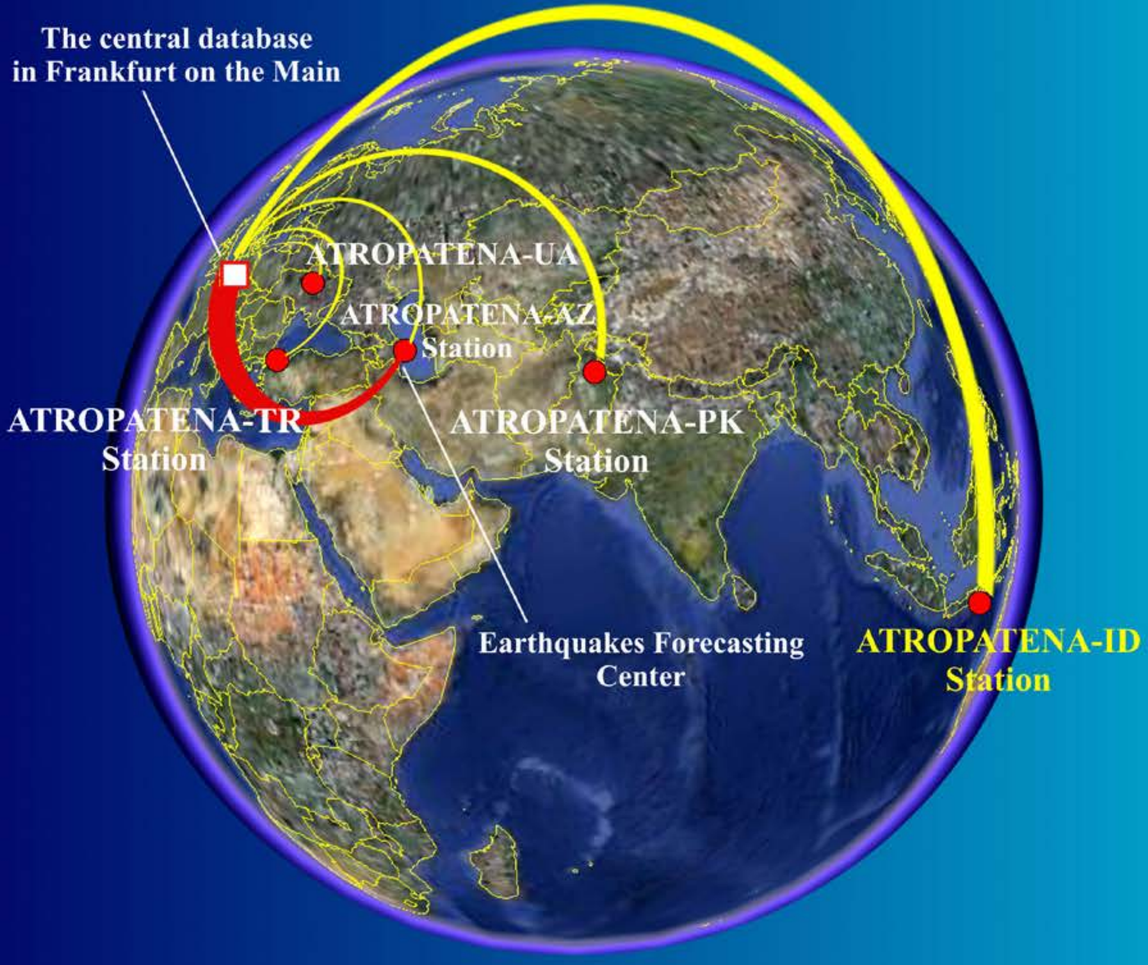
Global Network for the Forecasting of Earthquakes - GNFE

International System of Geodynamics Monitoring



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E.N.Khalilov

GLOBAL NETWORK FOR THE FORECASTING OF EARTHQUAKES – GNFE

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INTERNATIONAL SYSTEM OF GEODYNAMICS MONITORING

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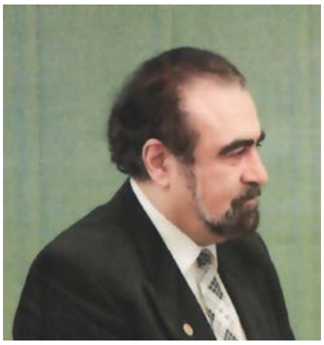

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There has been described the positive experience of short-term forecasting of strong distanced earthquakes on the basis of long-period gravitational harbingers. The information presented is about the initial results of the operation of the Global Network for the Forecasting of Earthquakes.

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CHAPTER 1

FORECASTING OF EARTHQUAKES: THE REASONS FOR FAILURES AND THE NEW TECHNOLOGY

Introduction

Throughout history, people have tried to accurately predict cataclysms. Ancient historical sources, legends, myths, and religious writings all detail their efforts. They used what was accessible to them based on their level of knowledge and philosophy. They tried to use astronomical phenomena and associated the natural cataclysms with them. For example, ancient people took the solar eclipses, approaches of Mars to the Earth, appearance of spots on the Sun, unusual behavior of animals and unusual phenomena in the atmosphere as special signs of approaching catastrophes.

How far have modern scientists come from their predecessors? Modern science studies with great interest the influence of the planets of the solar system, solar activity, and other cosmic factors on seismicity and volcanism. Meanwhile, for short-term forecasting, the different harbingers of earthquakes are used much as they were in earlier times. The main difference is in the explanations of the connections between the observed harbingers and the gestation of the earthquakes. Another significant difference is the application of modern high technology recording equipment. In other respects, the "philosophy" of forecasting the earthquakes hasn't changed that much, practically speaking.

Scientific research aimed at creating technology to forecast earthquakes has been financed for about 100 years in many developed countries of the world. However, the absence of serious achievement caused disappointment amongst public officials and in the wider mass population. Seismologists, who forecast earthquakes and spent millions of dollars, found themselves in difficult and delicate situations. Most of them were looking for justifications of their scientific failures, and gladly found them during an international scientific meeting 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 earthquakes. His main idea is that the earthquake source has such a large probability of randomness that it approximates a chaotic process. Many further articles and speeches of Dr. Robert Geller propagate his ideas about the impossibility of forecasting the earthquakes. This idea is reflected in his basic statement: "Research in the sphere of forecasting earthquakes has been carried out for more than 100 years without evident success. The results of research didn't result in great achievements. The extensive research was not able to find reliable harbingers. Our theoretical work supposes that break displacement is a 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?

First, he gave "seismologists-pessimists" good reason to "scientifically" avow their failures.

Second, he slowed down the development of science in the sphere of earthquake forecasting for more than ten years, because after his speeches "the epidemic of mass pessimism and skepticism" arose in the sphere of earthquake forecasting.

Third, he divided seismologists into two enemy camps - the adversaries of earthquake forecasting and the adherents of earthquake forecasting. The followers of Robert Geller published articles which "proved" the impossibility, in principle, of earthquake forecasting and they still do today /10, 12-15/.

Robert Geller thinks that "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 elements and the dynamics of avalanche, has a strong sensitivity 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 fact of the matter is that a mistake in choosing the physical model causes mistakes in all further mathematical models. Everything depends on the 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 do not want to say that Dr. Robert Geller and his followers are not at all right. Our assertion is that these statements are true only for one type of earthquake harbinger - local harbingers. But the point of view of Dr. Robert Geller and his followers isn't accurate 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, in recent years there has been a significant impulse into research on the problem of earthquake forecasting, and this new research results in a better understanding of the physical origin of earthquake harbingers and the reasons for failures in their forecasting.

1.1. Low-frequency three-dimensional variations of gravitational field

During recent years began research of earthquake harbingers, which were based on the 2003 discovery of a previously unknown effect of low-frequency three-dimensional changes of gravitational field before strong earthquakes at large distances from their sources, at times as large as 10,000 km (E.N. Khalilov, 2003) /7, 22, 24/.

These signals are registered with the help of an unusual physical instrument – the "Torsion three-component detector of low-frequency gravitational variations" – which was named the ATROPATENA station by the author. The ATROPATENA station uses a 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 ATROPATENA station continuously registers in three mutually-perpendicular directions the influence of changes of gravitational fields of geological origin on interaction of masses in a "Cavendish balance" and tideless variations of gravity. So, this simultaneously answered one of the most asked questions of fundamental physics about reasons of variations of "gravitational constant", registered by different scientists at different times in many countries of the world.

From 2007 there were officially given many forecasts of strong earthquakes for the Special Region of Indonesia – Yogyakarta, to the 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.

1.2. Classification of the considered "long-range" harbingers

So, the brief review allowed marking out a few harbingers of earthquakes, which appear at large 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 themselves at large distances from epicenters of strong earthquakes (variations of different parameters of ionosphere, electromagnetic noise disturbances, electric, magnetic and other harbingers).

1.3. What and how did the seismologists forecast heretofore?

The philosophy of short-term forecasting of earthquakes has not undergone essential changes during the whole history of its existence. The basis of all technologies of short-term forecasting of earthquakes is to create a network of stations which register the changes of geophysical, geochemical, hydro-geological and other parameters of the geological medium before strong earthquakes near potential sources of possible earthquakes. It is believed 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 is 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 was shown in the brief review, changes in the geological medium at large distances from the sources of future earthquakes take place before strong earthquakes. What is the physical mechanism of these changes?

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

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

1.4.1. 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 the lithosphere along the viscous asthenosphere (Elsasser W., 1969). Later, this model was used for quantitative assessment of aftershock activity transfer (Kasahara K., 1985; Baranov B.V., 1980).

Afterwards, Elsasser's model was supplemented by J. Rice with the effect of viscous-elastic reaction of the asthenosphere on horizontal shifts of the lithosphere. He also took into account the real two-dimensionality of the process (Rice J. R., 1982).

Theoretical analysis of the propagation of waves of seismic activity in the 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 bending of the lithosphere on the liquid lithospheric base found its reflection in the works of Nadai A. and Artushkov E.V. (Nadai A., 1969; Artushkov E.V., 1979). Later, in the works of

Nikolayevskiy N.V., Karakin A.V. and Lobkovskiy L.I. an attempt was made to develop the two-dimensional theory of waves of bending - compression of the lithosphere on the viscous asthenosphere (Karakin A.V., Lobkovskiy L.I., 1984).

V.V. Rujich put forward a hypothesis (Institute of the Earth's Crust, Irkutsk, oral report, 1998), according to which each earthquake is accompanied by the generation of compressional 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 corresponds well to the contrast deformation anomaly, fixed by Stepanov I. I. on 27 June 1998, 26 days after the Shipun earthquake of 1 June (which consisted of 3 contrast single impulses with amplitudes of 92, 140, and 43 conventional units and intervals between them of about 7 hours).

It allows assessment of the propagation velocity of SDW of about 0.05 m/sec. In the high background of cubic strains during the day of perceptible earthquakes 1.5-24 hours before the event, unit impulse signals which exceed the noise by a factor of 2-3 or more times are observed.

For example, on 1 June 1988 two such signals were registered with amplitudes of 38 conventional units for a day and night and 41 conventional units 1.5 hours before the event. And on 27 August 2000 before a weaker event two impulse signals were also noted: 68 conventional units 6.5 hours and 40 units 3.5 hours before the earthquake at a background of about 20 units. It allows one to suppose that such impulse signals in the high background can take the role of short-term harbingers before strong seismic events.

More extensive analysis of research devoted to tectonic waves with a large number of references to original sources has been cited in the works /7,24/. In what way can the tectonic waves have an influence on changes of different parameters of the natural environment?

1.4.2. Gravitational harbingers of earthquakes

Fig. 1.1 schematically shows the model of tectonic wave generation by the earthquake source and their successive passage under the ATROPATENA-AZ (Azerbaijan) and ATROPATENA-PK (Pakistan) stations.

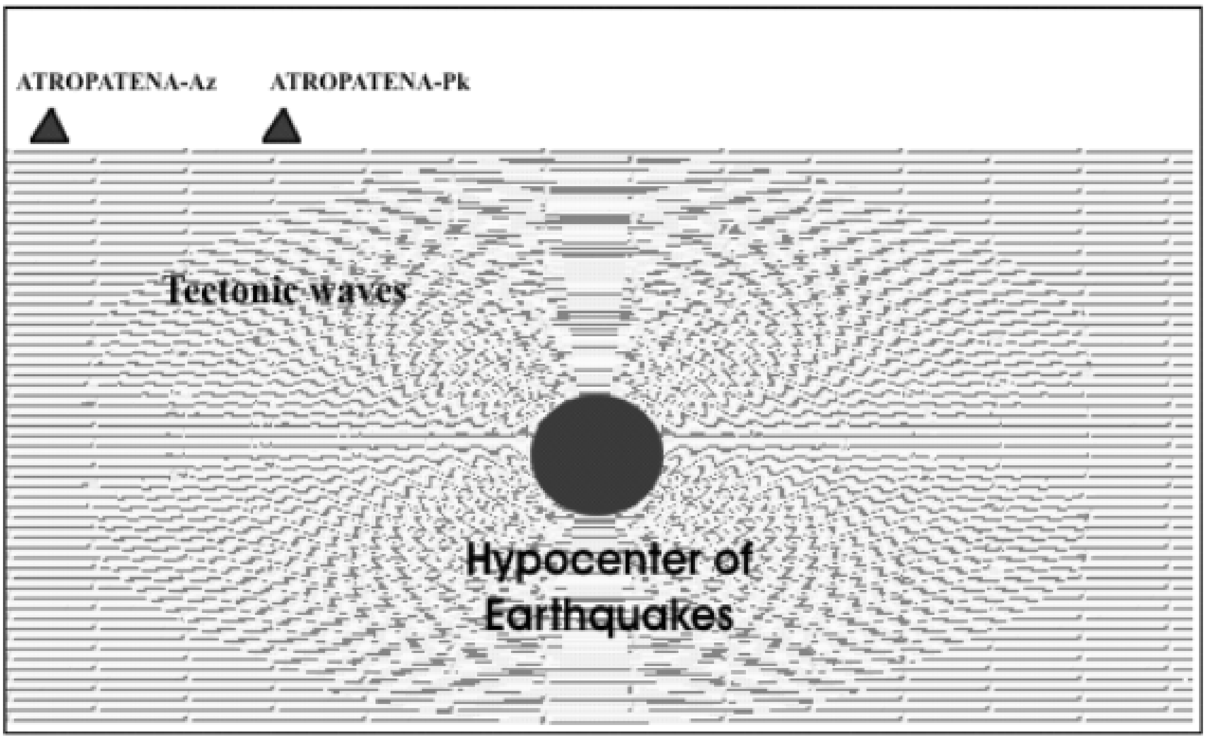


Fig.1.1. Schematic model of tectonic wave generation by the earthquake source.

In accordance with many research efforts and the rated models of different authors, the tectonic wave, similar to the seismic wave, has compressional and transverse components. Fig. 1.1 shows the model of a possible mechanism of non-spherical tectonic wave propagation by an earthquake source. The compressional tectonic wave propagation causes alternating changes of rock density in a large stratum of the lithosphere, along the direction of wave movement, Fig. 1.2.

Successive compression and expansion of the lithosphere in the field of the passing condensational wave causes an alternating increase and decrease of the mass of the rocks under the registering stations. Therefore, the ATROPATENA stations register the alternating changes of gravity acceleration, as is shown in the model, Fig. 1.2.

Movement of transverse tectonic waves causes alternating changes of rock density in a large stratum of the lithosphere, perpendicular to the direction of wave propagation, Fig. 1.3. The successive alternate compression and expansion of lithosphere in the field of the passing transverse wave, causes an alternating increase and decrease of the mass of the rocks from different sides from the registering stations. Therefore, the ATROPATENA stations register the alternating changes of the gravitational field in two perpendicular horizontal directions, as is shown in the model, Fig. 1.3.

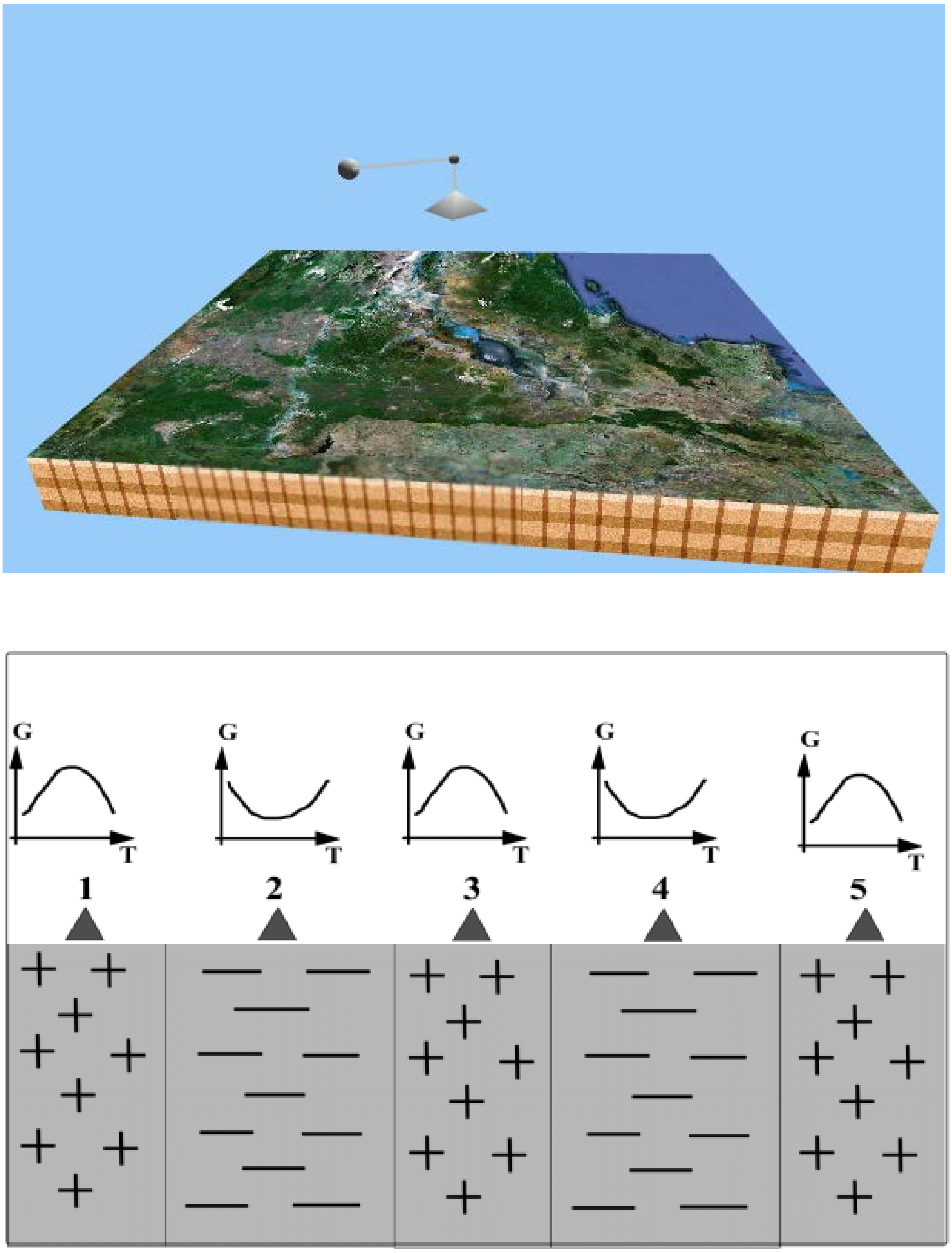
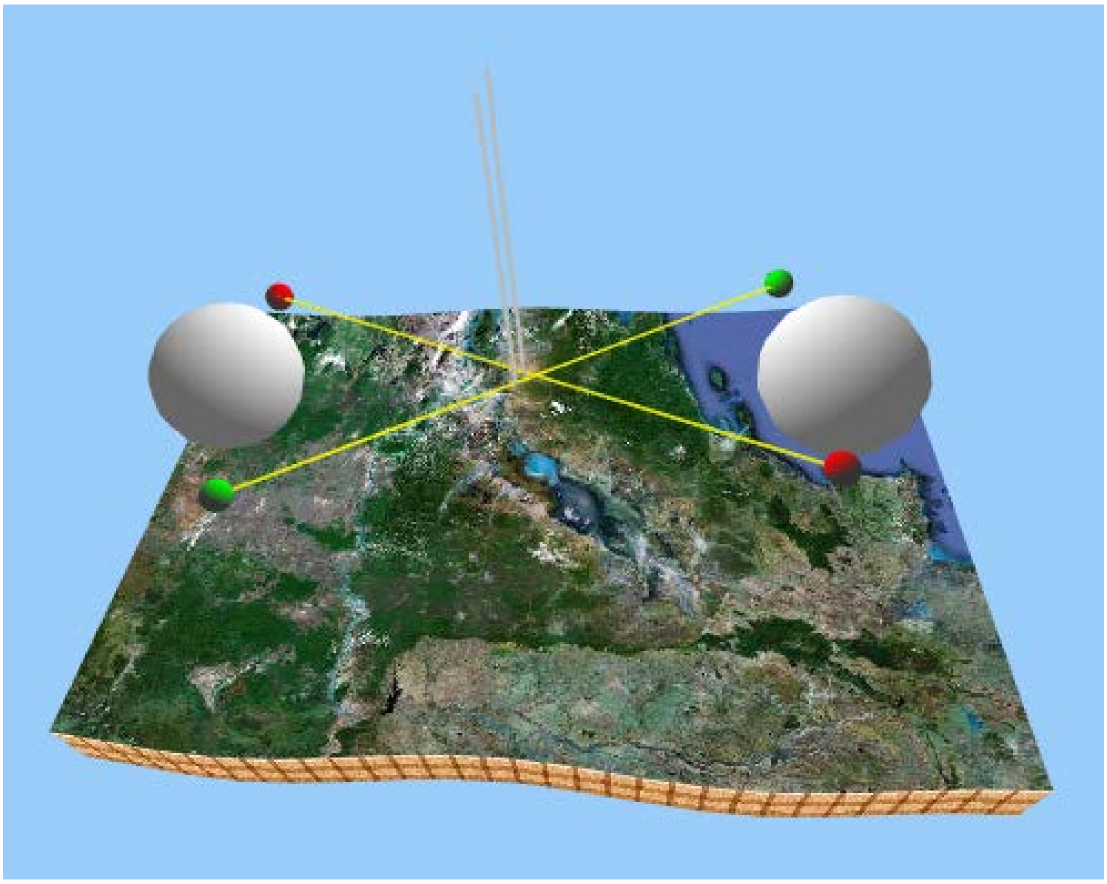


Fig.1.2. Model of influence of longitudinal tectonic wave on alternate changes of rock density and the corresponding variations of gravity.

1-5 - ATROPATENA registering stations.



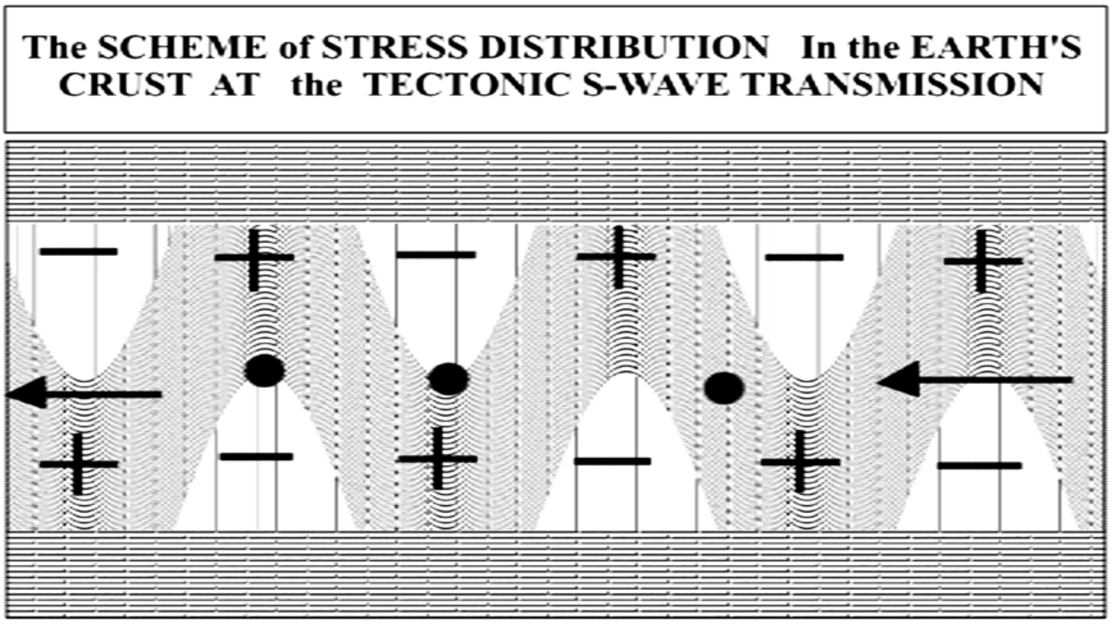


Fig.1.3. Model of influence of the transverse tectonic wave on variations of changes of the density of rocks in horizontal direction.

Fig. 1.4 shows an example gravitogram which was recorded by the ATROPATENA-AZ station of earthquake forecasting before strong earthquakes in the province of Sichuan (China) in May 2008.

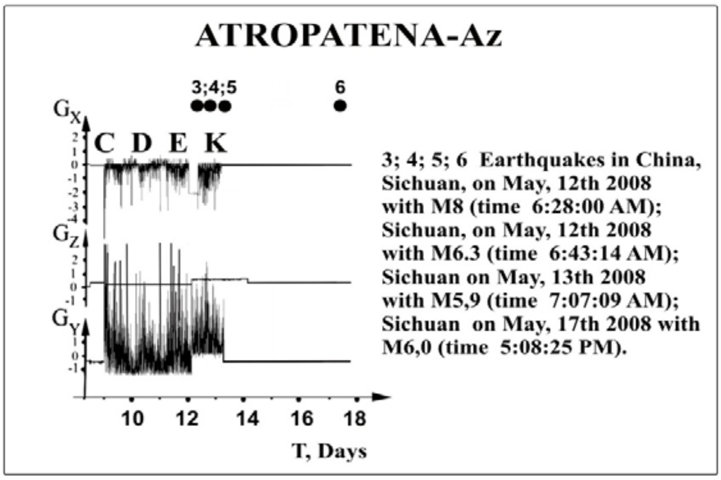


Fig.1.4. The registered anomalies of the gravitational field by the station ATROPATENA-AZ (Baku) before strong earthquakes in the province of Sichuan, China in May 2008.

Thereby, the physical mechanism of influence of tectonic waves on the gravitational field of the Earth, to our opinion, is logically and 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 a logical explanation of the mechanism of influence of tectonic waves on geochemical characteristics of the geological medium, including hydro-geochemical, gas-geo-chemical ones, and others.

1.4.3. Geo-chemical harbingers of earthquakes

The work of I. I. Stepanov (I. I. Stepanov, 2002) gives very important, in our opinion, results of research on monitoring of volume deformations with the help of the geochemical deformometer in the region of Avachin bay /5/. The concept, taken as the principle of the deformometer, is based on I. I. Stepanov's discovery that the special condition of atoms of some chemically inert elements in the volume of crystal lattices of minerals is similar in some relations to the ideal gas, and therefore, they are called "quasi-gaseous". In I. I. Stepanov's opinion, such substances are able to play the role of a sensitive indicator of the quantity of deformations of minerals' crystal lattices. When the volume of the lattice decreases, the partial pressure of this "quasi-gas" inside it increases. So far as this process in first approximation can be considered adiabatic, some of the atoms gain additional energy and the possibility to overcome the potential barrier which exists on the borders of the partition lattice / open environment. If the mineral system's surrounding atmosphere is a closed loop, then the equilibrium position inside it will vary to increase the concentration of steams of this substance in the gas over the mineral. This state is reversible, and when the volume of crystal lattice of the mineral increases, the atoms “extruded” from it come back to the mineral. So, by continuously measuring the content of atoms of this element in the gas over the mineral, one may judge of degree of mineral deformation. With a sufficiently low detection limit of the measuring device, registration of small deformations, about 10^{-6} or less, becomes possible.

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

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

Similarly, changes in radon concentration in zones of deep breaks can occur under the influence of a passing tectonic wave.

1.4.4. Hydro-geological harbingers of earthquakes

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

1.4.5. Seismic and acoustic harbingers of earthquakes

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

Therefore, the alternating changing density of large rock masses under the influence of a passing tectonic wave causes periodic changes of its seismic properties that cause modulation of micro-seismic noise and the so-called “synchronization of micro-seismic noise” by the tectonic wave.

Anisotropy of rocks put down in layers of the lithosphere causes the tectonic waves which pass at different angles to seismic stations, to synchronize (modulate) the micro-seismic noise differently. This means that there is 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 substantiated is the display of acoustic, particularly ultrasound and infrasound, harbingers of earthquakes.

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

Alternating changing stress conditions of the geological medium under influence of a tectonic wave should cause visibility of other known harbingers of earthquakes too. As is known, the change of the level of underground water and density of rocks causes changes in electric properties of rocks that displays as electric harbingers of earthquakes (changes of electrical resistance of rocks).

Also, changes in the density of rocks causes changes in their magnetic properties (changes of density and other characteristics of magnetic field).

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

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

The results of our research and discussions have shown that the display of earthquake harbingers has a considerably more complicated nature than seismologists have previously thought /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 causes of both types of earthquake harbingers are the same mechanisms - changes of the stress condition of rocks.

1.4.8. Local harbingers of earthquakes

Local harbingers of earthquakes are directly connected to the processes of critical increases of stress conditions of rocks in the focal zone. As a result, the processes of compression, extension, displacement, bend, etc. of large strata of the Earth in different areas of focal zone are displayed. It is practically impossible to model this process because of its nonlinearity /Dr. Robert J. Geller, 1997/.

Therefore, the same source of an earthquake can have different (dissimilar) displays of harbingers during repeated earthquakes. The majority of local harbingers of earthquake display unstably near the earthquake epicenter (gravitational, seismic, geo-chemical, electrical, magnetic, electromagnetic, deformational ones, etc.).

1.4.9. Long-range harbingers of earthquakes

Long-range harbingers of earthquakes are secondary harbingers and reflect changes in different parameters of geological medium (gravitational, seismic, geo-chemical, electrical, magnetic, electromagnetic, deformational parameters, etc.) under the influence of tectonic waves, generated by sources of upcoming earthquakes. The physical mechanism of the display of these harbingers was described above.

1.5. Fundamental error of seismology at short-term forecasting of earthquakes

From the above-mentioned arguments it is clear that in short-term forecasting of earthquakes, local and long-range harbingers of earthquakes are registered simultaneously. Therefore, frequently, as a principle component of local short-term forecasting of earthquakes (in the radius of several hundreds of kilometers from the epicenter of the earthquake) were taken long-range harbingers from earthquake sources which are large 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 useful for forecasting.

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

1.6. What to do?

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

In our opinion, the only way out of the situation that has arisen is the creation of the Global Network for the Forecasting of Earthquakes (GNFE), consisting of stations for forecasting earthquakes united into a single network, 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 for the Forecasting of Earthquakes will allow registration of long-range harbingers of earthquakes, and the local networks will simultaneously register the local harbingers. Interconnecting of long-range and local harbingers will increase the accuracy of short-term earthquake forecasting. The beginning of a network has been created on the basis of the ATROPATENA stations with points in Baku (Azerbaijan), Islamabad (Pakistan) and Yogyakarta (Indonesia).

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CHAPTER 2

"ATROPATENA" EARTHQUAKE FORECASTING STATIONS: PHYSICAL PRINCIPLES AND FIRST RESULTS

2.1. Methodology

A new instrument for experimental study of the space-time variations of measured values of G was created, called the ATROPATENA detector (PCT patent pending) by the authors (12).

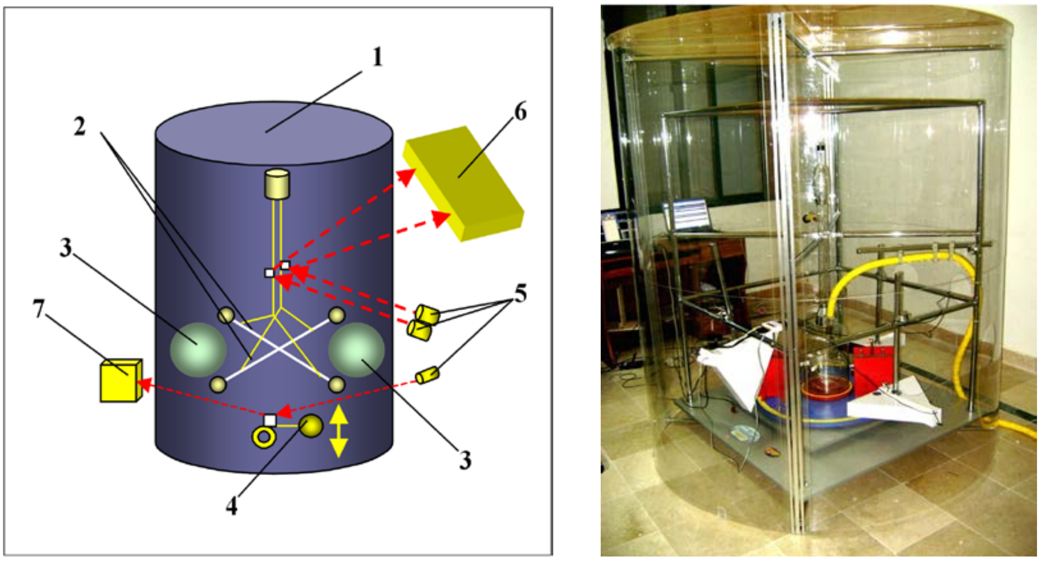
ATROPATENA is a system of sensors closed and isolated from the environment, using the physical principle of the Cavendish balance, with small weights on the ends of two (instead of one) mutually perpendicular balance-beams hung by threads 2. Between the small weights large weights are placed equally spaced 3, Fig. 2.1 (a).

The third measuring sensor, the trial mass 4, is hung on a special elastic lever and makes available the possibility of vertical displacements during changes in the relative values of acceleration of gravity, Δg. Variations of Δg are stipulated for lunisolar floods and for the appearance of local gravitational anomalies, which can be caused by the changing of density of rock mass under the instrument as a result of changes in their stress condition, and consequently their mass.

As seen in the scheme, on the balance-beams with the weights 2 and on the lever of the vertical sensor 4, there are tiny mirrors on which three laser beams are directed. Being reflected from the mirrors, the beams hit the sensitive optical matrix 6 and 7, where the transformation of optical signal from laser mark into electric signals and their transmission into an analog-to-digital converter occurs.

After that, the digital signal is transmitted to a special block of the computer as the next record in a special format. The software, written at the Scientific-Research Institute of Prognosis and Studying of Earthquakes (SRIPSE), automatically records the information in the form of separate files for a period of time determined by the operator.

In Fig. 2.1 (a) the ATROPATENA instrument is shown schematically.



(a). **(b).**

Fig.2.1. Design layout (a) and photo (b) of ATROPATENA detector.

1 – glass body of the detector; 2 – balance-beams with small weights on the ends; 3 – big weights; 4 – trial weight, which is hung on elastic lever; 5 – laser emitters, 6 – sensitive optical matrix for horizontal sensors, 7 – sensitive optical matrix for vertical sensor.

The entire sensitive system is placed into the special, isolated from the environment, glass body 1, where a deep vacuum has been created and is constantly supported (10^{-4} MPa).

Temperature sensors accurate to 0.1C° are placed in different sections of the sensitive system and connected to the temperature control block. The room where ATROPATENA is located is kept to a consistent temperature with ± 1° C inaccuracy.

For excluding the mechanical effects and for better heat insulation, the vacuum body with the sensitive system is placed into translucent plastic body which also allows for visually observing the work of the system (Fig. 2.1(b)).

Together with the noted sensors, ATROPATENA is also provided with a digital seismic station using a three-component seismic receiver, the information of which is also transmitted to the computer and is continuously digitally recorded in three channels X, Y, and Z.

The registration of seismic fluctuations is necessary in order to exclude the possible influence of these fluctuations on destabilization of the sensitive system of the ATROPATENA detector and the appearance of false anomalies caused by seismic processes. The remote control of the detector and remote pickup of information minimize the external influences on sensitive system.

All elements of the sensitive system have been made of non-metallic materials to exclude the influence of magnetic fields and electromagnetic radiation on these elements. ATROPATENA is placed in the building of Scientific Research Institute of Prognosis and Studying of Earthquakes in Baku (Azerbaijan). Since 1 April 2007 the station has been in operation, and has recorded high-quality information about variations of gravitational field over time in three axes X, Y, and Z, and the seismologic information simultaneously recorded by means of the Tethys-SD wide-band digital seismic station. First, ATROPATENA was provided for experimental research on the possible influence of super-long gravitational waves on the indications of a Cavendish balance.

If one proceeds from classical ideas of fundamental physics, then the ATROPATENA detector, at first sight, is accepted as an absolutely senseless instrument, as it is considered incontestable that the gravitational constant is a fundamental constant and cannot be changed in time or in space. But the author didn't rule out the possibility of an influence of super-long gravitational waves on a Cavendish balance and wanted to check out that idea (10).

Meanwhile, ATROPATENA registered numerous signals which have definite regularities and high correlation with strong earthquakes in different regions of the Eastern Hemisphere of the Earth. Fig. 2.2 shows the schematic sketch of the actual orientation of Cavendish balance in the ATROPATENA station. The sketch represents the view from above, X and Y designate correspondingly oriented balance-beams with small weights on the ends, and m1 and m2 are large weights. N, S, W, E designate accordingly north, south, west, east.

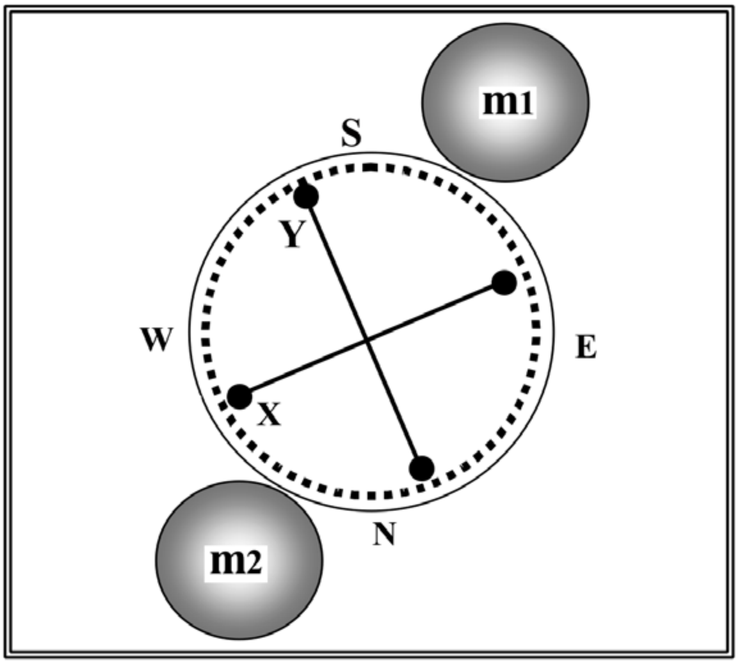


Fig.2.2. Schematic sketch of actual orientation of Cavendish balance in the ATROPATENA station.

For convenience, we call the recordings of the ATROPATENA detector "gravitograms", by analogy with seismograms. The detailed study of gravitograms with anomalous deflections of measured values of G can explain subtler physical nuances of these processes.

On the gravitograms, the graph G_x reflects the movement of the balance-beam X, and the graph G_Y reflects the movement of the balance-beam Y (Fig. 2.2), the graph G_Z reflects the changes of gravity, that is, the vertical movements of the trial weight. An increase of values G_x and G_Y means approaching of small weights on the balance-beams to the large weights, and a decrease means moving away from the large weights. On the coordinate axis are shown the conventional units, which reflect the deviation amplitude of small weights on the ends of balance-beams relative to large weights.

The registration of values of all three sensors is carried out with discontinuity in one second. Using of red lasers with the length of wave 645 nm and special optical matrixes for registration of the laser mark and its displacements allowed registering of the deviations of laser-beams on the angle to 0.1 degree. The whole process of registration takes place in digital form automatically, without participation of the operator, and the received time series are archived by means of a special program. These deviations correspond with variations of gravitational constant G in the third and fourth digits after the decimal point.

2.2. Results

Fig.2.3. shows the gravitograms with two gravitational anomalies, registered on 5 January and 10 January 2008. In both graphs, G_X and G_Y show the conventional units of amplitudes of variations in time of the indications of the Cavendish balance, oriented, correspondingly, in parallel with axes X and Y. The axis G_Z shows the conventional units of the amplitudes of variations in time of gravity, Δg.

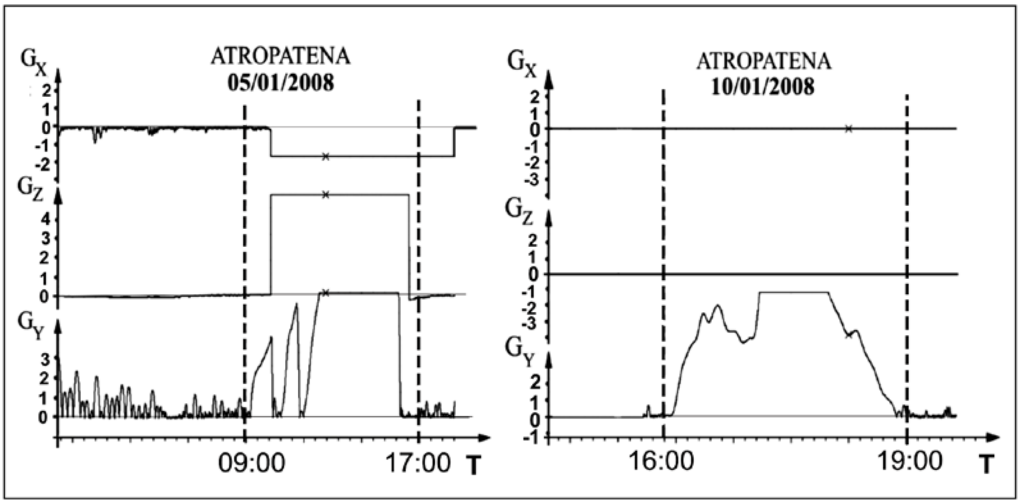


Fig.2.3. Gravitograms of 05 and 10 January 2008.
T – time.

As is seen in the gravitogram of 5 January, whereas small weights of the balance-beam X are moving away from the large weights (G_X is decreasing), the weights of the balance-beams and G_Y are approaching with noticeably more amplitude (G_Y is increasing). At the same time, G_Z also shows the increasing of gravity almost synchronously with G_Y. The 64 minute lag of the beginning of changes in G_Z and G_X relative to G_Y is also notable. Also, G_Z comes back to its former position 30 minutes later than G_Y, whereas G_X does it 2.5 hours later than G_Y. We see that all three sensors show a strongly pronounced gravitational signal, which evidently has the same nature, but with great displacements in time of its registration. The duration of the signal is also quite long at 8 hours. During these anomalies, the seismic station didn't register any seismic fluctuations which exceed the background noise. In addition, seismic signals cannot have the period of several hours. A strong earthquake with M (magnitude) 5.9 took place on 7 January in the region of Indonesia (coordinates are 0.795 S 134.012 E).

The other example of registration of a quite intensive variation in time of gravitational constant G with strict selectivity to the direction is interesting. This signal was registered only by the sensor G_Y. The other two sensors, as is seen in the gravitogram, "keep silent". The duration of the signal is three hours. During the recording of the signal, no seismic fluctuations were registered. A strong earthquake of M6.5 took place on 15 January in the region of the Fuji islands (coordinates are 21.966 S 179.530W).

The authors took all data about earthquakes in this article from the catalogues of U.S. Geological Survey Earthquake Hazards Program – USGS
(http://earthquake.usgs.gov/eqcenter/eqarchives/significant/)

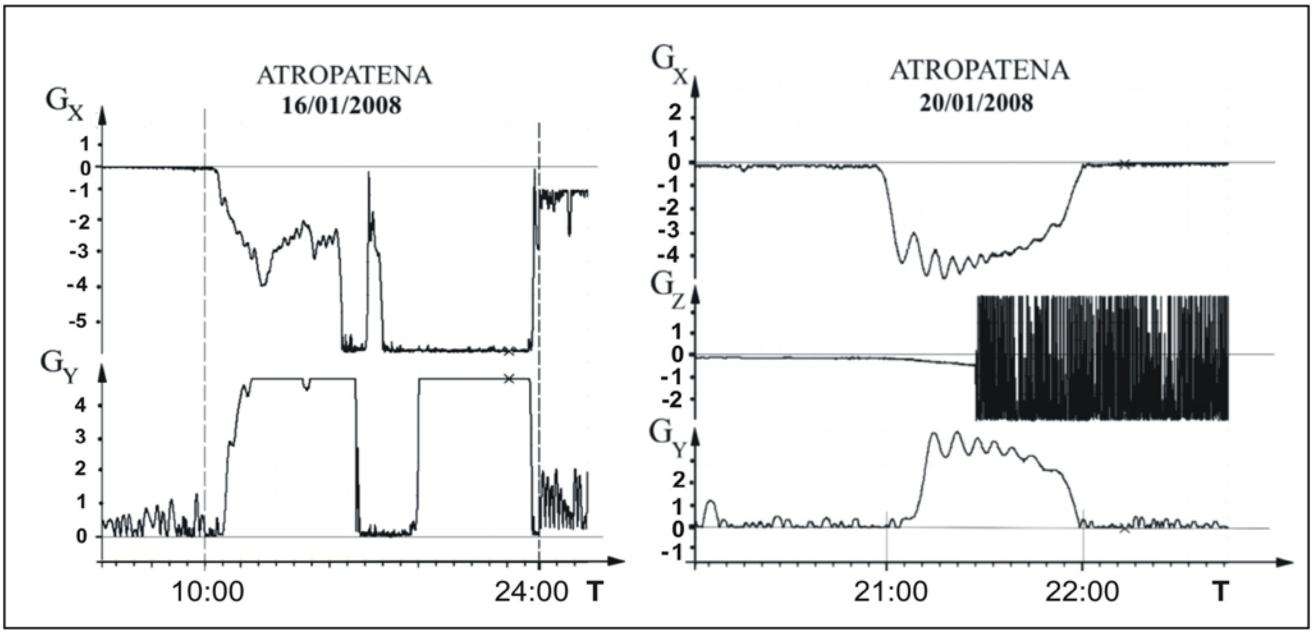


Fig.2.4. Gravitograms of 16 and 20 January 2008.

T – time.

First we'll consider the gravitogram of 16 January, Fig. 2.4. Because of the absence of signals in G_Z, this graph isn't demonstrated. Since 10:00 the decreasing of value G_X and increasing of G_Y have begun synchronically. As it is seen there is some difference in the form of graphs G_X and G_Y, but the whole tendency shows a high negative correlation, which does not raise doubts.

The graphs practically mirror each other. While the small weights of the balance-beam X move away from large weights, the weights on the ends of the balance-beam Y approach, and the same takes place in reverse direction. The duration of the observed signal is 14 hours. A quite interesting signal was also registered on 20 January, when the graphs G_X and G_Y during 2 hours register the signal almost mirrored in both gravitograms.

Meanwhile, approximately an hour later, after the appearance of this signal, G_Z began to continuously register a high-frequency quasiharmonic signal with the period of 4-8 minutes. After the sensors G_X and G_Y stop registering the signals, G_Z continues registering the high-frequency signal right up to 23 January inclusive, and such duration of uninterrupted appearance of that signal is quite unusual for the sensor G_Z. On 22 January a strong earthquake of M6.2 took place in Indonesia (coordinates are 1.011 N 97.438 E).

In the gravitograms of 02-03 February, very interesting anomalies were registered, Fig. 2.5. G_Y registered three alternate long-period signals in series, with periods accordingly 11, 8, and 7 hours, then G_X registered the mirror image of these signals, but the first (I) and second (II) of them are modulated by high-frequency constituent with the period of 4-9 minutes, and the modulatory high-frequency signal in both cases lasts about 5 hours.

On 04-05 February on the gravitogram, again the typical signal appears, reminiscent in character the signal of 02-03 February, but the gravitational signal G_X is modulated by high-frequency constituent with period of 4-9 minutes at the beginning (III) and at the end (IV) of the anomaly.

The duration of the modulatory signal is approximately the same and it is about 2 hours. This fact is quite interesting, as the signal G_X is clearly limited at the beginning and at the end of the high-frequency constituent.

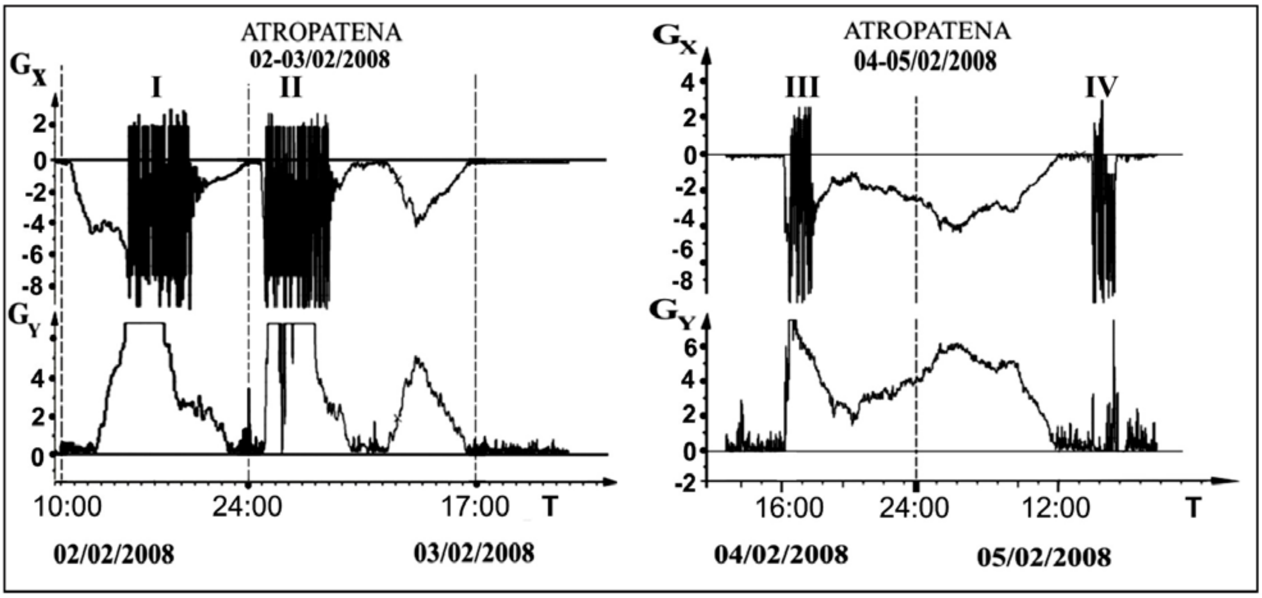


Fig.2.5. Gravitograms of 02-03 and 04-05 February 2008.
T – time.

A strong earthquake of M7.2 took place on 8 February (coordinates are 10.725 N; 41.898 W) in the region of the north middle-oceanic ridge in central part of the Atlantic ocean, and on 10 February a strong earthquake of M6.5 took place in the sphere of the south Sandwich islands (coordinates are 60.757 S; 25.582 W). In our opinion, it is possible that the anomalies registered on 02-03 February are connected with the earthquake of 8 February, and the anomalies of 04-05 February are connected with the earthquake of 10 February.

Two strong earthquakes took place on 07 May 2008 near the coast of Honshu in Japan: the first one of M6.2 – at 16:02:01 (coordinates are 36.21S 141.47E) and the second one of M6.8 – at 16:45:20 (coordinates are 36.14S 141.45E). The analysis of the recordings of ATROPATENA showed that on 2 May the sensor G_X began to register the intensive negative anomaly “A” (Fig.2.6) which lasted till 3 May 04:25. 2 hours later after this anomaly the sensor G_X registered the second negative anomaly “B”, which lasted till 5 May. It is notable that these anomalies are the high-frequency pulse bursts with the periods 3,5 – 6,5 minutes. Two strong earthquakes took place in Japan on 7 May 2008 with a small difference in time. So, the earthquakes took place 5 days after the beginning of recording the anomaly and two days after the anomaly has stopped.

The catastrophic earthquake of M8 took place on 12 May 2008 in China in the region of Sichuan at 06:28:00 (coordinates are 31.08S 103.27E) and the second earthquake of M6,3 took place at 06:43:14 (coordinates are 31.25S 103.68E), as a result of which, according to provisional data, about 70 thousand people died, and the death toll is being specified now.

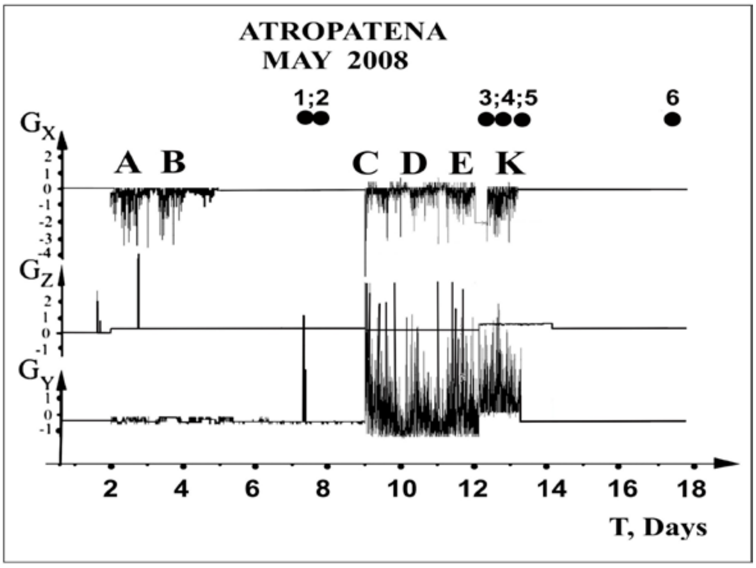


Fig. 2.6. Gravitogram of 1-17 May 2008.

A,B,C,D,E,K – the registered anomalies of gravitational field;
1;2 – the earthquakes in Japan near the coast of Honshu on 7 May 2008, of M6.2 (time – 16:02:01) and of M6.8 (time – 16:45:20); 3;4;5;6 – the earthquakes in China, Sichuan on 12 May 2008 of M8 (time – 06:28:00); of M6.3 (time – 06:43:14); Sichuan on 13 May 2008 of M5,9 (time – 07:07:09); Sichuan on 17 May 2008 of M6,0 (time – 17:08:25).(http://www.iris.edu/cgi-bin/wilberII_EnO_page4.pl?evname=20080517_170825.9.spyder)

On 9 May two sensors G_X and G_Y simultaneously began to register strong anomalies C, D, E, and K of the gravitational field (Fig. 2.6). G_Y registered an intense positive anomaly which consists of high-frequency pulse burst with periods of 3.5-8 minutes, and G_X registered a negative anomaly which consists of pulse bursts with analogous periods. The amplitude of anomalies of the G_Y sensor is more than three times larger than the amplitude of anomalies of the G_X sensor. The anomalies of G_Y during visual analysis consist of four well-separable pulse bursts (anomalies) according to amplitude modulation – C, D, E, K. Anomaly K differs from the anomalies C, D, and E, in several respects. First, after completion of anomaly E, G_X decreases by two conventional units for 15 hours without modulation, and after returning to the background value, anomaly K begins. Anomaly K begins at 15:22 on 12 May and completes at 09:30 on 13 May. Second, on G_Y the K anomaly also differs from previous anomalies. Anomaly K begins on 12 May and completes at 10:55 on 13 May, and the lower extent of the values of anomaly K are approximately two units higher than the lower extent of anomalies C, D, and E. After the completion of anomaly K, the values return to the background level. So, in our opinion, the anomalies C and D are the harbingers of the Chinese earthquakes 3 and 4 (Fig. 2.6), and anomalies E and K are the harbingers of the earthquakes 5 and 6. The ATROPATENA detector has simultaneously registered different variations of G in two mutually perpendicular directions and variations in Δg before distant earthquakes since April 2007 until now in 93% of cases. In previous research, the author together with V.E. Khain discovered the changes of gravity before strong distant earthquakes by means of standard gravimeters (13).

Starting from the rules of general relativity, gravitational interaction by its nature represents the changes of space curvature caused by masses and is an integral property. In the Cavendish balance, the interaction of small weights on the ends of the balance-beams hung on a thin thread with stationary large weights takes place, which causes the turning of balance-beams on their axis for some angle. The angle of the turning of the balance-beam is compensated by the elastic force of torsion of the thread, upon the value of which the gravitational constant is calculated. But if other large weights appear near the Cavendish balance, they introduce additional distortions into the curvature of space formed by the large weights in the Cavendish balance. So, we'd have a new system of weights interacting, where the changes of space curvature will be the resultant one of interaction of weights in the Cavendish balance and additional weight. In this case, Cavendish balance would show another result.

In real conditions of the Earth, there are many geological factors which create quite intensive gravitational anomalies, changing in space and in time, that are many times larger than the gravitational effects caused by movement of planets of solar system, including the additive effect of lunisolar floods. These effects can be caused by convective flows in the mantle, movement of lithospheric plates, tectonic waves, etc. In our opinion, this explains the fact that during last ten years, in spite of increasing accuracy of instruments which register the gravitational constant G up to the sixth digit after the decimal point, it has nevertheless been impossible to register G with accuracy higher the third digit after the decimal point, about which the yearly published data of CODATA witness. In our opinion, it isn't ruled out that ATROPATENA registered tectonic waves which can be emitted by the centers of future earthquakes. Tectonic waves, in contrast to seismic waves, are very slow and long, and are also called "stress waves" (14). Tectonic waves are mechanical (15), as are seismic waves, and in a solid medium they have longitudinal and transversal constituents. Passing through under the station, these waves compress and stretch the thick layers of the Earth and with that they change their density and, as a consequence, their mass.

The changing of mass under the ATROPATENA detector is registered by three sensors - X, Y, and Z, depending on the type of wave and its direction. Longitudinal and transverse tectonic waves influence the Cavendish balance differently, depending on the orientation of balance with respect to the wave. For more accurate determination of coordinates of a future strong earthquake, it is necessary to use, at least, three ATROPATENA stations situated at large distances from one another.

2.3. Conclusions

On the basis of this research the author has come to several important conclusions:

1. The anomalous changes of the measured values of gravitational constant G over time have been registered authentically, and they differ from each other depending on the orientation of Cavendish balance.
2. It has been determined that the variations of the measured values of G, registered by different scientists earlier, are connected, mainly, with the influence of external gravitational fields of geological origin on indicators of the Cavendish balance.

3. A new instrument has been created, the ATROPATENA detector, which allows continuous registration of changes in time of variations of G in different directions together with the variations of acceleration of gravity, Δg, that gives the opportunity to access to a new resource of physical information about geological and cosmic processes.
4. The ATROPATENA detector simultaneously has registered time variations of gravitational constant G, which are different in sign and amplitude, in two mutually perpendicular directions and variations of gravity, Δg, before strong distant earthquakes in 93% of cases, which gives us grounds for creation of a new technology of prognosis of strong earthquakes.

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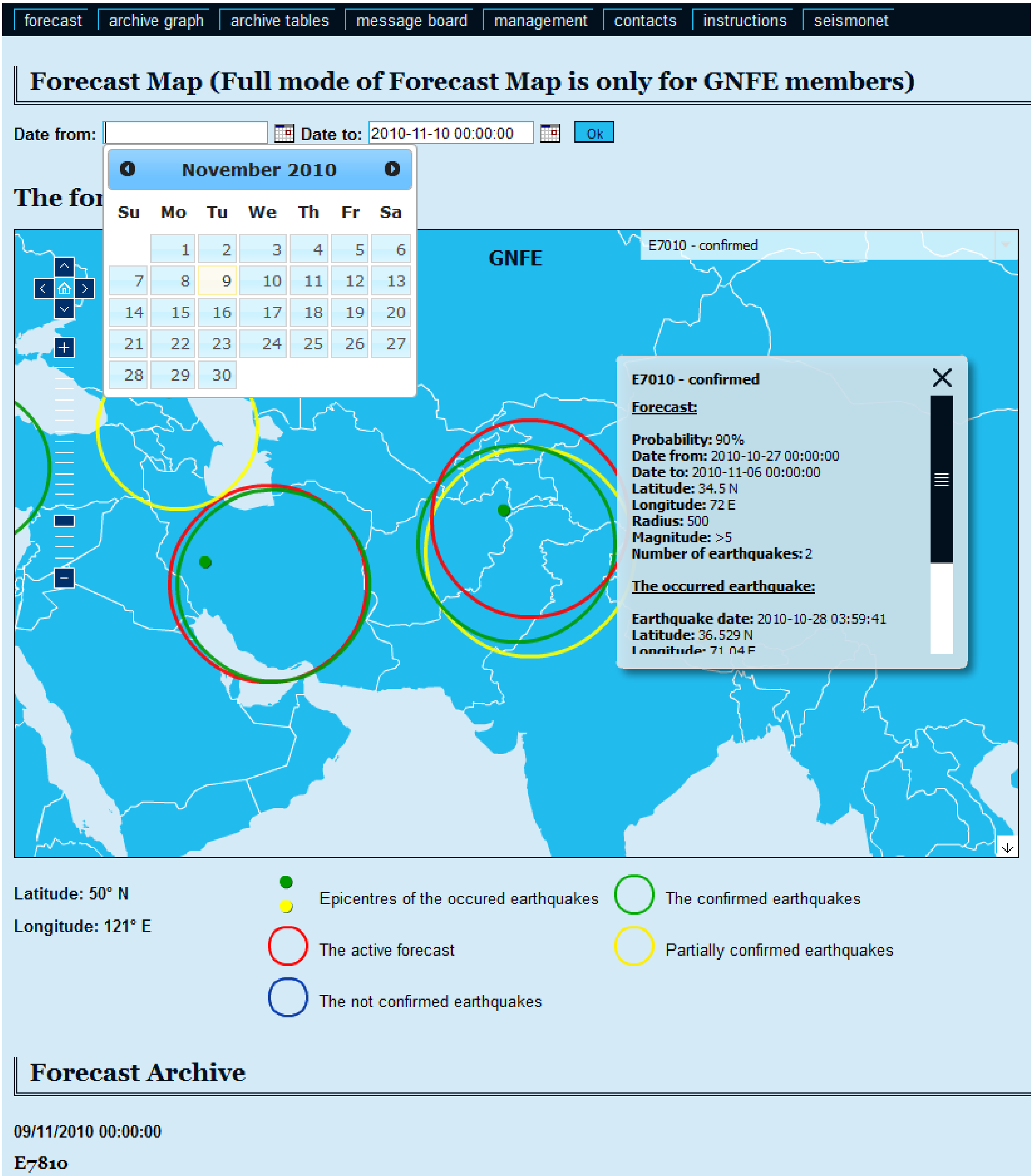
EXAMPLE OF GNFE FORECAST MAP



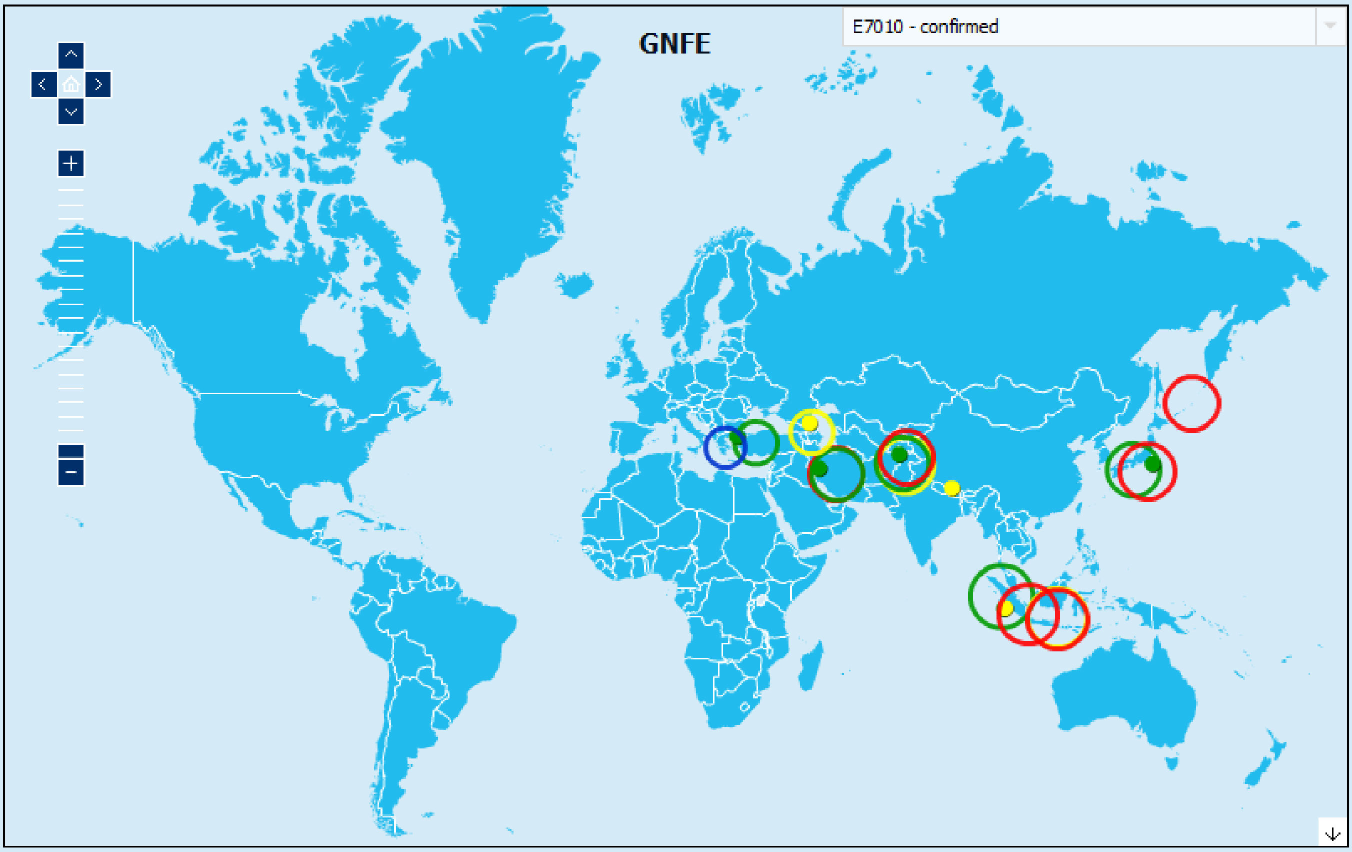
EXAMPLE OF GNFE FORECAST MAP

forecast | archive graph | archive tables | message board | management | contacts | instructions | seismonet

Forecast Map (Full mode of Forecast Map is only for GNFE members)

Date from: **Date to:** 2010-11-10 00:00:00 Ok

The forecast for 30 days



Latitude: 66° N

Longitude: 213° E

Epicentres of the occured earthquakes

The confirmed earthquakes

The active forecast

Partially confirmed earthquakes

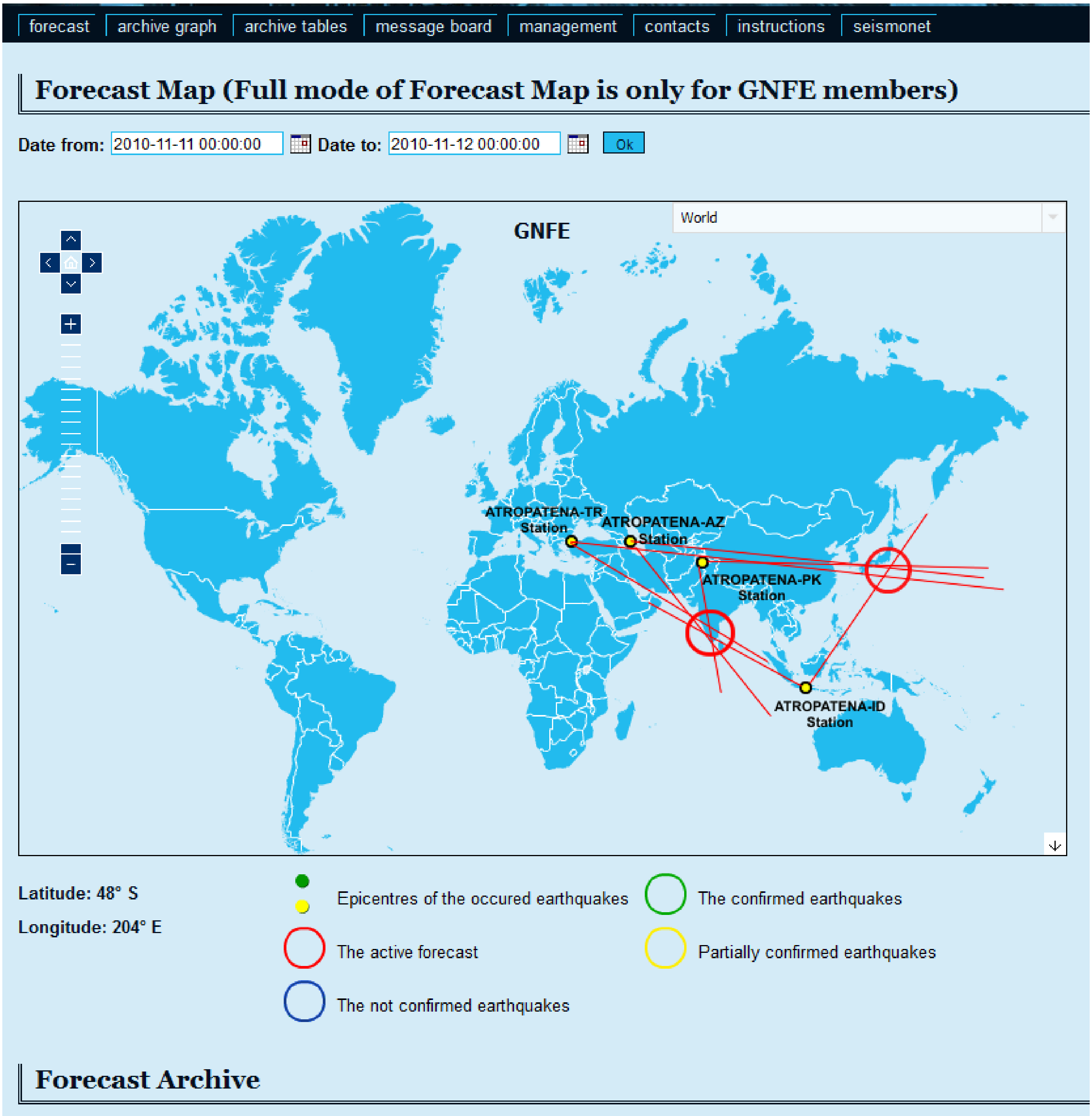
The not confirmed earthquakes

Forecast Archive

09/11/2010 00:00:00

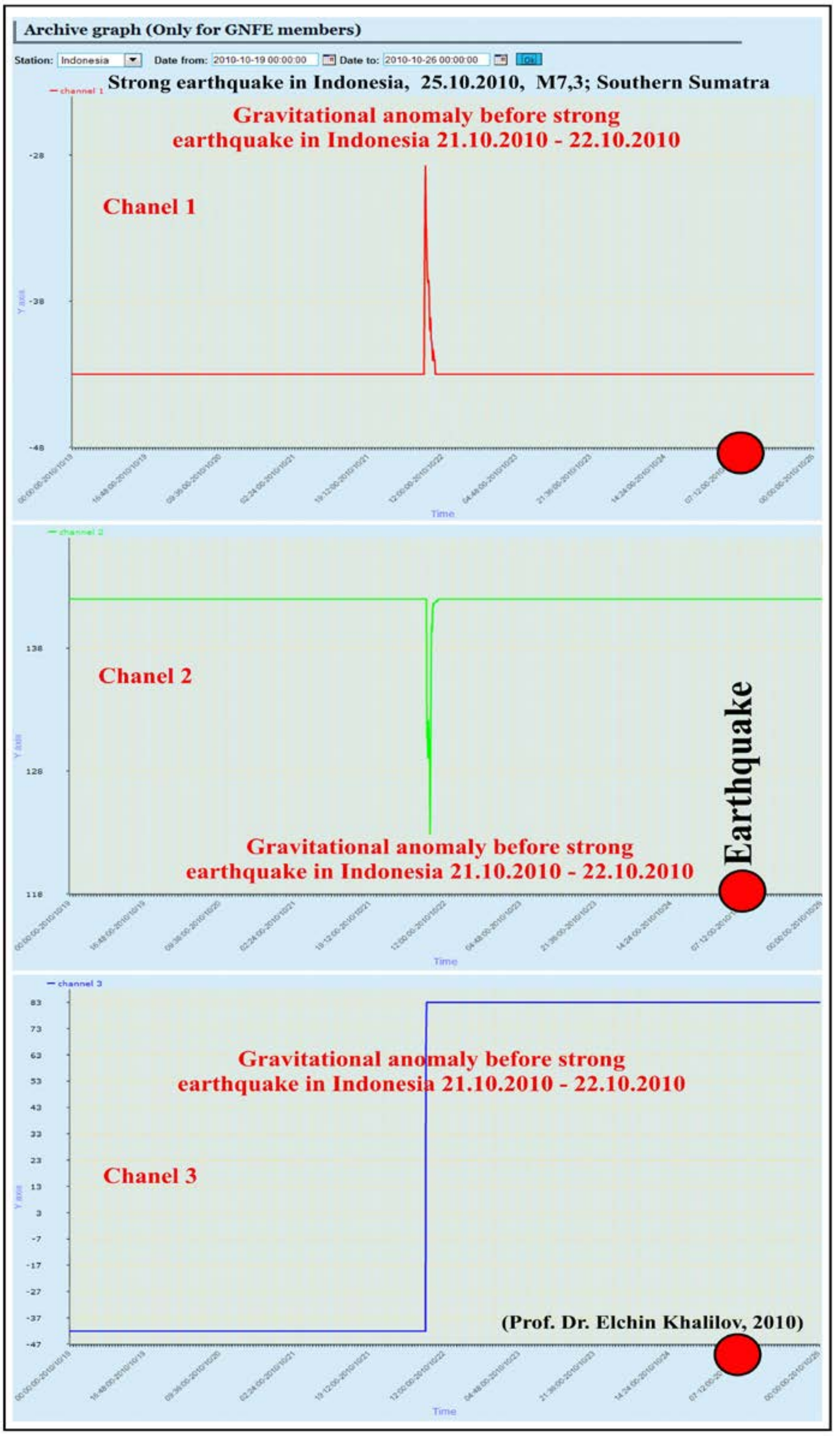
E7810

EXAMPLE OF GNFE EARTHQUAKE EPICENTER FORECAST MAP

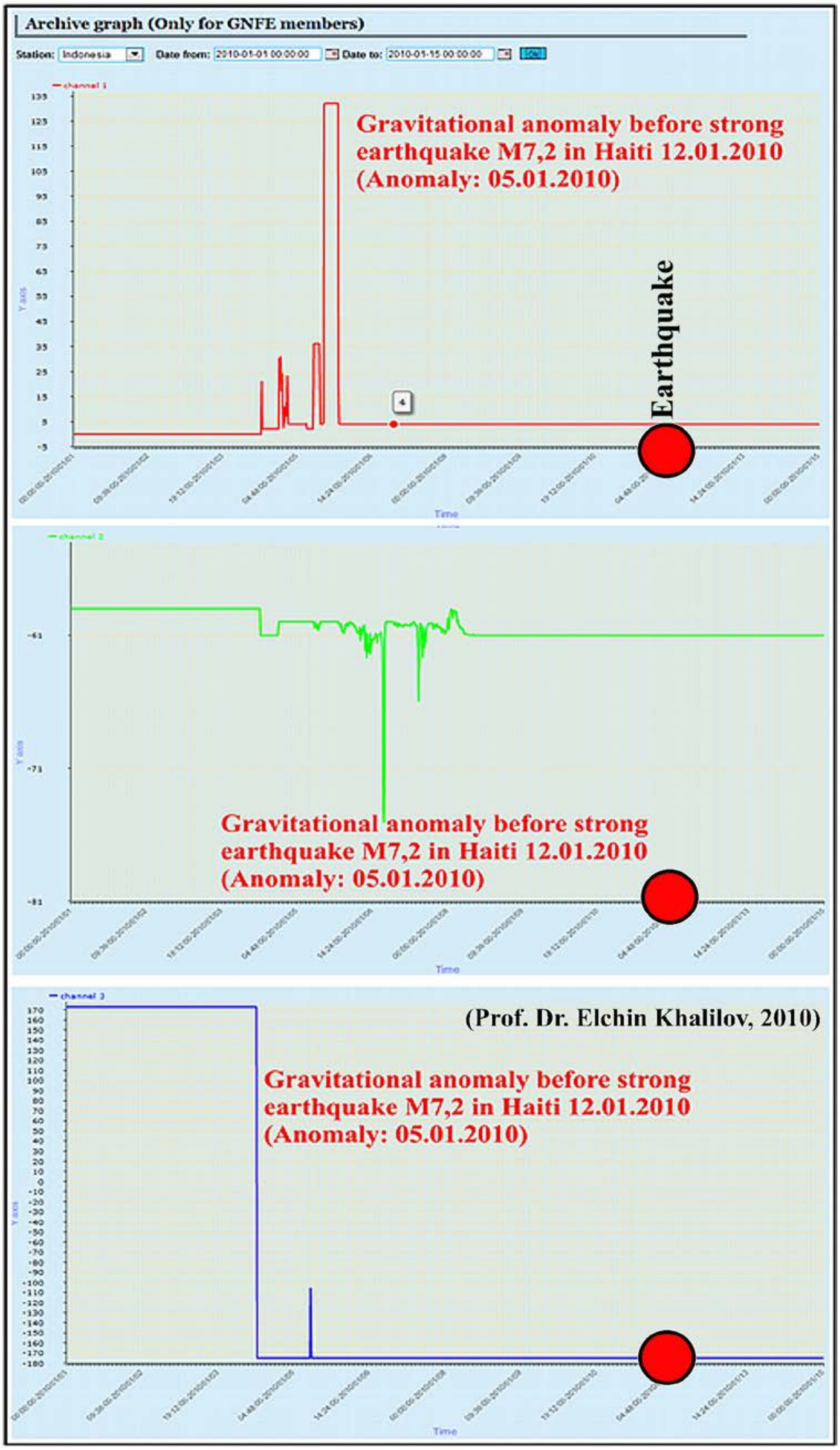


EXAMPLES OF ATROPATENA STATIONS RECORDS BEFORE STRONG EARTHQUAKES

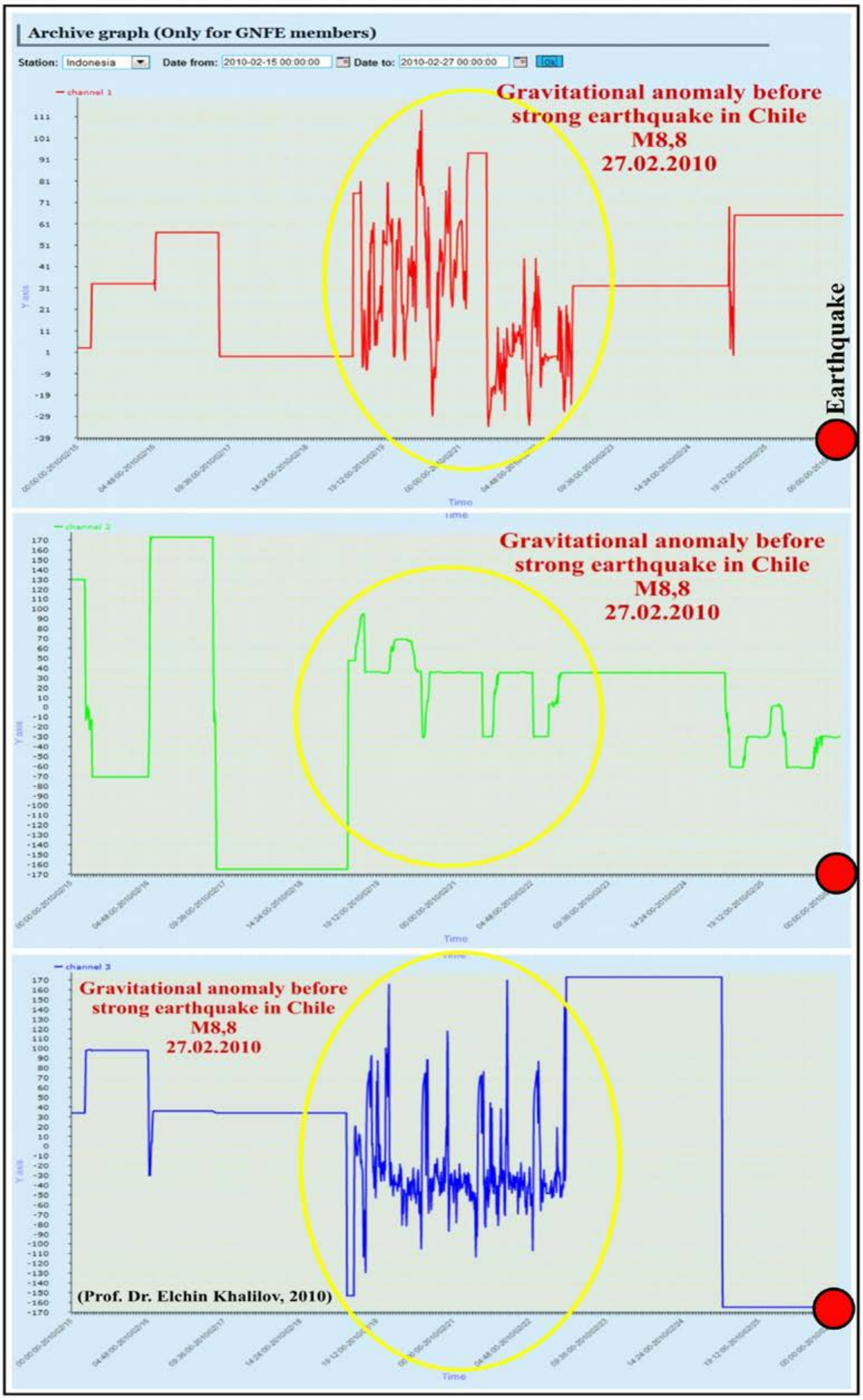
Station ATROPATENA-ID (Indonesia) record before strong earthquake in Indonesia, 25.10.2010, M7,3; Southern Sumatra



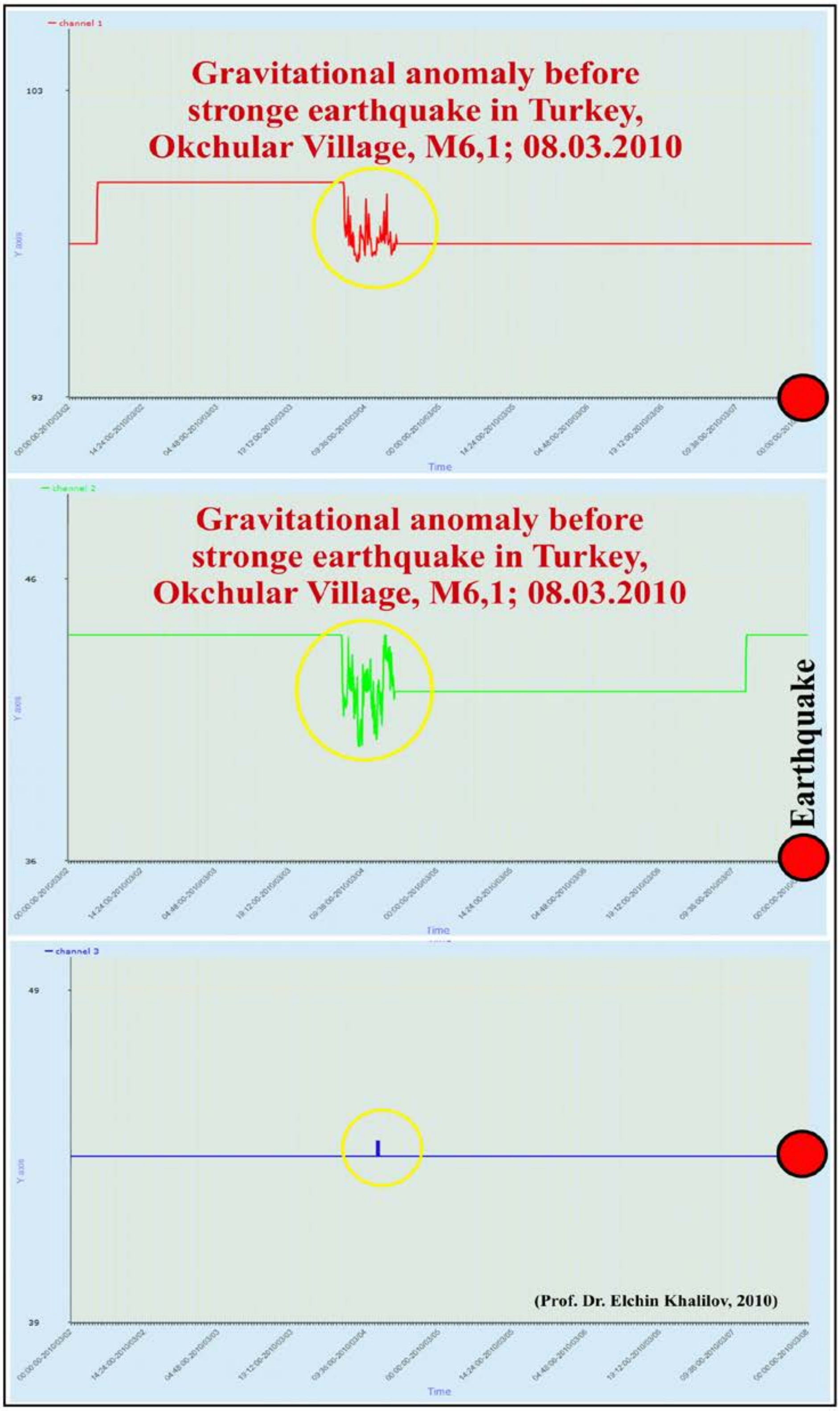
Station ATROPATENA-ID (Indonesia) record before strong earthquake in Haiti 12.01.2010, M 7,0;



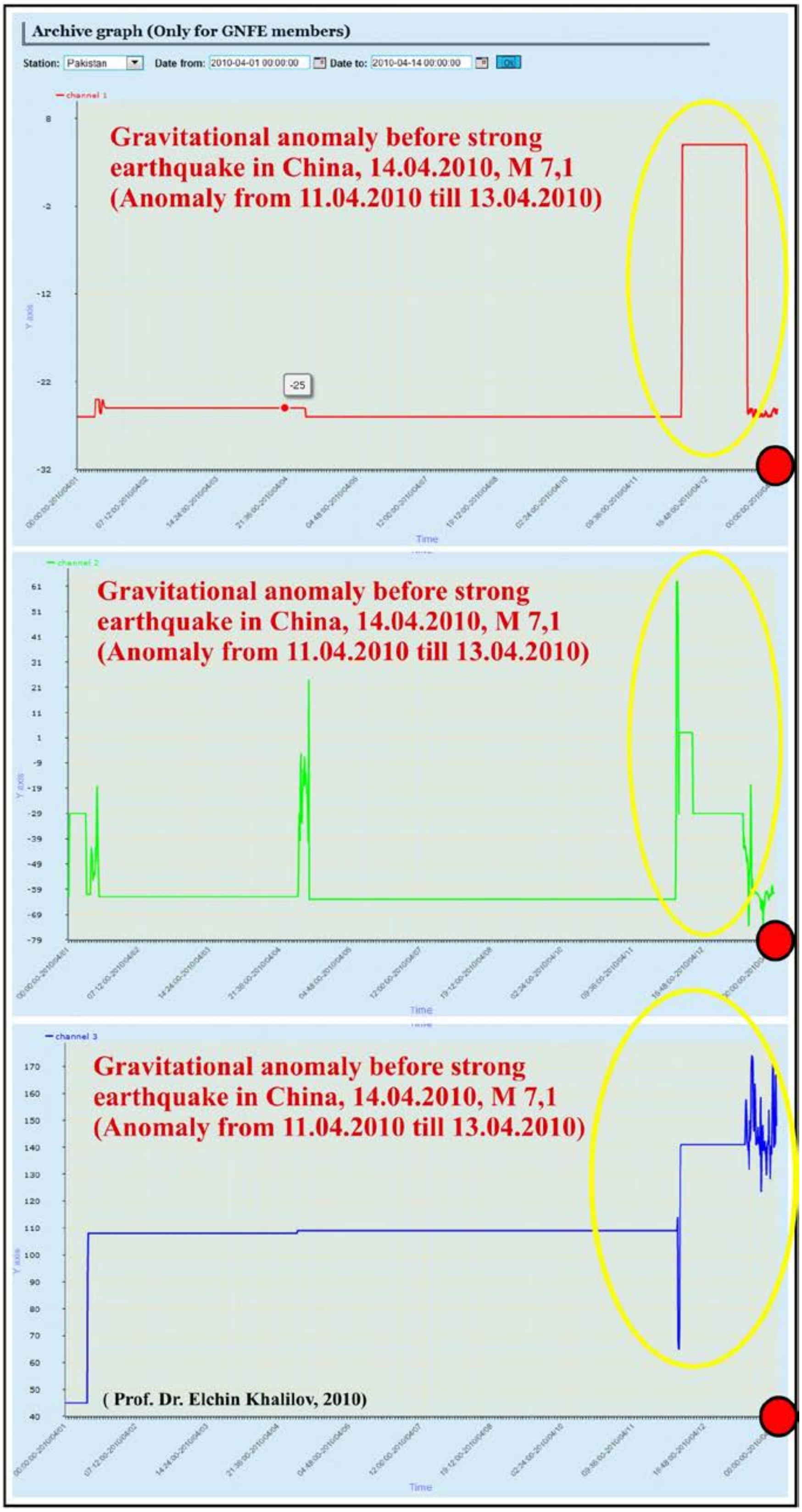
Station ATROPATENA-ID (Indonesia) record before strong earthquake in Chile, M8,8; 27.02.2010 (Anomaly from 18.02.2010 till 22.02.2010)



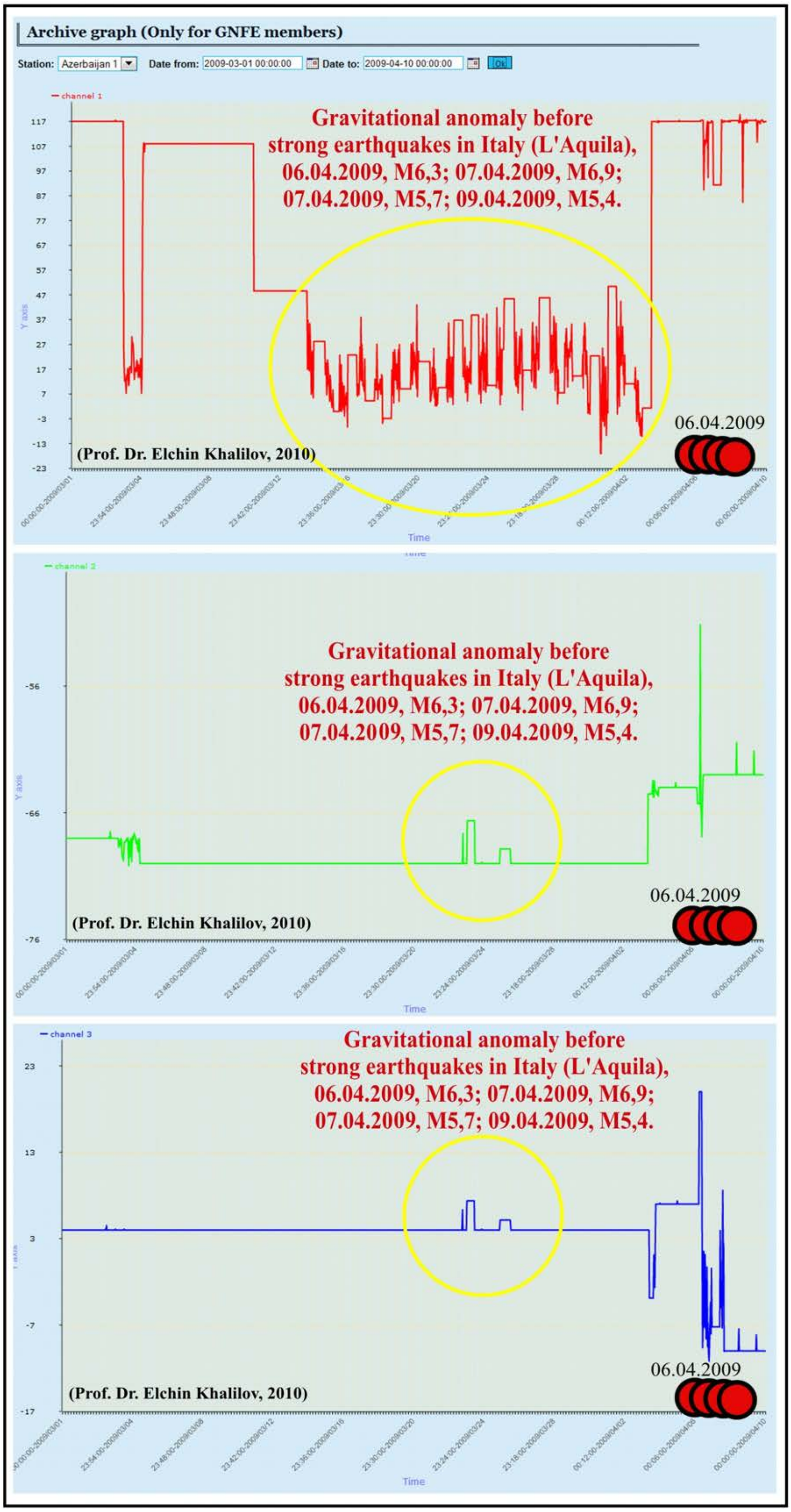
Station ATROPATENA-Az1 (Azerbaijan) record before strong earthquake in Turkey, Okchular village, M6,1; 08.03.2010 (Anomaly from 03.03.2010 till 04.03.2010)



Station ATROPATENA-PK (Pakistan) record before strong earthquake in China (Qinghai Region), 14.04.2010, M7,1; (Anomaly from 03.03.2010 till 04.03.2010)

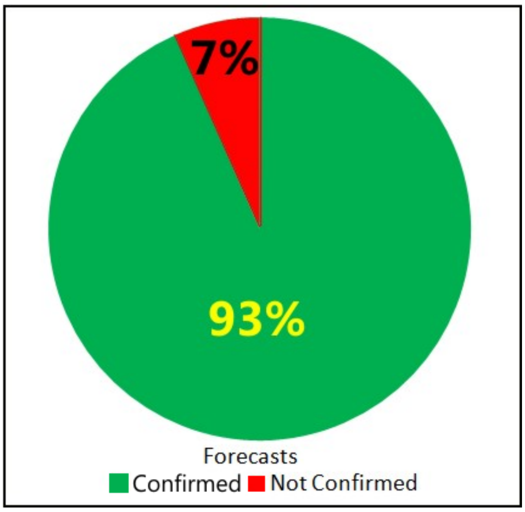


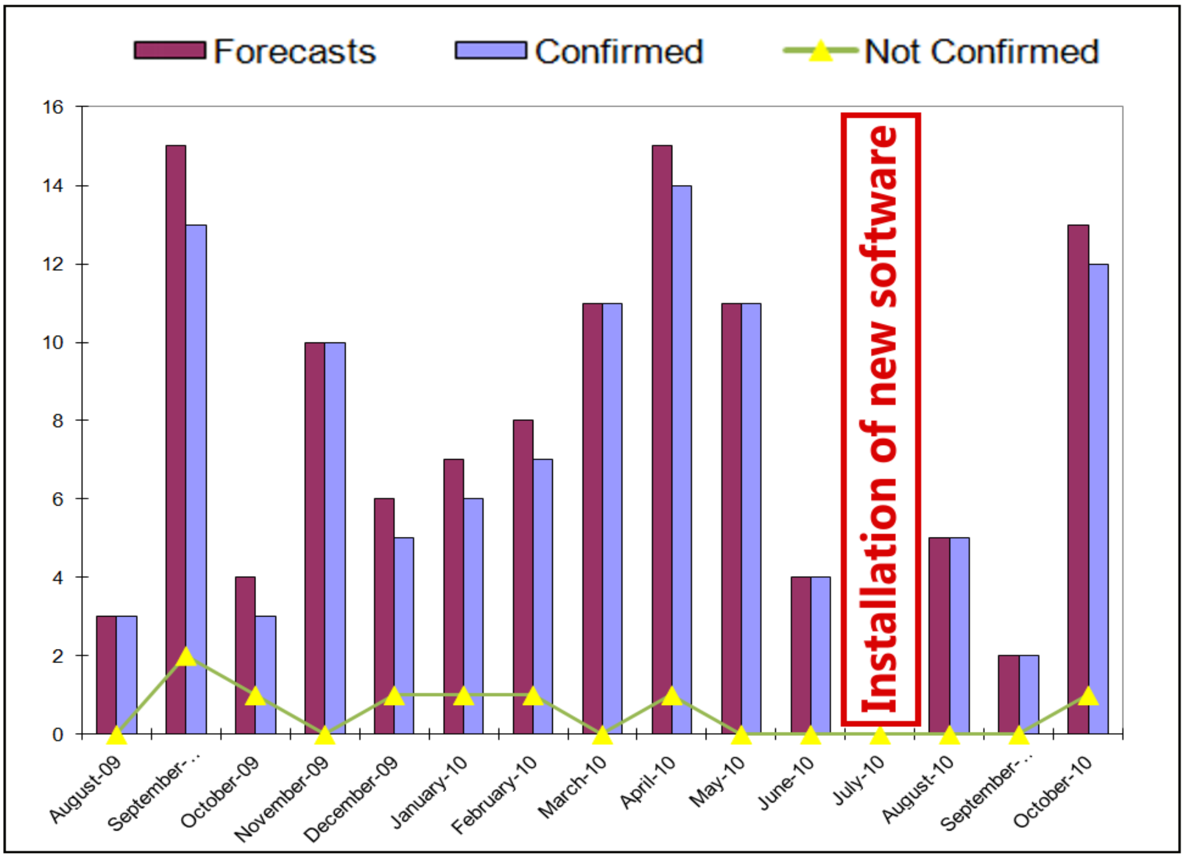
Station ATROPATENA-Az1 (Azerbaijan) record before strong earthquake in Italy (L'Aquila), 06.04.2009, M6,3; 07.04.2009, M6,9; 07.04.2009, M5,7; 09.04.2009, M5,4. (Anomaly from 12.03.2009 till 04.04.2009)



STATISTICS OF GNFE FORECASTS

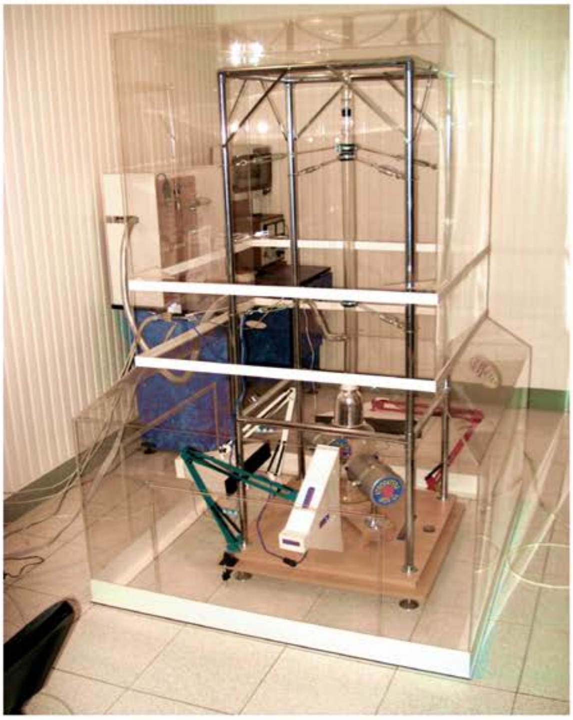
From 01 August 2009 to 10 November 2010, the Global Network for the Forecasting of Earthquakes has officially issued 115 forecasts of strong earthquakes, of which 93% have been confirmed.





The monthly statistics of the confirmed earthquake forecasts by GNFE

Stations of forecasting of earthquakes in the different countries



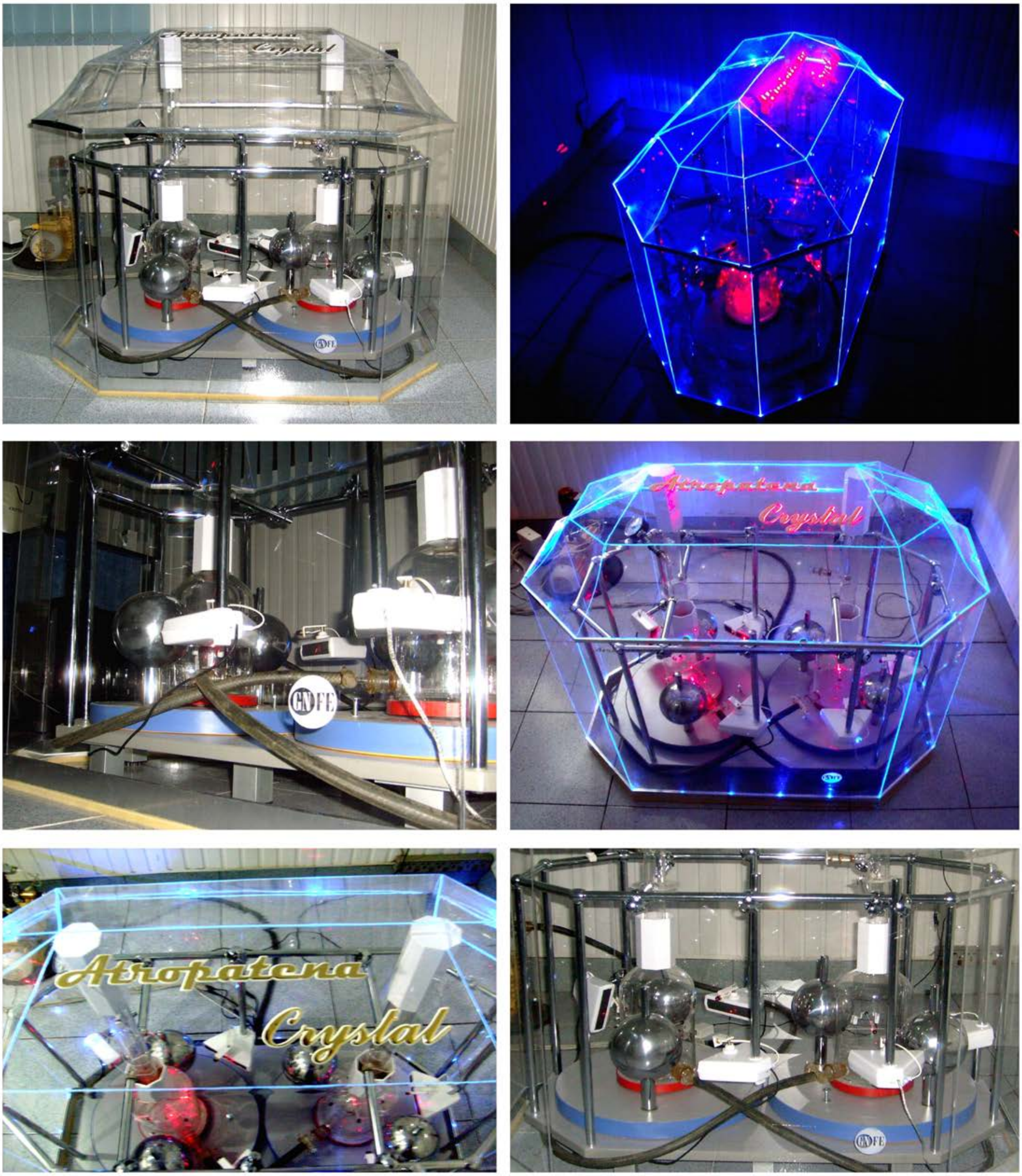
Station Atropatena-Az1, Baku, Azerbaijan, 2006

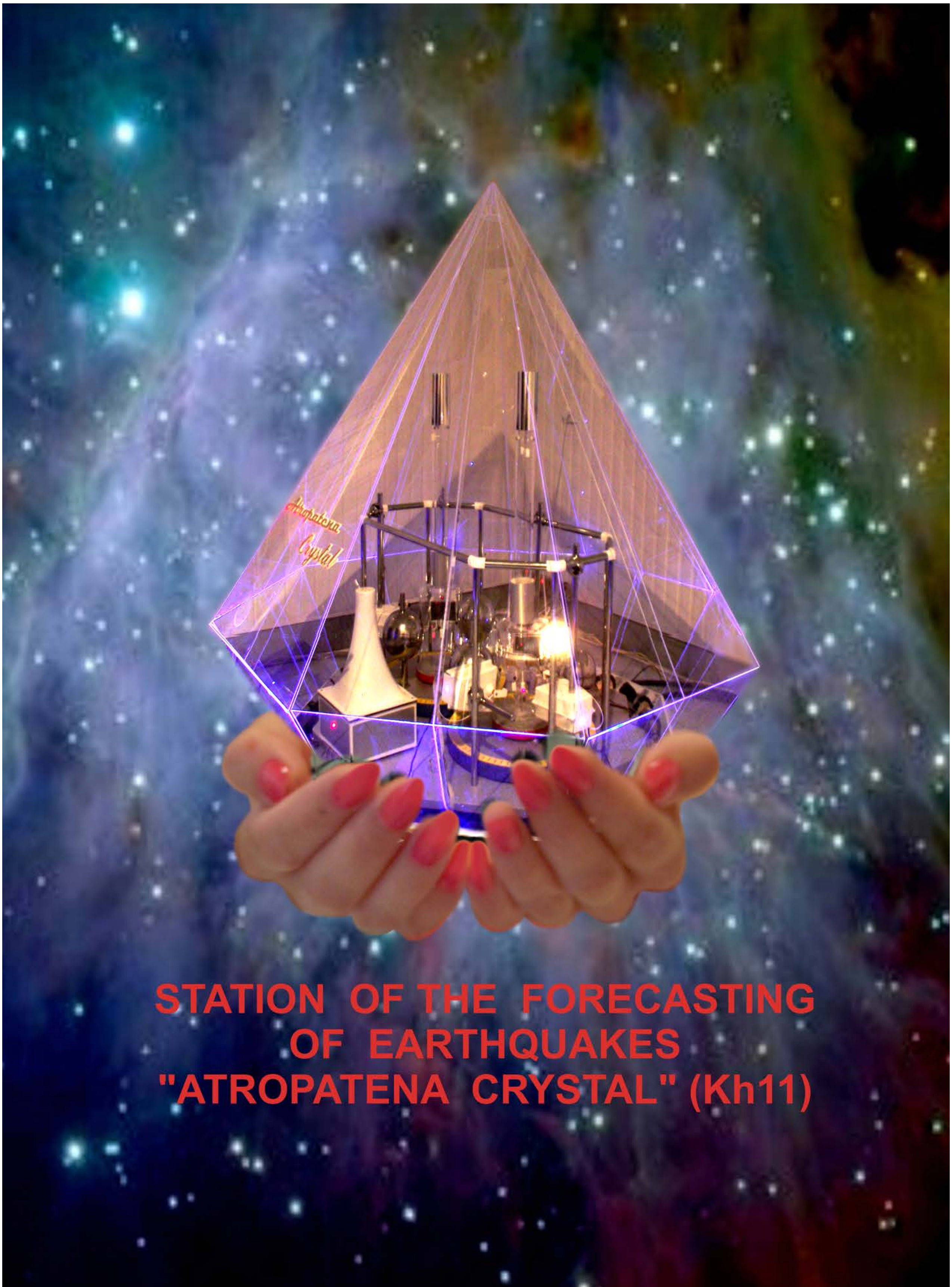
Station Atropatena-Az2, Baku, Azerbaijan, 2009

Station Atropatena-Pk, Islamabad, Pakistan, 2009

Station Atropatena-Id, Yogyakarta, Indonesia, 2009

Station ATROPATENA CRYSTAL in Istanbul (Turkey) and Baku (Azerbaijan), 2010

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