussions have shown that the display of earthquake harbingers has considerably more complicated nature, than the seismologists have thought till now /7/.

Thereby, we can suppose that there are two types of earthquake harbingers:

- Local harbingers of earthquakes;
- Long-range harbingers of earthquakes;

The biggest problem is that the main reason of both types of earthquake harbingers are the same mechanisms – changes of stress condition of rocks.

4.1. Local harbingers of earthquakes

Local harbingers of earthquakes are directly connected with the processes of critical increasing of stress conditions of rocks in focal zone. As a result of it, are displayed the processes of compression, extension, displacement, bend, etc. of big strata of the Earth in different areas of focal zone. It is practically impossible to model this process because of its nonlinearity /Dr. Robert J. Geller, 1997/. Therefore, the same source of the earthquake can have different (dissimilar) displays of harbingers during the repeated earthquakes. Majority of local harbingers of earthquake unstably display near the earthquake epicenter (gravitational, seismic, geo-chemical, electrical, magnetic, electromagnetic, deformational ones, etc.).

4.2. Long-range harbingers of earthquake

Long-range harbingers of earthquakes are secondary ones and reflect the display of change of different parameters of geological medium (gravitational, seismic, geo-chemical, electrical, magnetic, electromagnetic, deformational ones, etc.) under influence of tectonic waves, generated by source of the preparing earthquakes. Physical mechanism of display of these harbingers was described above.

5.Fundamental mistake of seismology at short-term forecasting of earthquakes

From the above-mentioned arguments it is clear that at short-term forecasting of earthquakes there are simultaneously registered the local and long-range harbingers of earthquakes. Therefore, frequently, as a principle of local short-term forecasting of earthquakes (in the radius of several hundreds kilometers from the epicenter of the earthquake) were taken the long-range harbingers from the earthquake sources, which are in big distances from the registering points (up to 10 000 kilometers).

As the local harbingers obey the model of Doctor Robert Geller, their display is hardly forecasted.

Meanwhile, the long-range harbingers of earthquakes, which are the result of generation of tectonic waves by the sources of strong earthquakes, are the stable and high-quality. As the experience of using the station ATROPATENA during two years shows, the long-range gravitational harbingers of earthquakes allow to forecast with 90% accuracy, and this probability will be increased as including the new stations ATROPATENA into the Global Network of Forecasting the Earthquakes.

5. What to do?

Almost during 100 years of history of forecasting the earthquakes the seismology has not only stored the extensive information about different harbingers of earthquakes, but also created the unique local networks of points of monitoring of different parameters of geological medium around focal zones of strong earthquakes and deep breaks. In different countries were created the multiple seismological polygons for monitoring of geological medium.

To our opinion, the only way out of the arisen situation is the creation of the Global Network of Forecasting the Earthquakes, consisted of the united into the single network the stations of forecasting the earthquakes, registering the most stable and high-quality long-range harbingers of earthquakes. The global network must be connected with multiple local networks. Thereby, the Global Network of Forecasting the Earthquakes will allow to register the long-range harbingers of earthquakes, and the local networks will simultaneously register the local harbingers. Interconnecting of long-range and local harbingers will allow to increase the accuracy of short-term forecasting the earthquakes.

I would like to inform that the analog of similar network has already begun to be created on the basis of the stations ATROPATENA with points in Baku (Azerbaijan), Islamabad (Pakistan) and Yogyakarta (Indonesia).

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