Mud volcano seismo-geodynamics

Oktay Babazade[1], Nigyar Babazade[2]

1. Centre of Seismology and Earth's Physics, Azerbaijan, oktay_babazade@yahoo.com
2. Centre of Seismology and Earth's Physics, Azerbaijan, bnigyar@hotmail.com

ABSTRACT

Different scale migration manifestations of mud volcanic activity dynamics in processes of main earthquake preparation with magnitude 5.0 – 9.0 were invented. Some remarkable migration of mud volcanic eruptions prior to the main earthquakes are described based on the systematic analysis of the National Catalogue of the active mud volcanoes in the period of 1810-2004 in and around the South Caspian depression including the region of east Central Iran. The discovery of pattern of migration of the mud volcanic activity before the main earthquake can be considered as new precursory phenomena. There was used a methodology of finding of two types of migrations of mud volcanic eruptions by reconstruction of the earthquake preparing pattern. There are provided the detailed results of revealing the ordered migration of the mud volcanic eruption by reconstructions of the preparatory phase of earthquakes of November 25, 2000 (M=5.8; 6.3) and December 6, 2000 (M=7.3), having respectively, arisen in a few kilometres to the south-west and north-west of Baku in Caspian Sea and to the west Turkmenistan. These Absheron mud volcanic eruptions were triggered by M 9.0 great earthquake preparation patterns that occurred on December 26, 2004 of the west coast of northern Sumatra, Indonesia. The relationship between Caspian Sea level oscillations and the seismic dynamics the largest magnitude 6.0 to 8.0 and greater, earthquakes worldwide in the Sumatra-Andaman main event preparation regions during the last 200 years is revealed.

Caspian; Absheron; mud; oscillations.

Oktay Babazade is Doctor of physical-mathematical sciences in geophysics. Graduated from Geophysical Engineering Degree – Institute of Oil and Chemistry**.** From 2002 – up to date he is President of Azerbaijan Centre of Seismology and Earth's Physics, 2002 – 2003 Director of National Data Center of CTBTO in National Academy of Sciences of Azerbaijan, 1993 – 1998 Azerbaijan State Ecology and Environment Protection Committee.
1979 – 2003 Head of Earthquake Focal Zones Research laboratory of Institute of Geology, National Academy of Sciences of Azerbaijan, 1984 – 1985 working in Earthquake Research Institute, Tokyo, Japan, 1982 working in Roma, National Geophysical Institute, Italy, 1970 – 1979 Senior Research-Worker, Junior Research Worker at laboratory of Seismology and Earth's Physics, Institute of Geology, Azerbaijan Academy of Sciences., 1967 – 1970 Postgraduate courses, 1963 – 1970 Seismic technician, engineer, geophysicist in expedition of Deep Seismic Sounding, Azerbaijan Marine Geophysical Prospecting Department (KMGR) and Azerbaijan Branch of All-Union Scientific Research Geophysical Institute (AzVniigeofizika). Specialization: Deep Seismic Sounding, seismic geodynamics, prediction of earthquake focal zones, seismological and geophysical precursory, engineering seismology.
Member of Seismological Society of America, from 2006 up to date. Member of Asian Seismological Committee of IASPEY from 1996 up to date, General Secretary of National Committee of Geophysicists of Azerbaijan, Member of International Advisory Committee (Azerbaijan). Publications: Author of more than 150 scientific, technical publications

Real time forecasting of M≥4.0 earthquakes in New Zealand

Rodolfo Console[1], Maura Murru[2], Giuseppe Falcone[3,4]

1. Istituto Nazionale di Geofisica e Vulcanologia, Italy, console@ingv.it
2. Istituto Nazionale di Geofisica e Vulcanologia, Italy, murru@ingv.it
3. Istituto Nazionale di Geofisica e Vulcanologia, Italy, falcone@ingv.it
4. Dipartimento di Scienze della Terra, Messina University, Italy

ABSTRACT

We have applied a short-term clustering model to data collected by the New Zealand Seimological Observatory-Wellington for forecasting earthquakes of moderate and large magnitude in the New Zealand region. The forecasting algorithm, based on the classical epidemic-type model, uses earthquake data only, with no explicit use of tectonic, geologic, or geodetic information. In this model every earthquake is regarded, at the same time, as being triggered by previous events and triggering following earthquakes.
A maximum likelihood estimate of the model parameters has been performed on the learning period from 1960 to 2005 for earthquakes of magnitude 4.0 and larger. Forecast verification procedures have been carried out in forward-retrospective way on the January 2006-April 2008 data set, making use of statistical tools as the log-likelihood ratio, the Relative Operating Characteristics (ROC) diagrams, the Molchan error diagrams, the probability gain and the R-score. These procedures show that the clustering epidemic model performs up to several hundred times better than a simple random time-independent, spatially variable forecasting hypothesis.
This study is related to the preparation of the algorithm for its possible application to the real-time data at the New Zealand Earthquake Forecast Testing Centre. In this context, the grid-based forecast algorithm has been implemented in a computer code that matches all the standard input-output requirements for its real-time test. For this application the learning period extends over all the data set up to April 2008.

Key words: earthquake forecasting, real time forecasting, epidemic model, hypothesis testing, error diagrams.

PRESENTER'S BIOGRAPHY

Rodolfo Console was born in 1944 and graduated in Physics at the University of Rome in 1967. His activities, started as seismologist at the Istituto Nazionale di Geofisica e Vulcanologia (INGV) in 1968, until formal retirement in 2004, included:

- Upgrading of the Italian National Seismological Network (1968-1982);
- Development of computer procedures for the preparation of National Seismological bulletins (1972-1982);
- Implementation of the Italian nation-wide automatic acquisition system of seismological data (1982-1987);
- Development of seismological research focusing in particular on earthquake clustering models and short-term earthquake forecast, having published more than 100 papers on international journals.

His present position after formal retirement is: scientific advisor at the INGV.
His academic activities included lecturing as for the annual course in Seismology at the University of Rome "Roma Tre" (1997-present), and for the course "Physics of earthquake sources" for the PhD course organized by the Universities of Bologna, Rome and Napoli (2001-present).
He has been granted as visiting professor by Japanese and Greek universities.
He has been coordinator of several international meetings, member of international committees, editor of scientific volumes and he is, at the present time, Associate Editor for "Annals of Geophysics" (1990-present), and "Journal of Geophysical Research" (2005-present).

Physics of Groundwater level Changes Induced by Earthquakess

Huang Fuqiong[1,2], Zhang Yan[2], Yan Rui[1]

1. China Earthquake Network Center, CEA, China, hfqiong@seis.ac.cn
2. Institute of Geophysics, CEA, China

ABSTRACT

The physics of earthquake induced groundwater level changes are kept controversial because of the unknown mechanism and good quality observation data. In this paper we show the data of water level changes and volumic strain changes induced by the 2008 Wenchuan earthquake and 2007 Sumatra earthquake observed in a bore hole in Liaoning province, north-east of China. The bore hole was drilled into granite aquifer with depth of 60 m. The cracked formation located in 27m and 48-49m. The volumic strain meter was buried at the bottom of the bore hole. The hydraulic sensor is located 1-10 m below the water surface in the bore hole. Both the volumic strain meter and hydraulic sensor are made in China with accuracy of 10-9 and 0.5 cm respectively. The observation data show clear-cut earth tide which means the aquifer is well confined. The 2008 Wenchuan earthquake and 2007 Sumatra earthquake induced both the water level and the volumic strain changes. We compared the process on the induced changes. The result is that the water level changes kept pace with the volumic strain changes. We inferred that the water level changes induced by earthquakes can be considered as volumic strain changes induced by the earthquake. The well confined water level –aquifer system can be as a kind of volumic strain meter.

Earthquake Prediction and Anomalies

David D. Jackson

Department of Earth and Space Sciences, UCLA

Finding anomalies is easy. Predicting earthquakes convincingly from such anomalies is far from easy. Why? Why have so many beautiful geophysical abnormalities not led to successful prediction strategies?

What is earthquake prediction? By my definition it is convincing information that an earthquake of specified size is temporarily much more likely than usual in a specific region for a specified time interval.

We know a lot about normal earthquake behavior, including locations where earthquake rates are higher than elsewhere, with estimable rates and size distributions. We know that earthquakes have power law size distributions over large areas, that they cluster in time and space, and that aftershocks follow with power-law dependence on time. These relationships justify prudent protective measures and scientific investigation. Earthquake prediction would justify exceptional temporary measures well beyond those normal prudent actions. Convincing earthquake prediction would result from methods that have demonstrated many successes with few false alarms.

Predicting earthquakes convincingly is difficult for several profound reasons.

First, earthquakes start in tiny volumes at inaccessible depth. The power law size dependence means that tiny unobservable ones are frequent almost everywhere and occasionally grow to larger size. Thus prediction of important earthquakes is not about nucleation, but about identifying the conditions for growth.

Second, earthquakes are complex. They derive their energy from stress, which is perniciously hard to estimate or model because it is nearly singular at the margins of cracks and faults. Physical properties vary from place to place, so the preparatory processes certainly vary as well. Thus establishing the needed track record for validation is very difficult, especially for large events with immense interval times in any one location.

Third, the anomalies are generally complex as well. Electromagnetic anomalies in particular require some understanding of their sources and the physical properties of the crust, which also vary from place to place and time to time. Anomalies are not necessarily due to stress or earthquake preparation, and separating the extraneous ones is a problem as daunting as understanding earthquake behavior itself.

Fourth, the associations presented between anomalies and earthquakes are generally based on selected data. Validating a proposed association requires complete data on the earthquake record and the geophysical measurements over a large area and time, followed by prospective testing which allows no adjustment of parameters, criteria, etc. The Collaboratory for Study of Earthquake Predictability (CSEP) is dedicated to providing such prospective testing. Any serious proposal for prediction research should deal with the problems above, and anticipate the huge investment in time required to test hypotheses.

PI forecast for the Sichuan-Yunnan region: retrospective test after the May 12, 2008, Wenchuan earthquake

Jiang Changsheng[1], **Wu Zhongliang**[2]

1. Institute of Geophysics, China Earthquake Administration, China, jiang_cs79@sina.com
2. Institute of Geophysics, China Earthquake Administration, China, wuzhl@gucas.ac.cn

ABSTRACT

To explore whether there were some indications of the increase of strong earthquake probabilities before the May 12, 2008, Wenchuan M_S8.0/M_w7.9 earthquake, we conducted retrospective forecast test using the Pattern Informatics (PI) algorithm for the earthquakes in Sichuan-Yunnan region since 1992. Regional earthquake catalogue down to M_L3.0 from 01/01/1977 to 15/06/2008 was used. Fifteen-year long 'sliding time window' was used in the PI calculation, with 'anomaly training time window' and 'forecast time window' being both 5 years. Receiver operating characteristic (ROC) test was conducted for the evaluation of the forecast result. Setting 'target magnitude' for the forecast as M_S5.5, the ROC test shows that the PI forecast outperforms not only random guess but also the simple number counting approach based on the clustering hypothesis of earthquakes (the RI forecast). 'Hotspots' can be seen in the region of the northern Longmenshan fault which is responsible for the Wenchuan earthquake. Remarkably, the 'hotspot' cluster strikes along the earthquake rupture zone just before the earthquake. However, when considering bigger grid size and higher cutoff magnitude as conventionally done, such 'hotspots' disappeared and there was almost no indication of the approaching of this great earthquake. Based on this observation we argue that in the analysis of seismicity, small events may contain important information and cannot be neglected.

Key words: pattern informatics; statistical physics; intermediate-term earthquake forecast; ROC test; Wenchuan earthquake

PRESENTER'S BIOGRAPHY

Wu Zhongliang (Z. L., Wu), Research scientist at the Institute of Geophysics, China Earthquake Administration (IGPCEA). Director of IGPCEA (2004-2008). President of IASPEI (2007-2011).

Earthquake forecasting using a new theory concerning the anomalous behavior of precursory weak high frequency seismic waves

Ikram KERIMOV[1], Seymur KERIMOV[2]

1. Prof, Dr., Director, Scientific Centre of Seismology, Presidium of the National Academy of Sciences, Azerbaijan Republic, scseismo@azdata.net
2. Director of Seismotech Globe B.V., the Netherlands, seymourki@web.de

ABSTRACT

A discovery of characteristic precursory anomalous changes of weak high frequency seismic waves enables more reliable earthquake forecasting and correct determination of focal coordinates and intensities. This previously unknown behavior of microseisms has been accorded the status of Scientific Discovery of a new physical phenomenon by the USSR State Committee for Discoveries and Inventions in March 1988, with priority from May 1979 with the description: "Previously unknown regularity of changes in microseisms before an earthquake has been established, which stipulates that at distances that exceed the size of the epicentral zone a multistage increase in the intensity of microseisms occurs, with simultaneous decrease of their main frequency. Along with this, there are also characteristic recurring impulses (zugs) of oscillations that increase in intensity and decrease in time between their appearances, which are polarized in the direction of the epicenter of the future earthquake".

This discovery also explains the origin of many other natural processes associated with earthquakes, and serves as the basis for a nonlinear theory of the relation of weak seismic signals with the medium in which they occur. The latter theory has many beneficial applications: earthquake forecasting, specifying the stress state of a medium, modeling the effects of induced seismicity, ecological control of large industrial activity, and enabling the creation of unified seismological and geophysical monitoring systems.

The requirements for a seismologic observation network set up to monitor strong seismic events like earthquakes and explosions, and for a network for recording weak precursory signals with intensity close to the Earth's natural background seismicity at the point of observation are different. Which explains why so little progress has been made in earthquake prediction: existing seismological networks do not meet these criteria.

The former should be set up on basement rock with a minimum thickness of sedimentary column as this arrangement significantly absorbs the intensity of strong signals. Seismic networks set up for forecasting earthquakes conversely must be placed in regions with thick sedimentary column which are natural amplifiers of weak signals.

The seismic and gravity fields interactions study suggests that the gravitation force could be explained not only by the mass of one body, but also by its stressed state and vibration processes.

We have also reviewed the conventional approaches to earthquake prediction that measure multiple geophysical fields, requiring that one precursory field observation must be confirmed by changes in other fields. We have shown that they cannot all appear at the same time. The decrease of the dominant frequency of anomalous microseisms over various periods of time is a major factor which activates one or more of the precursory events in other geophysical fields. A change in one geophysical field suggests when an abnormal change will happen in another field, predicting a chain of precursory of events, and even changes that have taken place already but were not recorded. The more the delay between these changes in various geophysical fields, the bigger the ensuing earthquake, with the time of its main shock being related to the time delays.

Key words: prediction, precursors, networks, methodology.

PRESENTER'S BIOGRAPHY

Ikram G. KERIMOV,

Professor, Doctor of the physical and mathematical sciences

Director, Scientific Centre of Seismology,

Presidium of the Azerbaijan National Academy of Sciences

Major scientific positions

1993 – 1999 Head of the Azerbaijan –Ukrainian Inter-Governmental Programme on induced seismicity prevention

1985 – 1992 Head of the USSR State Project *"Land - Space Geophysical System Creation*"

1980 – 1992 Head of the Azerbaijan Section of the USSR State Programme *"Earthquake Prediction and Crust and Upper Mantle Structure Study"*

1977 - 1980 Head of the Azerbaijan Section of the International Programme *"Earth Crust and Upper Mantle Structure Study of Alpine Belt"*

Highest scientific achievements

- Scientific Discovery: "New Law of Conformity of Weak High Frequency Seismic Waves" registered on March, 1988, USSR State Committee for Inventions and Discovery
- New Earth's Structure Model with intermediate Layer in Mantle, 800 km - 1,500 km
- The Technology to Improve Hydrocarbon Production and Recovery

Forecast/prediction of extreme seismic events

Vladimir G. Kossobokov[1,2]

[1] International Institute of Earthquake Prediction Theory and Mathematical Geophysics, Russian Academy of Sciences, 84/32 Profsoyuznaya Street, Moscow 117997, RUSSIAN FEDERATION, volodya@mitp.ru
[2] Institut de Physique du Globe de Paris, 4 Place Jussieu, 75252 Paris, FRANCE, volodya@ipgp.fr

ABSTRACT

Usually forecast/prediction of extreme events is not an easy task. By definition, an extreme event is the rare one in a series of kindred phenomena. That is why a systematic study of extreme events usually implies a delicate application of small sample statistics to data of different accuracy collected in different environment. Although many extreme events of different kinds do not follow simple distribution, their small sample size does not allow rejecting such kind of hypotheses. Evidently, the situation complicates search and definition of precursory behaviors for monitoring and forecasts/predictions. Moreover, it creates a trap for premature accepting misleading hypothesis as a model process.

Making forecast/prediction claims quantitatively probabilistic in the frames of the most popular objectivists' viewpoint on probability requires a long series of "yes/no" forecast/prediction outcomes, which cannot be obtained without an extended rigorous test of the "black box" version of a candidate method. The set of errors ("success/failure" scores and space-time measure of alarm) and other information obtained in an enough durable test supplies us with data necessary to judge the performance of the candidate and its potential as a forecast/prediction tool, to accept or reject one, and, eventually to find improvements. This is to be done in comparison against random guessing or "null-hypothesis" algorithm, which results an estimate of confidence. Note that an application of the forecast/prediction tool(s) could be very different in cases of different costs and benefits, and, therefore, requires determination of optimal strategies. In their turn case specific costs and benefits may suggest an optimal modification of the forecast/prediction tool(s).

The observed seismic dynamics prior to and after many mega, great, major, and strong earthquakes demonstrate common features of predictability and diverse behavior in course durable phase transitions in complex hierarchical non-linear system of blocks-and-faults of the Earth lithosphere. The confirmed fractal nature of earthquakes and their distribution in space and time implies that traditional estimations of seismic hazard are usually based on erroneous assumptions of simple analytically tractable models. Understanding the complexity of seismic process along with its non-stationary self-organized behaviors, has led already to reproducible intermediate-term middle-range earthquake prediction technique that has passed control test in forward real-time applications during at least the last two decades.

To facilitate understanding the basics of reproducible seismic forecast/prediction methodologies, many cases from the on-going real-time testing are presented to evidence common features and complexities of earthquake sequences.

Key words: extreme events, statistics, forecast, prediction, earthquakes

PRESENTER'S BIOGRAPHY

Vladimir G. Kossobokov. Chief scientist at the International Institute of Earthquake Prediction Theory and Mathematical Geophysics – Russian Academy of Sciences, Moscow. MS in Mathematics, Department of Mechanics and Mathematics, Moscow State University (1975); PhD in Geophysics at the Institute of Physics of the Earth – USSR Academy of Sciences, Moscow (1984); Doctor of Science in Geophysics at the International Institute of Earthquake Prediction Theory and Mathematical Geophysics – Russian Academy of Sciences, Moscow (2004). Since 1999 an expert of European Advisory Evaluation Committee for Earthquake Prediction, Council of Europe; since 2007 a vice president of the IUGG GeoRisk Commission (Commission of Geophysical Risk and Sustainability). An author of reproducible earthquake prediction algorithms and their on-going global real-time testing aimed at the largest earthquakes worldwide (set up in 1992). He suggested a generalization of the Gutenberg-Richter scaling law, which takes into account the fractal properties of earthquake distribution. Author of 133 scientific publications.

Dr. V.F. OSTAPENKO **(OstVF@mail.ru),**

Prof. V.A. KRASNOPEROV **(krasva38@mail.ru).**

Institut of Seismology and Faculty of Engineering Suleyman Demirel University.

(ALMATY, KAZAKHSTAN)

ANOMALOUS VARIATIONS OF NATURAL NEUTRON FLUX AND EARTHQUAKE SHORT-TERM FORECAST ISSUES

In the seismic zone adjacent to the city of Almaty (Kazakhstan) since 1996 at about 40 meters of water equivalent underground there have been conducted continuous observations on natural Neutron Flux (NF) variations. It has been found that sometimes within an hour interval a neutron counting rate was sharply higher as compared to standard background. This happens prior to earthquakes, i.e. most often increase in NF rate takes place by 1 to 10 days earlier. 70% OF SUCH EVENTS ARE WITHIN THE INTERVAL OF 4 DAYS. There is a linear dependence between the neutron counting rate and the energetic class of the consequent earthquake with the epicenter of up to 450 km from the place of NF registration. In our opinion, the registered anomalous NF variations are caused by variations of the muon component of cosmic radiation. To explain this we propose two hypotheses. The first one is based upon changes in the condition of interplanetary space (solar wind) during solar flares. The energy of solar wind transferred to Earth puts into action a trigger mechanism of the process of earthquake initiation in those places where conditions have already been prepared for them. The other hypothesis assumes that some processes in the interior of the Earth result in increase in muon radiation rate over the seismic focus.

Key words: *earthquake, neutron, muon, background, drift mine.*

Earthquakes are amongst the most threatening natural disasters. They cause huge destruction and numerous casualties. To the extent that there is no means for preventing earthquakes the question is to develop a forecast of such an act of nature. All over the world investigations are conducted regarding various effects in the environment that could be used as earthquake signs. We believe that Anomalous Variations (AV) of natural neutron flux represent such effect. Some results of our AV research are listed below.

The continuous observations on the NF value being conducted both in a drift near Almaty at the altitude of 1600m and on the exposed surface in the same region have shown that sometimes the NF value had been dramatically increased within a certain hour as compared to the standard one. Statistical distribution of dispersions of the NF value is close to normal one; however deviations from the average number, exceeding the latter more than by triple mean-square error, are twice as much of theoretically expected value from Gauss distribution. Such values we consider as an anomaly. Obviously there is a certain natural factor resulting in such anomalies [1, 2].

It is a well-known fact [3] that a natural neutron flux consists of three components. Firstly, neutrons are formed as a result of interaction of cosmic radiation with atomic kernels of substance of atmosphere and the earth's crust. Secondly, free neutrons segregate during spontaneous fission of uranium kernels. And finally neutrons can be generated by nuclear reactions during interaction of alpha particles of natural radionuclides with atomic kernels of light elements, which are present in atmosphere and the earth's crust. Therefore a change of the NF value can be caused either by variations of intensity of cosmic radiation or by alteration of concentration of uranium and other radioelements emitting alpha particles to the space adjacent to the place of position of a neutron detector.

It has been cited in literature that neutron flux bursts were associated with larger quantities of radon emissions during either rock fracturing under the influence of extreme tidal forces cased by new or full moon or under earthquake initiation processes [4]. Comparison of measurement results showed that anomalous increase in the NF value could not be explained by any additional inflow of radon, which is the most mobile radioelement in the nature. The fact is that in the drift with no ventilation, which is behind the tightly closed doors, the NF anomalies resulting from additional inflows of radon had to be observed during the time substantially exceeding the one-hour interval as long as radon half-value period is 3.8 days. Direct measurements of radon and its short-lived isotope (thoron) in the surface layer in immediate proximity to a neutron detector [5] have shown no relationship between neutron bursts and isotope variations (see Figure 1).

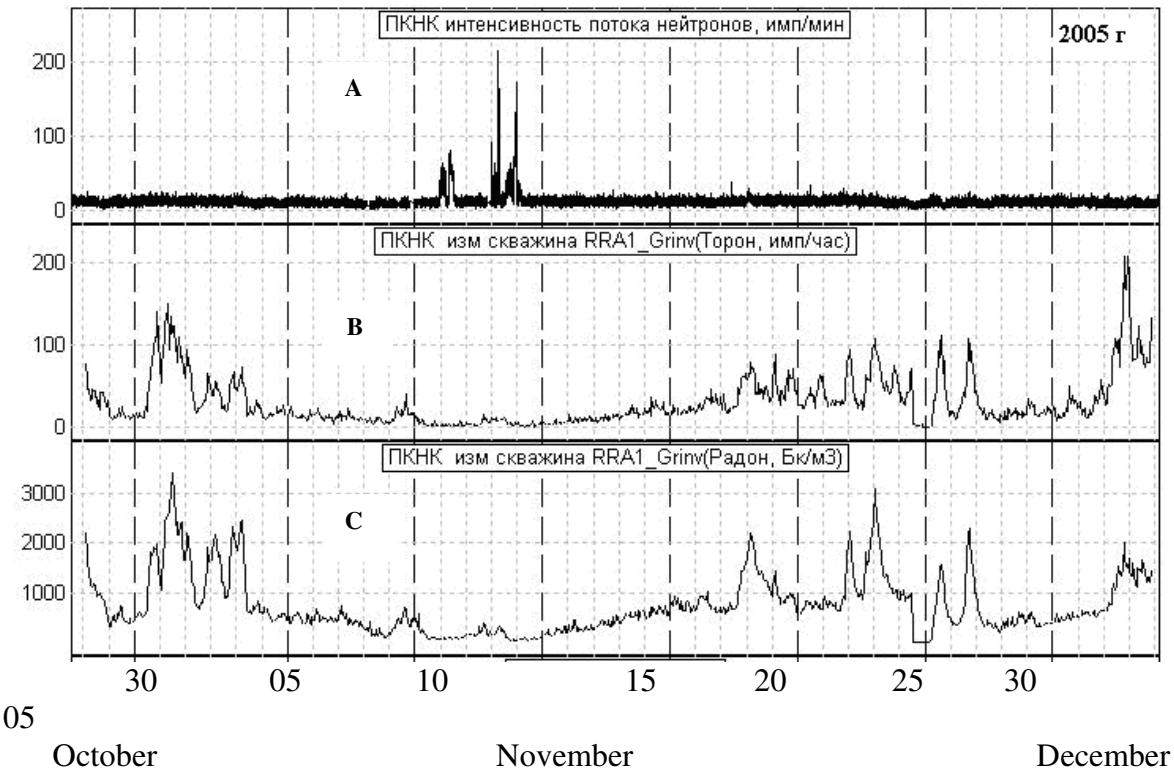


Figure 1. **A** – neutron flux level, **B** and **C** – respective activity concentrations of thoron and radon in soil air.

Contents of other radioactive elements in the ambient the neutron detector environment is practically stable. Thus, a change of the NF value most likely is caused by variations of cosmic radiation and particularly by variations of mu-mesons relating to the hard component thereof, as since only these particles have been able to penetrate the drift through tens meters of rock. Besides, evaluations have shown that in our case in the drift the neutron component that was formed by spontaneous uranium decay and interaction of alpha particles with atomic nuclei was 10 per cent of the total registered underground NF. According to bibliography [6] the thickness of rock layer over our neutron detector damps muon flow tenfold. On the exposed surface the same detector registered a twelvefold increase in neutron rate. Such a correlation represents a high probability of muon origin of the neutron flux measured in the drift.

On analysis of measurement results it has been determined a certain connection between the NF value and seismic occurrences. Periods of increase of frequency of anomalies usually agree with the periods of seismic activity increase (see Figures 2-4).

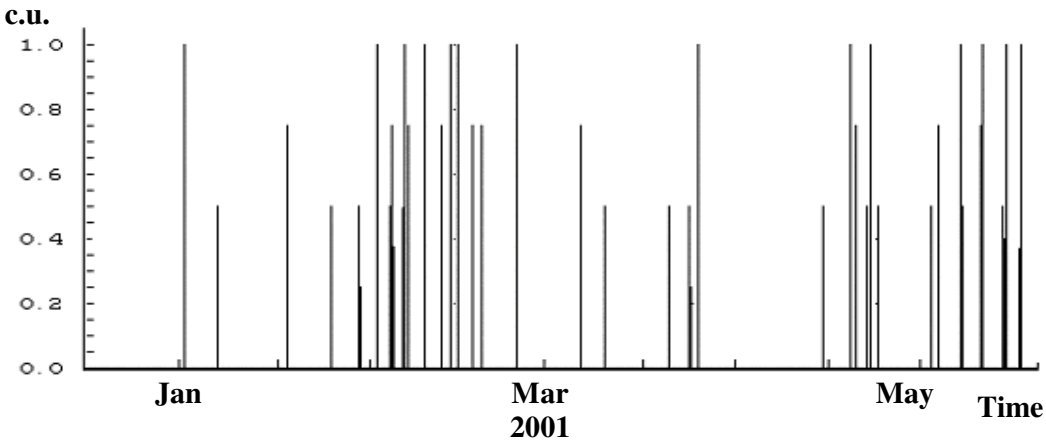


Figure 2. NF anomaly occurrences vs. earthquakes. 1 c.u. = earthquakes of energetic classes K ≥ 10; 0.75 and 0.5 c.u. = anomalies of surface NF and underground NF respectively.

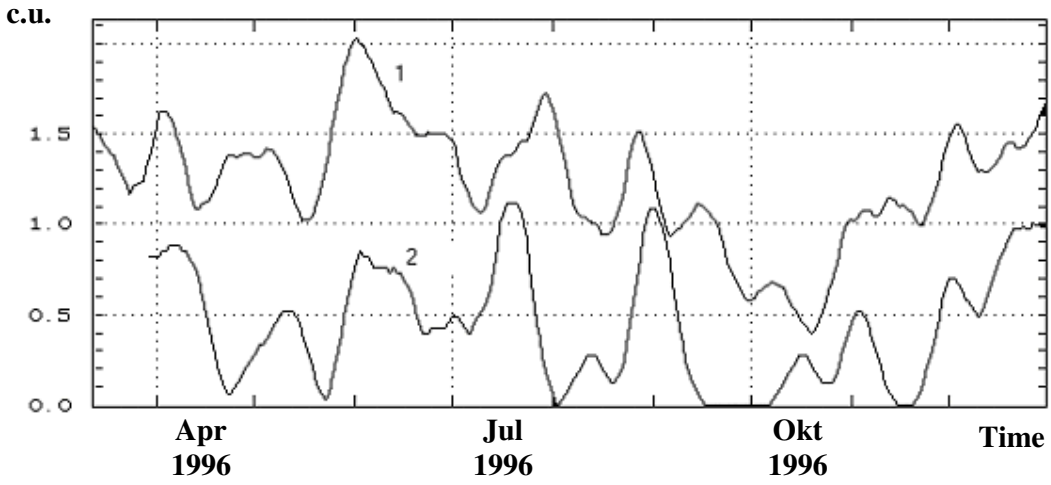
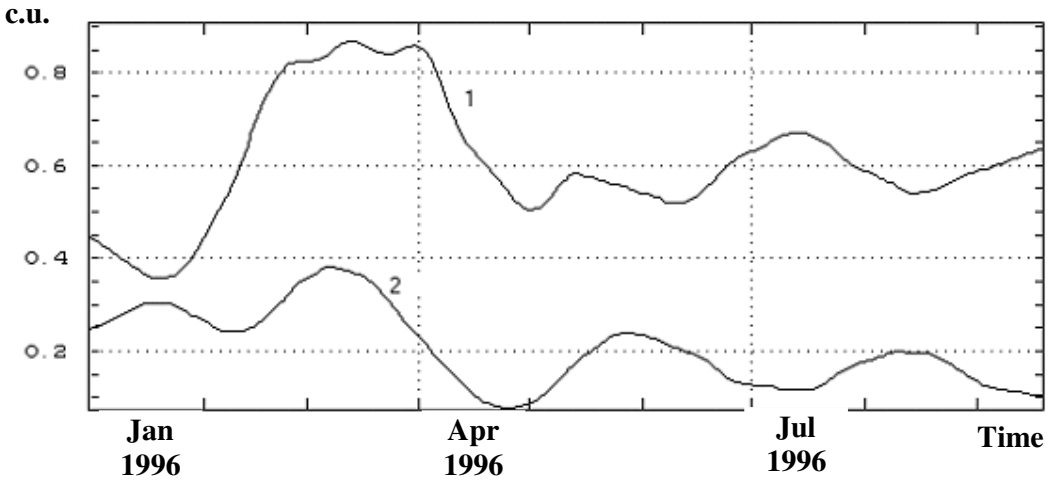


Figure 3. Smoothed curves of timing of moments of anomalies onset of the underground NF (1) and earthquakes of energetic classes K≥ 10 (2).



Fugure 4. The same as Figure 3 but for the year 1999.

Anomalously high NF values registered within a one-our interval have been accompanied as a rule by subsequent earthquakes of energetic classes K ≥ 10, epicenters of which have been located within the range of 450 km from the place of the NF registration. Figure 5 below illustrates such an occurrence.

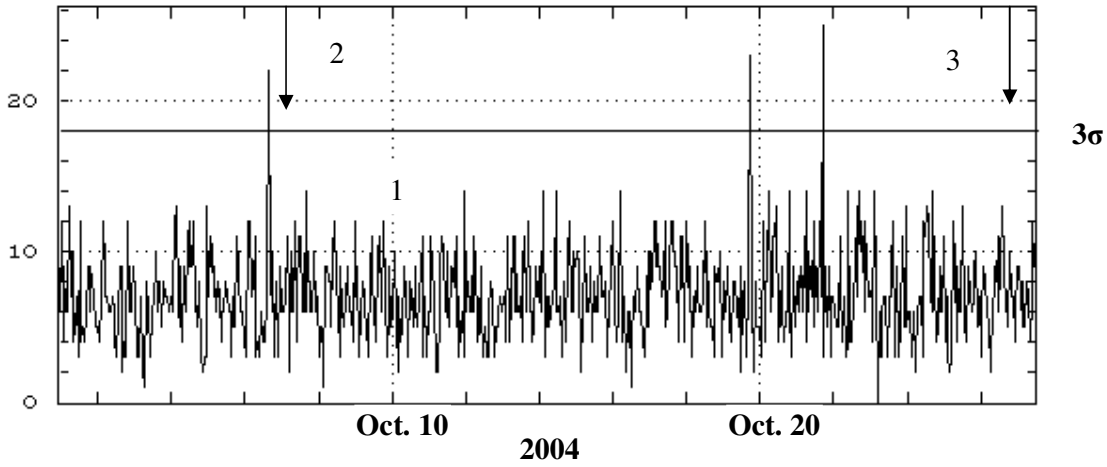


Figure 5. A fragment of temporal series of the underground NF (1) earthquake occurrences (2) and (3) of energetic classes 12.1 и 12.9 with epicenters at the distance of 315 km (7 October 2004) and 325 km (27 October 2004) from the Medeo station respectively.

Anomalies take place from 1 hour to 10 days prior to earthquakes but mainly (up to 70% of cases) the time interval is not more than 4 days. It is also indicated a tendency of growth of the anomaly magnitude in accordance with the growth of the energetic class of the subsequent earthquake (Figure 6).

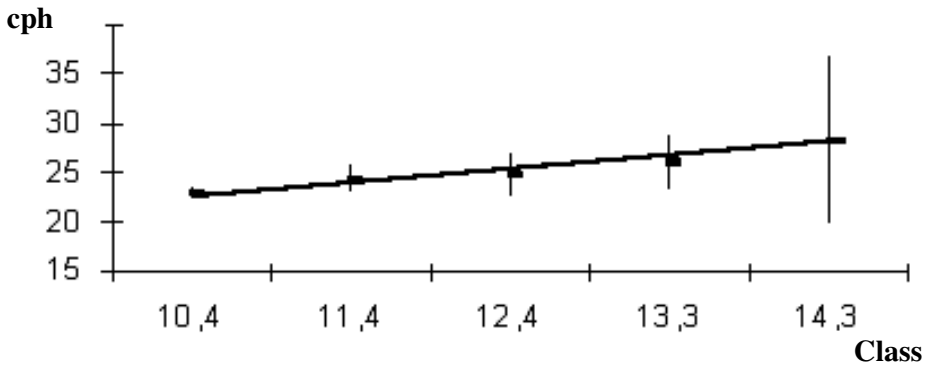


Figure 6. Amplitude dependence between anomalies of the underground NF and the energetic class of earthquakes.

All the abovementioned is not in contradiction with the data published in literature. Thus in the work of Armenian researchers [7] it is stated that 30 minutes prior to the earthquake in Spitak there has been registered the 100% increase of the hard component of cosmic radiation in stratosphere over Erevan. In another work [8] it is distinguished a linear dependence between intensity of cosmic radiation registered by neutron monitors and the total energy-release caused by earthquakes all over the terrestrial globe. It is also indicated [9] that at the Baksanskaya neutrino observatory there were registered short-term (not more than 15 minutes) bursts of high energy mu-mesons due to bursts of solar material into interplanetary space during solar flares.

A character of connection between the NF and earthquakes is still not clear. It is proposed that the NF anomalies caused by variations of cosmic radiation intensity under action of fluxes of solar material, which is burst into interplanetary space (solar wind) during solar flares. Energy of the solar wind transferred to Earth puts into action a trigger mechanism of the process of initiation of earthquakes at those places where conditions have already been prepared for them.

However in spite of the apparent physical grounds for the hypothesis it is difficult to explain some facts. Thus our investigations have shown that in most cases magnetic storms after solar flares had no effect to any change in NF variations. Therefore the anomalous variations of the NF can not be accounted for solar wind impact.

Assumed that anomalous NF bursts result from sharp increases of muon component of cosmic rays we can make another explanation for this effect. The hypothesis is based on the fact that some changes occur in the space over the source of subsequent earthquake. Particularly there can be changes in magnetic intensity. In this case an increase in muon component of cosmic radiation is possible that in turn results in anomalous NF variation. An added reason for the hypothesis is the direct dependence between the neutron anomaly amplitude and the class of subsequent earthquake. This is possible in the presence of relationship between the degrees of changing of space characteristics, e.g. magnetic field over the source of potential earthquake, and the energy accumulated in the source. Furthermore, earthquakes with epicenters of more than 450 km far from the neutron detector have not been preceded by NF anomalies and this could be an evidence of finiteness of the space with changed characteristics. Obviously this is true in the event the space with changed characteristics has been formed over the source

of subsequent earthquake, and naturally the volume of the space depends on the source size. This assumption conforms to the investigations conducted by members of the Moscow Engineering and Physics Institute (MEPI) on the base of equipment mounted on board of artificial satellites [10]. Their results show effects of pouring out of charged particles from radiation belts in the areas over epicenters of subsequent earthquakes. They explain such effects by the influence over ionosphere of low-frequency electromagnetic radiation originating from processes of earthquake preparation.

For the period of observations of more than five years (from March 1996 to November 2001) within the range of 450 km from the place of location of the neutron detector there have been registered 44 earthquakes of classes from 12 to 12.9 and 18 earthquakes of classes K ≥ 13. All the earthquakes of the second group had been anticipated by NF anomalies. Only 5 earthquakes in the first group took place without preliminary anomalies (see Table 1). Hence, for the earthquakes with energetic class range of 12 to 14 and higher (62 total) five occurrences only had no anomalous NF variations. This is 8.06%, i.e. "guessing" percentage in the case in question is of more than 90%. At the same time false anomalies are at 14%.

Table 1

Comparison of the underground NF anomalies with the subsequent earthquakes of classes K ≥ 11 for the period from 13 March 1996 to 18 November 2001

Years	1996	1997	1998	1999	2000	2001	Total
Total quantity of anomalies	329	310	272	206	82	26	1225
Quantity of false anomalies	73	29	5	33	20	9	169
% of false anomalies	22	9	2	16	25	35	14
Total quantity of earthquakes of classes:							
11-11,9	12	46	47	18	17	9	149
12-12,9	5	15	11	5	4	4	44
13-13,9	-	6	6	1	-	-	13
≥14	1	3	1	-	-	-	5
Total:	18	70	65	24	21	13	211
Missed earthquakes of classes:							
11-11,9	-	-	-	-	1	5	6
12-12,9	-	-	1	-	1	3	5
13-13,9	-	-	-	-	-	-	-
≥14	-	-	-	-	-	-	-

In 2005 there were organized observations for variations of natural neutron flux in a drift of the Kurty seismic station, which is at the distance of 120km north from Almaty. Here again anomalous bursts similar to the above have anticipated earthquakes.

At the present time we continue to collect underground statistical data in the both stations. For the period of 2001 – 2005 within the range of 450 km from the places of neutron detectors there were registered 201 earthquakes with the energetic classes of 10-11. NF anomalies took place in 139 cases. A group of earthquakes with the energetic classes of K > 12 includes 20 occurrences, all of them had anticipated by NF anomalies.

It should be noted that there is a time shift between the anomalous NF bursts registered on either station (compare Figures 7 and 8).

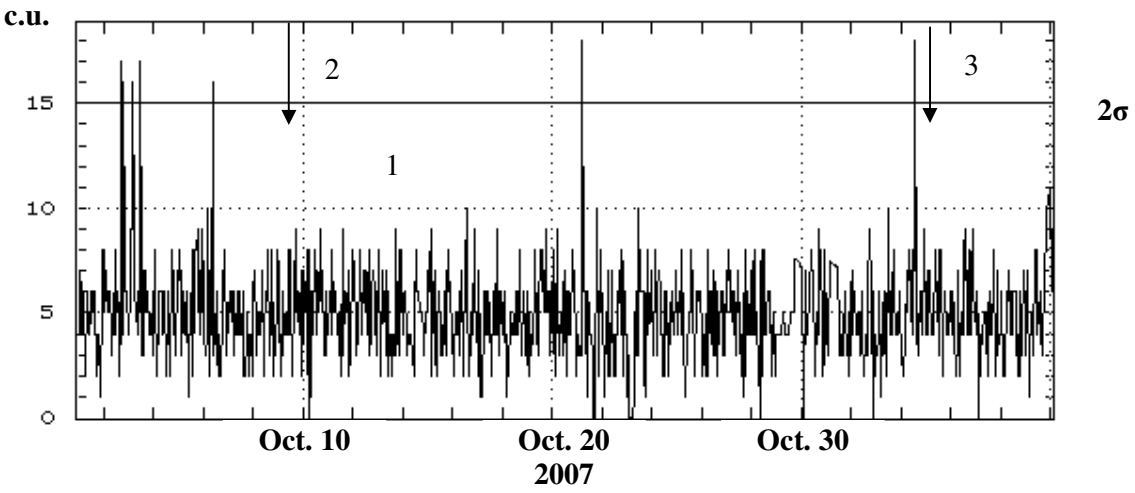


Figure 7. 1 – a fragment of temporal series of NF (1) at the Kurty station; 2 - earthquake (9 October 2007), K=12.9, R=135 km; 3 - earthquake (3 November 007), K=10.3, R=225 km

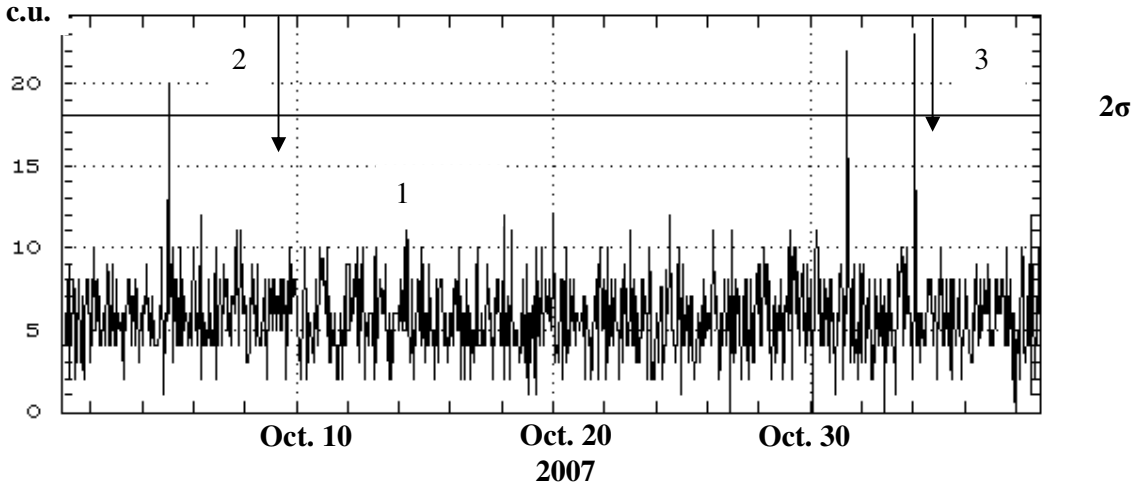


Figure 8. 1 – a fragment of temporal series of NF (1) at the Medeo station; 2 - earthquake (9 October 2007), K=12.9, R=65 km; 3 - earthquake (3 November 2007), K=10.3, R=140 km

Our results have shown a high probability of anomalous NF variations preceding strong earthquakes. Yet such factors as time and strength of a future earthquake are not sufficient for a complete forecast. It is necessary to determine where the potential earthquake can take place. The problem could be solved by a network of NF registration stations. We propose to start building the network in 2008.

On the basis of the data received it can be concluded that monitoring NF is promising for the development of earthquake short-term forecasts.

REFERENCES

1. Ostapenko V. F., Zhusupov M. A., Krasnoperov V. A., et al.. Variations of Natural Neutron Flux and Seismic Activity. Abstracts of papers at 2nd Nuclear and Radiation Physics International Conference, Almaty 1999. P.117.
2. Ostapenko V. F., Krasnoperov V. A. Analysis of Natural Neutron Flux in a Seismically Active Zone Letter to the Editor. Natural Hazards and Earth System Sciences (2003) 3: 777 – 780
3. Gorshkov G. V., et al. Natural Neutron Background of Atmosphere and Earth's Crust. Atomizdat, M., 1966.
4. Volodichev N. N., et al. Phenomenon of Neutron Intensity Bursts during New-Moon and Full-Moon Phases // Cosmic Investigations. 1997. V.35. No 2. P. 144-154.
5. Kuzmin Yu. D. Neutron Flux Intensity Registration on Kamchatka regarding Earthquake Forcasts. In Geophysical Monitoring of Kamchatka. OTTISK, Petropavlovsk-Kamchatski, 2006, P. 149 - 156.
6. Viktorov G. G., Bondarenko V. M. Muon Method for Rock Density Determination. Atomizdat. M. 1973. P. 24.
7. Asatryan G.A., Asatryan Gr.A., Babayan V.H., Stozhkov Yu.I., Oganyan G.Zh. //Proc. AS USSR, Ser. Phys. 1991. V. 55, No.10, P. 1979-1981.
8. Sobolev G.A., Shestopalov I.P., Kharin E.P. Geoeffective Solar Flares and Seismic Activity of the Earth. // Physics of the Earth. 1998. No.7, P. 85-90.
9. Karpov S.N., Miroshnichenko L.I., Vashenyuk E.V. // Proc. RAS. Ser. Phys. 1997. V. 61, No.7, P. 1466-1469.
10. Galper A.M. Eearthquakes: Prognosis from Space // Science in Russia. 1994. Issue 1. P.39.

В. Ф. ОСТАПЕНКО(VFOst@mail.ru),

В. А. КРАСНОПЕРОВ (krasva38@mail.ru).

Институт сейсмологии МОН РК, Университет Сулеймана Демиреля.

Алматы. КАЗАХСТАН.

АНОМАЛЬНЫЕ ВАРИАЦИИ ЕСТЕСТВЕННОГО НЕЙТРОННОГО ПОТОКА И ПРОБЛЕМА КРАТКОСРОЧНОГО ПРОГНОЗА ЗЕМЛЕТРЯСЕНИЙ.

В сейсмической зоне близ Алматы (Казахстан) с 1996 года ведутся наблюдения за вариациями естественного нейтронного потока под землей на глубине порядка 40 м водного эквивалента. Отмечено, что иногда на протяжении часового интервала скорость счета нейтронов резко увеличивается по сравнению с фоном. Это происходит накануне возникновения землетрясений. Возрастание интенсивности нейтронного потока чаще всего опережает их на время от 1часа до 10 суток. 70% ТАКИХ СОБЫТИЙ УКЛАДЫВАЕТСЯ ВО ВРЕМЕННОЙ ИНТЕРВАЛ ДО 4СУТОК. Между скоростью счета нейтронов и энергетическим классом последующих землетрясений, эпицентры которых находились на удалении до 450 км, прослеживается линейная зависимость. Отмечаемые нами аномальные вариации нейтронного потока обусловлены, по нашему мнению, вариациями мюонной компоненты космических лучей. Для объяснения таких вариаций предлагаются две гипотезы. Первая гипотеза основывается на изменениях состояния межпланетного пространства (солнечный ветер), во время вспышек на Солнце. Энергия солнечного ветра, передаваясь Земле, приводит в действие спусковой механизм процесса возникновения землетрясений в тех местах, где для них уже подготовлены условия. Другая гипотеза предполагает, что в пространстве над очагом готовящегося землетрясения происходят за счет процессов в недрах такие изменения, которые приводят к увеличению интенсивности мюонного излучения.

Ключевые слова: землетрясение, нейтрон, мюон, фон, штольня.

Землетрясения относятся к одним из наиболее грозных стихийных бедствий. Они производят огромные разрушения и вызывают многочисленные жертвы среди населения. Поскольку предотвратить землетрясения невозможно, возникает проблема разработки прогноза этого природного явления. Во всем мире проводятся исследования различных эффектов в окружающей среде, которые могли бы быть использованы в качестве предвестников землетрясений. Одним из таких эффектов, по нашему мнению, являются аномальные вариации естественного нейтронного потока (НП), исследования которых описаны ниже.

Непрерывные наблюдения за величиной НП, проводимые нами в штольне вблизи Алматы (Казахстан) на высоте 1600м над уровнем моря, а также на открытой поверхности в том же районе показали, что иногда величина НП на часовом интервале резко возрастает по сравнению с обычной. Статистическое распределение разбросов величины НП близко к нормальному, однако количество отклонений от среднего значения, превышающих его более чем на утроенную среднеквадратичную погрешность, выше в два с лишним раза теоретически ожидаемого из распределения Гаусса. Такие значения мы принимаем за аномальные. Очевидно, существует некий природный фактор, который обуславливает появление подобных аномалий [1,2].

Известно [3], что естественный нейтронный поток состоит из трех компонент. Во-первых, нейтроны образуются в результате взаимодействия космического излучения с атомными ядрами вещества атмосферы и верхних слоев земной коры. Во-вторых, свободные нейтроны выделяются при спонтанном делении ядер урана. Наконец, нейтроны могут образовываться в ядерных реакциях при взаимодействии альфа-частиц естественных радионуклидов с атомными ядрами легких элементов, входящими в состав атмосферы и земной коры. Следовательно, изменение величины НП может вызываться либо вариациями интенсивности космических лучей, либо изменением концентрации урана и других радиоактивных элементов, испускающих альфа-частицы, в пространстве, прилегающем к месту расположения детектора нейтронов.

В литературе указывалось, что всплески нейтронного потока обусловлены выбросами из недр радона в больших, чем обычно количествах, происходящими при процессах растрескивания горных пород под действием экстремальных значений приливных сил в моменты новолуния или полнолуния, или же при процессах подготовки землетрясений [4].Обработка результатов измерений показала, что аномальные

возрастания величины НП не удается объяснить дополнительным притоком радона - наиболее подвижного в природе радиоактивного элемента. Дело в том, что в штольне, плотно закрытой дверьми, отсутствует вентиляция воздуха, поэтому при дополнительном притоке радона аномалии НП должны были бы наблюдаться в течение времени, существенно превышающего часовой интервал, так как период полураспада радона составляет 3,8 суток. Имеются также результаты прямых измерений содержания радона и его короткоживущего изотопа – торона в приземном слое атмосферы в непосредственной близости от места расположения детектора нейтронов [5], которые показывают, что возникновение всплесков нейтронов не связано с вариациями этих изотопов (см. рис.1).

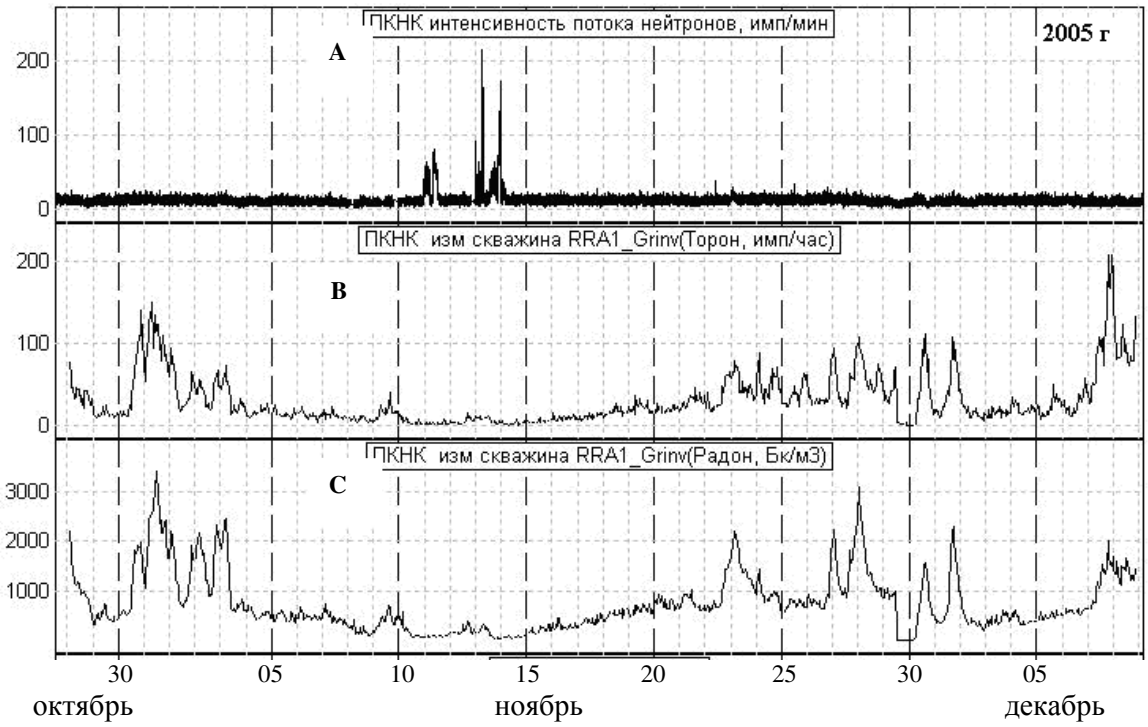


Рисунок 1. **A** – интенсивность потока нейтронов, **B** и **C**- объемная активность торона и радона в почвенном воздухе соответственно.

Содержание других радиоактивных элементов в окружающем детектор нейтронов пространстве остается практически неизменным. Таким образом, причиной изменения величины НП, скорее всего, являются вариации космических лучей и, в частности, вариации мю-мезонов, относящихся к их жесткой компоненте, так как только эти частицы способны проникнуть в штольню через десятки метров горной породы. К тому же оценки показывают, что в наших условиях в штольне компонента нейтронного потока, обусловленная спонтанным распадом урана и взаимодействием альфа-частиц с атомными ядрами, составляет примерно лишь 10% от всего регистрируемого подземного НП. По литературным данным [6] толщина слоя горных пород, под которым в штольне находится наш детектор нейтронов, ослабляет поток мюонов в 10 раз. При извлечении детектора из штольни на открытую поверхность скорость счета нейтронов возросла в 12 раз. Очевидно, близость этих значений также говорит о весьма вероятном мюонном происхождении нейтронного потока, измеряемого в штольне.

При анализе результатов измерений было установлено, что между величиной НП и сейсмическими событиями имеется определенная связь. Периоды увеличения частоты

появления аномалий обычно совпадают с периодами возрастания сейсмической активности (см. рис.2-4).

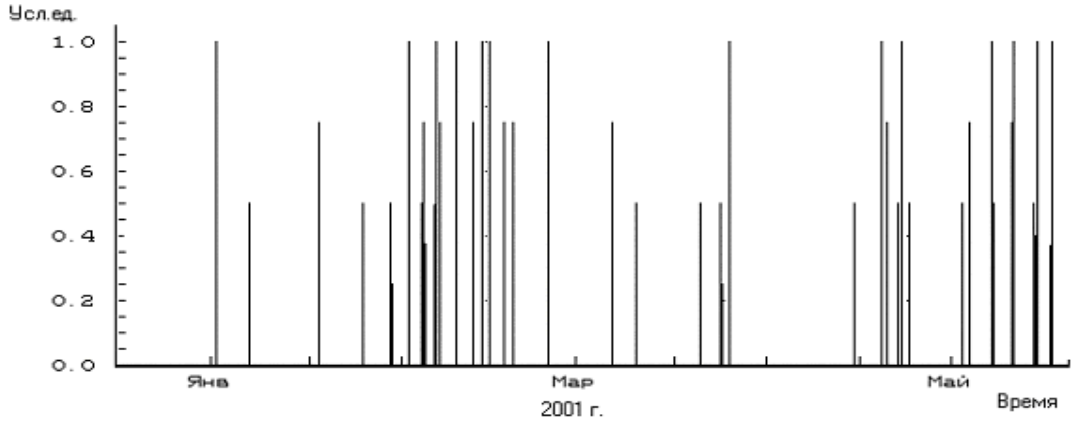


Рисунок 2. Сопоставление моментов возникновения аномалий НП и землетрясений. 1 усл.ед – моменты землетрясений энергетических классов $K \geq 10$; 0,75 и 0,5 усл.ед – моменты аномалий наземного и подземного нейтронных потоков соответственно.

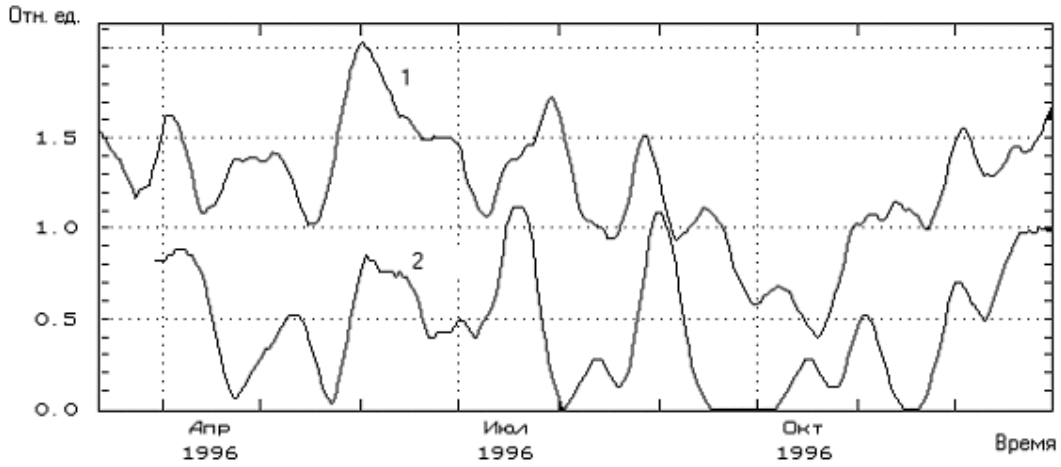


Рисунок 3. Сглаженные кривые распределения во времени моментов возникновения аномалий подземного НП (1) и землетрясений энергетических классов $K \geq 10$ (2).

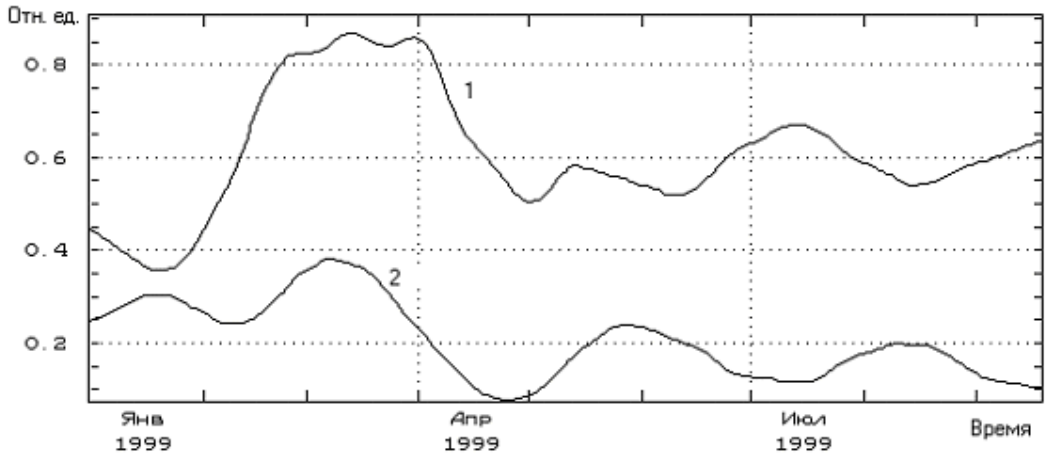


Рисунок 4. То же, что и на рис.3, но для 1999-го года.

Аномально большие значения величины НП, зарегистрированные на часовом интервале, сопровождаются, как правило, последующими землетрясениями с энергетическими классами К ≥ 10, эпицентры которых располагаются в радиусе до 450 км от места регистрации НП. В качестве иллюстрации подобного явления приведен рис. 5.

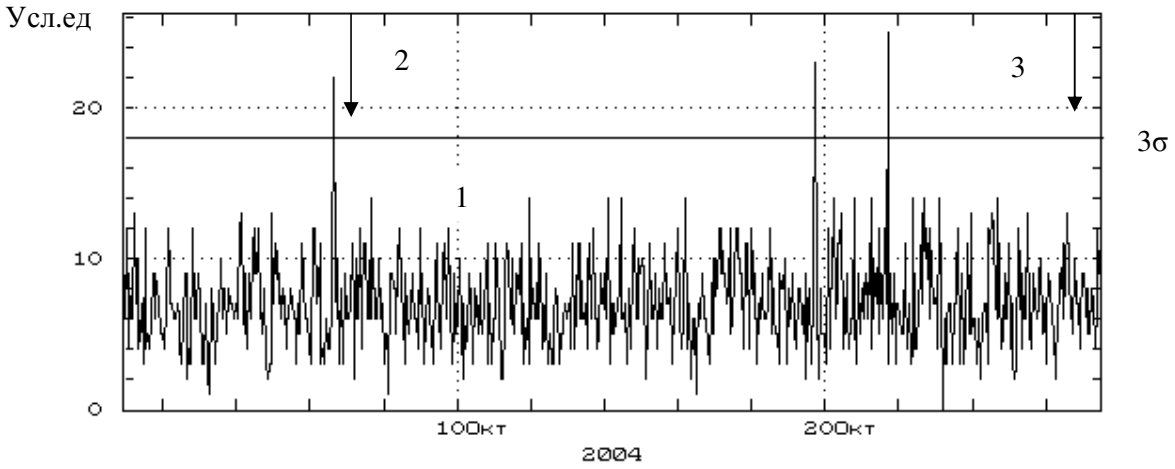


Рисунок 5. Фрагмент временного ряда вариаций НП (1) и моменты землетрясений (2) и(3) энергетических классов 12.1 и 12.9 соответственно, произошедших 7 и 27 октября 2004 года на расстояниях 315 и 325 км от станции Медео.

Аномалии опережают землетрясения на время от 1 часа до 10 суток, но в основном (до 70% случаев) этот временной интервал не превышает 4 суток. Отмечена также тенденция роста величины аномалии с увеличением энергетического класса последующего землетрясения (рис.6).

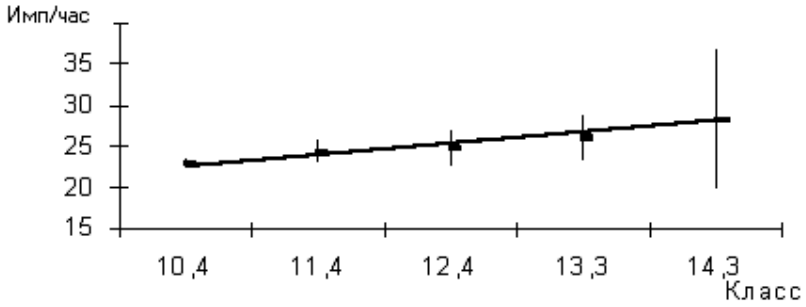


Рисунок 6. Зависимость амплитуды аномалии подземного НП от энергетического класса землетрясений.

Все это не противоречит данным, опубликованным в литературе. Так, в работе армянских исследователей [7] указано, что за 30 минут до Спитакского землетрясения в стратосфере над Ереваном наблюдалось 100%-ное увеличение жесткой компоненты космических лучей. В другой работе [8] отмечается линейная зависимость интенсивности космических лучей, регистрируемых нейтронными мониторами, от общего энерговыделения при землетрясениях по всему Земному шару. Указывается также [9], что на Баксанской нейтринной обсерватории были зарегистрированы кратковременные (не

более 15 минут) всплески мю-мезонов высоких энергий, обусловленных выбросами солнечного вещества в межпланетное пространство при вспышках на Солнце.

Природа связи между НП и землетрясениями пока неясна. Можно предположить, что аномалии НП вызываются вариациями интенсивности космических лучей под действием потоков солнечного вещества, выбрасываемого в межпланетное пространство (солнечный ветер) во время вспышек на Солнце. Энергия же солнечного ветра, передаваемая Земле, приводит в действие спусковой механизм процесса возникновения землетрясений в тех местах, где для них уже подготовлены условия. Однако, несмотря на кажущуюся физическую обоснованность данной гипотезы, имеются данные, которые трудно объяснить в ее рамках. Так, например, наши исследования показали, что при магнитных бурях, проявляющихся после вспышек на Солнце, аномальных вариаций НП в большинстве случаев не наблюдается. Следовательно, объяснить возникновение аномальных вариаций НП наличием эффектов солнечного ветра не удается.

Полагая, что причиной аномального всплеска НП является резкое увеличение мюонной компоненты космических лучей, можно для такого эффекта предложить и другое объяснение. Суть этой гипотезы заключается в том, что в пространстве над очагом готовящегося землетрясения происходят некоторые изменения, в частности, может изменяться величина магнитного поля. При таком эффекте возможно возрастание мюонной компоненты космических лучей, что, в свою очередь вызывает аномальную вариацию НП. В пользу данной гипотезы говорит факт прямой зависимости величины амплитуды нейтронной аномалии от энергетического класса последующего землетрясения. Такое возможно в том случае, когда мера изменения свойств пространства, например магнитного поля, над очагом готовящегося землетрясения зависит от энергии, накопленной в очаге. Кроме того, землетрясения, эпицентры которых находятся на удалении от места расположения нейтронного детектора, превышающем 450км, не предваряются аномалиями НП, что свидетельствует о конечных размерах радиуса области пространства с измененными свойствами. Указанное обстоятельство, очевидно, выполняется в том случае, когда область пространства с измененными свойствами формируется над очагом готовящегося землетрясения и, естественно, размеры такой области должны зависить от размеров очага. Такое предположение согласуется с исследованиями сотрудников МИФИ, проведенными с помощью аппаратуры, установленной на искусственных спутниках Земли [10], которые показали наличие эффектов высыпания заряженных частиц из радиационных поясов в районах над эпицентрами последующих землетрясений. Эти эффекты они объясняют воздействием низкочастотного электромагнитного излучения, возникающего при процессах подготовки землетрясения, на ионосферу.

За более чем пятилетний период наблюдений (с марта 1996г. по ноябрь 2001г.) в радиусе до 450км от места расположения детектора нейтронов произошло 44 землетрясения с классами от 12 до 12,9 и 18 землетрясений с классами $K \geq 13$. Все землетрясения второй группы предварялись аномалиями НП. В первой же группе только 5 землетрясений произошло без предварительных аномалий (см. табл. 1). Таким образом, для землетрясений с энергетическими классами в пределах от 12 до 14 и выше, общее количество которых составляет 62, лишь 5 не предварялось аномальными вариациями НП. Это составляет 8,06%, т.е. процент “угадывания ” будущего землетрясения превышает в данном случае 90%. В то же время общее количество ложных аномалий для всех классов землетрясений составляет 14%..

Таблица 1

Сопоставление аномалий подземного НП

с последующими землетрясениями классов $K \geq 11$

за период с 13.03.1996 по 18.11.2001 г.

Годы	1996	1997	1998	1999	2000	2001	Всего
Общее кол-во аномалий	329	310	272	206	82	26	1225
Кол-во ложных аномалий	73	29	5	33	20	9	169
% ложных аномалий	22	9	2	16	25	35	14
Общее кол-во землетрясений по классам:							
11-11,9	12	46	47	18	17	9	149
12-12,9	5	15	11	5	4	4	44
13-13,9	-	6	6	1	-	-	13
≥14	1	3	1	-	-	-	5
Всего	18	70	65	24	21	13	211
Пропущено землетрясений по классам:							
11-11,9	-	-	-	-	1	5	6
12-12,9	-	-	1	-	1	3	5
13-13,9	-	-	-	-	-	-	-
≥14	-	-	-	-	-	-	-

В 2005 году были организованы наблюдения за вариациями естественного нейтронного потока в штольне сейсмостанции Курты, находящейся севернее Алматы на удалении 120км. Здесь также отмечены аномальные всплески, предваряющие землетрясения, аналогичные описанным выше.

В настоящее время продолжается набор статистического материала в подземных условиях на двух пунктах наблюдений. За период 2001 – 2005г.г. в радиусе до 450км от точек расположения детекторов нейтронов произошло 201 землетрясение с энергетическими классами 10-11. Аномалии НП отмечены в 139 случаях. В группе землетрясений с энергетическими классами К > 12 произошло 20 землетрясений, и все из них предварялись аномалиями НП.

Следует отметить, что для одного и того же землетрясения аномальные всплески НП на обеих станциях проявляются с некоторым временным смещением относительно друг друга (сравни рис. 7 и 8).

. Усл.ед.

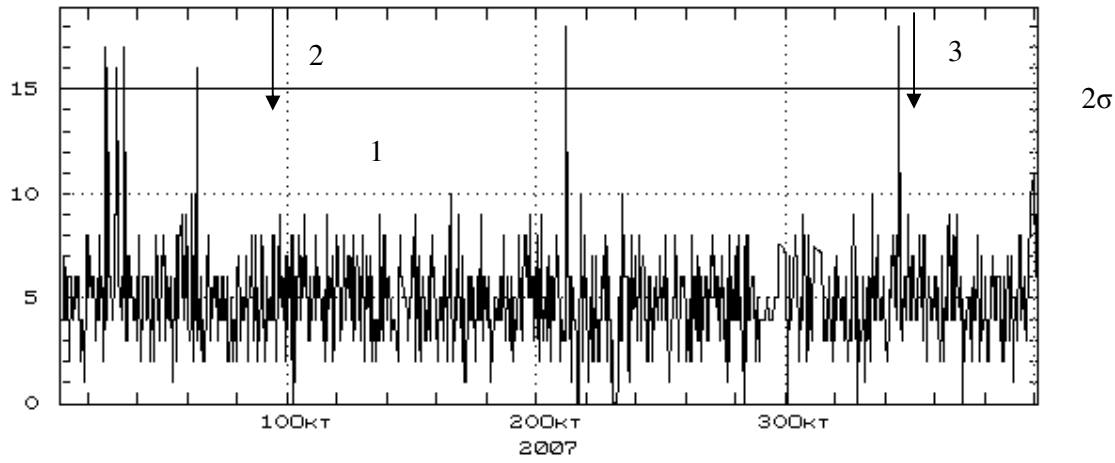


Рисунок 7. 1-Фрагмент временного ряда НП на ст. Курты; 2- землетрясение 9.10.2007 г.; К=12.9, R=135 км; 3- землетрясение 3.11.2007 г., К=10.3, R=225 км.

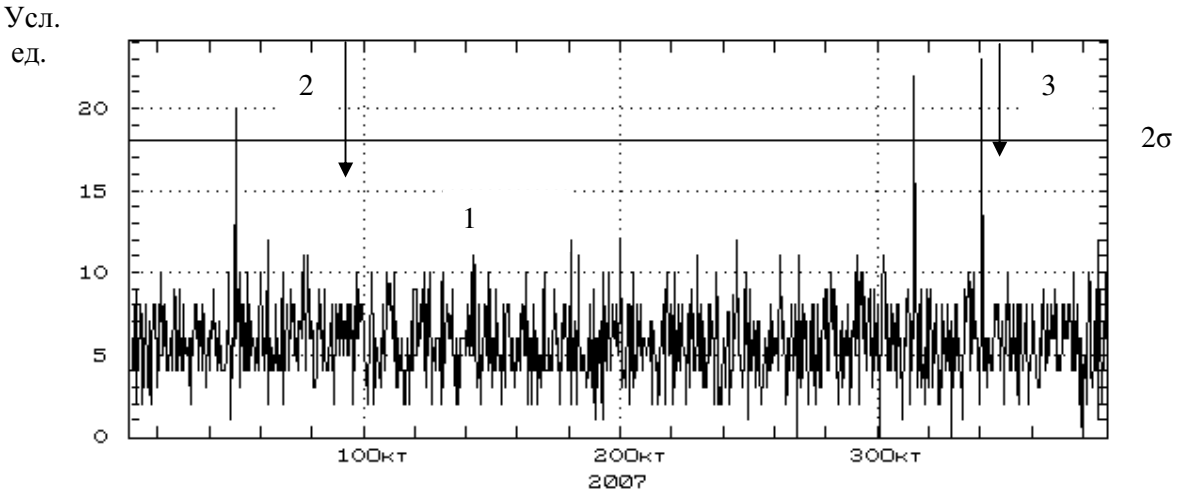


Рисунок 8. 1-Фрагмент временного ряда НП на ст. Медео; 2-землетрясение 9.10.2007 г.; К=12.9, R=65 км; 3-землетрясение 3.11.2007 г., К=10.3, R=140 км.

Полученные нами результаты показывают большую вероятность возникновения аномальных вариаций НП накануне сильных землетрясений. Однако для прогноза недостаточно указывать время и силу будущего землетрясения, нужно определять и возможный его район. Для решения этой проблемы двух пунктов недостаточно. Необходимо иметь сеть пунктов регистрации НП. К организации подобной сети мы предполагаем приступить в 2008 году.

Оценивая достигнутые результаты, можно сделать вывод о перспективности использования мониторинга НП для разработки краткосрочного прогноза землетрясений.

ЛИТЕРАТУРА

1.Остапенко В.Ф., Жусупов М.А., Красноперов В.А. и др. Вариации естественного нейтронного потока и сейсмическая активность. Тезисы докладов 2-й международной конференции “Ядерная и радиационная физика“, Алматы, 1999. С.117.

2. Ostapenko V. F., Krasnoperov V. A. Analysis of Natural Neutron Flux in a Seismically Active Zone. Letter to the Editor. Natural Hazards and Earth

System Sciences. (2003) 3: 777 – 780
3. Горшков Г.В. и др. Естественный нейтронный фон атмосферы и земной коры. Атомиздат, М., 1966.

4. Володичев Н.Н. и др. Явление возникновения всплесков интенсивности нейтронов во время фаз новолуний и полнолуний. // Космические исследования. 1997. Т.35. № 2. С. 144-154.
5. Кузьмин Ю.Д. Регистрация интенсивности нейтронного потока на Камчатке в связи с прогнозом землетрясений. В сб." Геофизический мониторинг Камчатки".ОТТИСК. Петропавловск-Камчатский, 2006, с. 149 - 156.
6. Викторов Г.Г., Бондаренко В.М. Мюонный метод определения плотности горных пород. Атомиздат. М. 1973. С. 24.
7. Асатрян Г.А., Асатрян Гр.А., Бабаян В.Х., Стожков Ю.И., Оганян Г.Ж. //Изв. АН СССР, Сер. физ. 1991. Т. 55. № 10. С. 1979-1981.
8. Соболев Г.А., Шестопалов И.П., Харин Е.П. Геоэффективные солнечные вспышки и сейсмическая активность Земли. // Физика Земли. 1998. № 7. С. 85-90.
9. Карпов С.Н., Мирошниченко Л.И. Вашенюк Э.В. // Изв. РАН. Сер. физ. 1997. Т. 61. № 7. С. 1466-1469.
10. Гальпер А.М. Землетрясения: Прогноз из Космоса? // Наука в России. 1994. Вып.1. С.39.

.

Resume.

Dr. V.F. OSTAPENKO **(OstVF@mail.ru),**

Prof. V.A. KRASNOPEROV **(krasva38@mail.ru).**

Institut of Seismology and Faculty of Engineering Suleyman Demirel University.

(ALMATY, KAZAKHSTAN)

ANOMALOUS VARIATIONS OF NATURAL NEUTRON FLUX AND EARTHQUAKE SHORT-TERM FORECAST ISSUES

In a seismically active zone in the near Almaty area (Kazakhstan) since 1996 observations of variations of a natural neutron flux have been conducted. Sometimes the neutron flux rises sharply within the one-hour interval in comparison with the background. It occurs on the eve of activation of seismic processes. Increase of the neutron flux level had taken place from 1 h to 10 days prior to earthquakes. It is also indicated a tendency of growth of the anomaly level in accordance with the growth of energetic class of the subsequent earthquake. A character of connection between the neutron flux and earthquakes is still not clear. It is proposed that the neutron flux anomalies caused by variations of cosmic radiation intensity under action of fluxes of solar material, which is burst into interplanetary space (solar wind) during solar flares. Energy of the solar wind transferred to Earth puts into action a trigger mechanism of the process of initiation of earthquakes at those places where conditions have already been prepared for them.

The neutron flux anomalies can be used as substantial additional information for classical geophysical methods of short-term earthquake prediction.

Резюме.

В. Ф. ОСТАПЕНКО (VFOst@mail.ru),

В. А. КРАСНОПЕРОВ (krasva38@mail.ru).

Институт сейсмологии МОН РК, Университет Сулеймана Демиреля.

Алматы. КАЗАХСТАН.

АНОМАЛЬНЫЕ ВАРИАЦИИ ЕСТЕСТВЕННОГО НЕЙТРОННОГО ПОТОКА И ПРОБЛЕМА КРАТКОСРОЧНОГО ПРОГНОЗА ЗЕМЛЕТРЯСЕНИЙ.

В сейсмически активной зоне около Алматы (Казахстан) с 1996 проводятся наблюдения изменений естественного нейтронного потока. Иногда нейтронный поток в пределах одночасового интервала резко повышается по сравнению с фоном. Это происходит накануне активации сейсмических процессов. Увеличение уровня нейтронного потока имеет место от 1 часа до 10 дней до землетрясений. Также отмечена тенденция роста уровня аномалии в соответствии с ростом энергетического класса последующего землетрясения. Природа связи между нейтронным потоком и землетрясениями все еще не вполне не ясна. Предполагается, что аномалии нейтронного потока, обусловлены изменениями интенсивности космических лучей. Высказываются две возможные причины таких изменений. Во-первых, это результат воздействия потоков солнечного материала, который выброшен в межпланетное пространство (солнечный ветер) в течение солнечных вспышек. Энергия солнечного ветра, переданная Земле, приводит в действие спусковой механизм процесса инициирования землетрясений в тех местах, где условия были уже готовы к ним. Во-вторых, это изменение свойств пространства над очагом готовящегося землетрясения. Аномалии нейтронного потока могут использоваться как существенная дополнительная информация для классических геофизических методов краткосрочного прогноза землетрясений.

Остапенко Виталий Федорович. (1932, Харьков, УССР).
ВНС Института сейсмологии МОН РК.
Казахский Государственный университет, физико-математический факультет, отделение физики (1955), научный сотрудник кафедры (1955-1957) , аспирант проф. Чердынцева В. В.(1958-60). Канд. ф.- м. наук (1970), ядерная геофизика, гамма- и рентгеновские методы изучения геологических сред. В НИСе Каз. ГУ с 1955 по 1978г., инженер, СНС, зав. лабораторией. Специалист по прикладной ядерной геофизике, основные исследования в области количественного опробования геологических сред в естественном залегании на месторождениях твердых полезных ископаемых.
С 1978 по 1992 – доцент кафедры физики Алма-Атинского института железнодорожного транспорта. С 1992 по 1995 – СНС лаборатории геофизического опробования КазНИИГеофизики (комплекс нейтронных методов каротажа на месторождениях барита, фосфоритов). С 1992 по н/в - ВНС Института сейсмологии МОН РК. Имеет около 60 печатных работ.

Красноперов Владимир Анатольевич. (1938, Алматы, Казахская ССР).
Профессор Университета Сулеймана Демиреля (Faculty of Engineering and Computer Sciences), Алматы, Казахстан.
Казахский горно-металлургический институт (1960), д. г-м. н. (1986), профессор по кафедре структурной и нефтяной геофизики (1991), академик РАЕН (1998). Гл. геофизик ПГО «Южказгеология» (1987-89), директор КазВИРГ- КазНИИГеофизика (1989-92), заведующий лабораторией геофизического опробования (1993-95), профессор Академии гражданской авиации (1995-2002), менеджер по геофизическим исследованиям скважин (ГИС) ОАО «Казпромгеофизика» (2002-2005). Интересы - ГИС, ядерная геофизика, состав геологических сред, прогноз землетрясений, энергетика геологических процессов.
Имеет около 200 работ, в т. ч. 8 монографий, , 2 авторских свидетельства СССР и 4 патента РК на способы и вещество, соавтор 13 отчетов по подсчету запасов в ГКЗ СССР.

.

.

Ostapenko Vitaly Fedorovich. (1932, Kharkov, Ukraine).
HS Institute of seismology Ministry of Sciences Kazakhistans Republic.
The Kazakh State University, physical and mathematical faculty, branch of physics (1955), the scientific employee of faculty (1955-1957), the post-graduate student Prof. Cherdyntsev V.V. (1958-60). Dr/ Ph. (1970), nuclear geophysics, scale - and x-ray methods of studying of geological environments. In Kazkh State University with 1955 on 1978г., the engineer, Hard Scholar, зав. Laboratory. The expert on applied nuclear geophysics, the basic researches in the field of quantitative approbation of geological environments in natural in sity on deposits of firm minerals.
With 1978 on 1992 – the senior lecturer of faculty of physics of the Almaty institute of a railway transportation. With 1992 on 1995 – CHC laboratories of geophysical approbation Kazakhisnan Geophisical Institute (a complex of neutron methods logging on deposits of barite, phosphorites). With 1992 on now – Higher Scholar Institute of seismology Ministry of Sciences Kazakhistans Republic. Has about 60 printed works.

Krasnoperov Vladimir Anatoljevich. (1938, Almaty, Kazakh SSR). Professor of University Suleyman Demirel University (Faculty Development and Computer science), Almaty, Kazakhstan.
The Kazakh mining - metallurgical institute (1960), DSc. (1986),
the Professor on faculty of structural and oil geophysics (1991), the Academician of Russian Academy of Natural Sciences (1998). Head Geophysicist "SouthKazakhGeology" (1987-89),
Director Kazakhstan Geophysical Institute (1989-92), managing laboratory geophysical approbation (1993-95), Professor of Academy civil aircraft (1995-2002), the manager on geophysical researches of chinks (Log) Open Society " Kazpromgeophysic " (2002-2005). Interests - Log, Nuclear geophysics, structure of geological environments, the forecast of earthquakes, power of geological processes.
Has about 200 works, including 8 monographics, 2 Patents USSR,
4 patents RK for ways and substance, the co-author of 13 reports by calculation stocks of gold, non-ferrous metals, phosphate rocks, oil , fluorine e. t. c in State Commission of the USSR.

.

Seismoacoustic response to Earth tides as an indicator of the meduim stress state: experience of earthquake prediction in Kamchatka

V. Saltykov [1], Yu. Kugaenko [2]

1. Kamchatkan Branch of Geophysical Survey of RAS,
Piip Blvd., 9 , Petropavlovsk-Kamchatsky, 683006, Russia, salt@emsd.ru
2. Kamchatkan Branch of Geophysical Survey of RAS,
Piip Blvd., 9 , Petropavlovsk-Kamchatsky, 683006, Russia, ku@emsd.ru

ABSTRACT

The investigation of phenomena connected with Earth crust deformation caused by the Earth tides is one of fundamental problems of geophysics. The medium expose their powerful deterministic periodical impact; as a result its parameters (conductivity, elasticity, viscosity, fluid-saturation, seismic and acoustic emission activity etc.) also change in periodic manner. The variations of these parameters reflect the geophysical fields' dynamics in upper crust layers and consequently may contain information on earth interior condition. Gravity impact of Moon and Sun is considered as natural etalon of deforming forces having accurate mathematic description, ideally forecasting in time and space and acting in global scale.

The investigations of seismoacoustic emission have been conducting on Kamchatka (Russia) since the end of 80-th in frames of fundamental problem of seismology connected with possibility of control over stressed medium condition and preparation of strong earthquakes on base of geophysical fields parameters study. Seismic oscillations in first tens of Hz frequency diapason with amplitudes about 10^-9 - 10^-12 m are considered. This type of signals is often called "high-frequency seismic noise" (HFSN). Its structure study gave opportunity to distinguish components connected with Earth tides; it is an evidence of endogenic nature of seismoacoustic noise. It was found: (1) the response on tide impact is not stable in time; (2) the synchronization of the HFSN and tides is observed during some time (usually one-two months) before large (with magnitude $M \geq 6.0$) earthquakes; it is manifested as stabilization of phase shift between tidal component of the HFSN envelope and tides on certain level. This specific feature of the HFSN response on tides is used for investigation of seismic noise connection with large earthquakes. During the HFSN observations period (1992-2007) 22 earthquakes with $M \geq 6.0$ occurred on Kamchatka. Since 1996 the precursor was not revealed only once: before earthquake on 08.03.1999 (M=7). The obtained experimental data confirm the hypothesis about correlation between values of stabilization level of the HFSN tide parameter ($\Delta\varphi$) with source characteristics of preparing earthquake and its geographic position:

The results of retrospective precursor detection in other seismoactive areas where the the HFSN observations are also conducted (Hokkaido and Shikotan islands) agree with the results obtained on Kamchatka. Consequently, the synchronization of the HFSN tide harmonic with corresponding wave of tide potential may be considered as a universal property of geophysical medium; it is connected with its stressed-deformed condition and manifesting, in particular, before strong regional earthquakes.

This investigation was supported by RFBR, grant 07-05-00225.

Key words: seismic emission, acoustic emission, earthquake prediction, Earth tides, Kamchatka.

SALTYKOV Vadim
Ph.D., Head of Seismic Monitoring Laboratory, Kamchatkan Branch of Geophysical Survey, Russian Academy of Sciences
EDUCATION: Diploma in Physics (1985), Moscow Lomonosov State University; Ph.D. (Phys.-Math.) (1994), Moscow Lomonosov State University
RESEARCH INTEREST: (1) Earthquake precursors. (2) Microscale seismology. (3) Modulation of seismic noise by long-period deformational processes. (4) Influence of the Earth tides upon seismicity of various scale.
ACTIVITY: Scientific Secretary (1998-…) of Kamchatkan Branch of "Russian Advisory Council for Earthquake Prediction, Seismic Hazard and Risk Estimation"; Member (1996 – 2003, 2008) of Asian Seismological Commission; Member (2007 - …) of Scientific Council of Geophysical Survey, RAS; Associate Professor (2003 - …) in Geophysics, Kamchatkan State University

The role of seismogenic activities on the fluvial sediment flux in the Alborz Mountain, NE Iran: A new approach to earthquake forecasting

Majid Shahpasandzadeh[1]

Assistant Professor, Industrial University of Kerman and International Center of Science and High Technology, P.O. Box 76315-117, Kerman, Iran
E-mail: mshahpasandzadeh@gmail.com

ABSTRACT

At decadal time-scale, active crustal deformation and mountain-belt erosion are associated with earthquakes and pulses of sediment in rivers, respectively. Because of suitable topographic, climatic, and seismic data sets, along with well constrained active tectonics processes, north of Iran is an ideal location to investigate the link of tectonic geomorphology, climate and seismogenic activities. The impact of moderate and large earthquakes on the Gorgan-Rud River sediment can be quantified using measurements of suspended sediment loads of the river. The results of the study would provide an important reference for future research on the application of climate, erosion, and active tectonics in earthquake forecasting.
In east of Alborz Mountain, Gorgan-Rud River discharges to the Caspian Sea, where build up the Gorgan-Rud delta. With an area of 6210.26 km^2 catchment, the river characterize by an annual discharge of about 482.630 cms and length of 135 km. Average annual suspended load of the river has been measured 2582.82 mcm, according to the available data of 22 hydrologic stations over the past 35 years.
The results indicate that modern erosion rates are strongly influenced by earthquakes and typhoons, both of which drive widespread sediment supply to river channels. The erosion rate is evidently not only connected with geological factors such as substrate strength and distribution of the active faults, but is also linked with the seismicity. Whereas the highest suspended load fluxes typically occurred during the typhoons, but reliable daily measurement reveals a temporarily increase of the sediment fluxes of the rivers after the seismogenic activities. Rapid bedrock and topographic relief uplift of the region due to seismogenic activities, which also trigger landslides under saturated conditions, enhance the denudation and erosion rate of the catchments. Although the pattern of erosion has changed over time in response to the migration of localized tectonic deformation, modern decadal erosion rates correlate with the historical seismicity.
In conclusion, by using erosion rate data we can improve our understanding of co-seismic sediment supply in the river channels. According to the detailed temporal-spatial patterns of suspended sediment flux of the river, prone areas of future earthquakes, where were not associated with the catastrophic historical earthquakes, are suggested.

Key words: 1 seismogenic activities, fluvial sediment flux, Alborz Mountain, NE Iran, earthquake forecasting.

PRESENTER'S BIOGRAPHY

I was working in the Geological Survey of Iran (GSI) from 1997-2000. As a senior geologist, I was responsible for checking the preliminary drafts of prepared geologic maps and also preparation of geologic maps (scale 1:100,000). In March, 2000, I received my PhD in geodynamic/Tectonics from Tarbiat Modarres University, Tehran, Iran. Employed as a lecturer at the Geology department of University of Gorgan, Iran, I taught courses of structural geology, tectonics, active tectonics, applied Geophysics, and field geology at undergraduate level from 2000 to 2004. Two years as the head of Geology department, I was in charge of both scientific and administrative managements.
I left this position because I felt I could use my capabilities more fully in a research position with a wider scope. Transferred to the International Institute of Earthquake Engineering and Seismology in January 2005, I have been responsible for management of active crustal deformation and active fault behavior research programs. My bibliography cover a variety of topics, including structural geology, active tectonics, and seismology..
From June-September 2006, as a visiting researcher at the Department of Earth Sciences, University of Bergen, Norway, I analyzed Alborz earthquake waveforms in order to decipher seismogenic behaviour of the existing faults. During September 2007 to May 2008, as a guest researcher at the department of Solid Earth Geology, Uppsala University, I was working on the fault interaction modeling. My current research focuses largely on aspects of active crustal deformation and earthquake forecasting. At the present, I am going to concentrate on studying active fault behaviors in central Alborz, Iran by approaching different methods, including, tectonic geomorphology, GPS and InSAR measurements, stress transferring technique, and analogical and numerical modeling of active faults.

Precursory Swarm Activity and Earthquake Forecast in Western Nepal Himalaya & its adjoining Indian region

D. Shanker[1], Harihar Paudyal[2, 3], H. N. Singh[3]

[1]*Department of Earthquake Engineering, Indian Institute of Technology Roorkee, 247667, India*,
Email; dayasfeq@iitr.ernet.in
[2]*Department of Physics, Birendra Multiple Campus, Bharatpur, Chitwan, Nepal*
[3]*Department of Geophysics, Banaras Hindu University, Varanasi, 221 005, India*
E-mail: hariharpaudyal@gmail.com

ABSTRACT

Significant fluctuations in seismicity at different times but mostly prior to large earthquakes have been observed in various regions of the world. Generally many phenomena appear to be precursory to major earthquake, which may be useful for earthquake prediction at different stages. Such precursory phenomena differ considerably for each earthquake and also from region to region. The changes in seismicity pattern are the most common precursory indicator. In the pending focal region of a large earthquake, probably numerous ruptures or heterogeneities exist on the main fault that can produce earthquakes in response to the loading process. It has been found that seismicity level drops to a low background level after the completion of mainshock sequence. Precursory swarm activity associated with major earthquakes in the Western Nepal Himalaya and its adjoining region have been studied in an area bounded by 28.0^{o}-31.0^{o} N and 79.5^{o}-82.2^{o} E using seismicity data from 1963-2006. In the present study, anomalous/precursory swarm seismicity and the delineation of preparation zones (~1.1×10^4 km^2) are carried out for the future seismic disturbances using the temporal and the spatial distribution of events considering the total events and the events with $m_b \geq 4.3$ in four anomalous episodes: Normal/ background (N); Anomalous/ swarm (A); Precursory gap (G) and Mainshock sequence (M), respectively. Five cases of anomalous seismicity have been identified: prior to three earthquakes that have already occurred and two cases for which quiescence episodes still continues. Three medium size earthquakes of 1980 (m_b 6.1), 1984 (m_b 5.6) and 1999 (m_b 6.6) occurred in the Western Nepal and its adjoining Indian region were preceded by well defined patterns of anomalous seismicity/ precursory swarm. The first of these was the Bajhang earthquake of which most of its preparatory processes during 1967-1980 were confined approximately in the central part of the area between the MCT and the MBT. Subsequently the seismic activity shifted towards east in the northeast-southwest direction which produced another mainshock of 1984 (m_b 5.6). Seismic activity started concentrating in and around Chamoli area (India) since 27 November 1995 which was preceded by a quiet low seismicity in the region. After Chamoli earthquake in 1999, a low seismic activity was observed in the region which continued for the next two years till 14 April 2001. The seismic activity again shifted towards southeast and started concentrating in the region east-northeast of Bajhang earthquake, since April 2001, in which anomalous pattern in seismicity is observed on two occasions. On analyzing the seismicity data from 1999 to 2006, two additional cases of characteristic seismicity patterns were observed: (1) 1999-2006, and (2) 2003-2006. In these two cases, though the anomalous seismicity exists, no mainshock has occurred so far. After critical analysis of the data, it is observed that the seismicity from 1999 onwards fluctuates in the order as low-high-low phases. The occurrence of the earthquake swarm sequence followed by quiescence with significant low seismicity, which is still continuing, is an indication of precursory seismicity gap in the region. From the predictive equation developed for the Himalayan frontal arc, it is estimated that an earthquake of M 6.5±0.5 may occur at any time from now onwards till 2011 in an area bounded by 29.3^{o}-30.5^{o} N and 81.2^{o}-81.9^{o} E, in the focal depth range 10 -30 km.

Key words: Precursory Swarm, earthquake prediction, Precursory gap, quiescence episodes

PRESENTER'S BIOGRAPHY

Dr. D. Shanker is presently an Assistant Professor of Engineering Seismology in the Department of Earthquake Engineering, Indian Institute of Technology Roorkee, India. After serving for more than 10 years in different institutions as Lecturer as well as Research Associate, he joined the University of Roorkee (presently IIT Roorkee) in year 1996. He has so far supervised one PhD thesis and three M.Tech. Dissertations. His research publications numbering more than 92 in International and National Journal of their repute as well as Conferences, have covered various field of earthquake seismology, seismic hazard and risk assessment, earthquake prediction, seismic microzonation and landslide hazard zonation, geophysical and geochemical earthquake precursor search and statistical seismology and earthquake engineering. As an active consultant and researcher, he has made a great contribution in teaching to PG and UG Science and engineering students. Having, more than two decades of research and teaching experience, he has served as scientific reviewer of dozens of international and national research Journals. He has participated various international and national training program and meetings. He has also completed several research projects and consultancies. Being a life member of different scientific societies he has been invited nationally and internationally for the scientific and public lectures. Besides academics, he has made a excellent contribution in extracurricular activities and administrative skill, like staff adviser Rowing Game, member of the board of examiners and Associate Manager of the senior Secondary School. He has visited more than 16 countries on mission to imbibe technological know-how and utilized them in the scientific programmme in India.

An optimized five-year forecast of earthquake larger than 5 in California based on smoothed seismicity

Qi Wang[1], David D. Jackson[2] Yan Y. Kagan[3]

1. University of California, Los Angeles, U.S.A, qiwang@ucla.edu
2. University of California, Los Angeles, U.S.A, David.D.Jackson@ucla.edu
3. University of California, Los Angeles, U.S.A, kagan@equake.ess.ucla.edu

ABSTRACT

Earthquake forecasting based on different geophysical methods is very important and has been discussed a lot. There are a lot of earthquake forecasting models based on seismic, geologic, tectonic and geodetic information. We tried to state a five-year forecast of California earthquakes with magnitude above 5.0 based on smoothed seismicity. A forecast method based on smoothed seismicity was presented by Kagan and Jackson (1994) and has been widely used since then. Based on earthquake occurrences, it assumes the earthquake rate density is constant in time and proportional to a smoothed version of past seismicity. We used extended sources to represent large earthquakes, because the rupture dimensions of large earthquakes can exceed the grid space of a forecast model, thus it is not suitable to use the traditional hypocenter coordinates to describe the location of a large earthquake. Kagan and Jackson (2007) have presented a five-year forecast of southern California earthquakes with magnitude 5 or larger. Here we extend the forecast region from southern California to all of California using the new California earthquake catalog with estimated moment magnitude, and in one case we include historic earthquakes as well as instrumentally recorded ones after considering catalog incompleteness. This forecast model differs from others like it because larger events are represented by multiple point sources and because the parameters in the spatial smoothing kernel have been optimized in learning period by using maximum likelihood estimation. Catalog data have errors in location, magnitude and focal mechanism that can influence the results of earthquake studies. Neglecting these errors, or estimating them poorly, could cause valid hypotheses to be rejected or invalid ones to be accepted. We tried to estimate how the uncertainty of catalog data especially uncertainty of magnitude influences our testable forecast results and discuss the confidence level of the results. Finally we found that Earthquakes during test interval 1987 – 2007 are very consistent with forecast based on earlier events; inclusion of historical events has strong influence on the forecast in the regions affected by the 1857 and 1906 earthquakes; the likelihood of our forecast does not change a lot when we consider magnitude errors and the forecasts are relatively robust with respect to modest magnitude errors.

Key words: earthquake forecast, long-term, smoothed seismicity, optimization, magnitude uncertainties

PRESENTER'S BIOGRAPHY

Qi Wang is a graduate student and PhD candidate in department of earth and space sciences in University of California, Los Angeles. He received a bachelor's degree in geophysics from University of Science and Technology of China in 2005, and received a master degree in geophysics from University of California, Los Angeles in 2007. At present, his research is focused on the following 3 fields: (1) Earthquake catalog quality; (2)The analysis of stochastic declustering models such as Epidemic Type Aftershock (ETAS) model and the estimation of the independence rate in different regions; (3) Probabilistic seismic hazard analysis, earthquake forecasting including both long-term and short-term forecasting and how the uncertainty of earthquake catalog influences the earthquake forecasting and testing results.

Temporal changes in S wave attenuation through a fault zone in the Bambanani gold mine, South Africa

Nana Yoshimitsu[1], Hironori Kawakata[2], Akihito Yamamoto[2], Hiroshi Ogasawara[2], Yoshihisa Iio[3], The Research Group for the Semi-controlled Earthquake-generation Experiments in South African Deep Gold Mines[4]

1. Ritsumeikan University, Japan, rp009049@se.ritsumei.ac.jp
2. Ritsumeikan University, Japan,
3. Kyoto University, Japan,
4. Research Group, Japan and South Africa,

ABSTRACT

We investigated temporal changes in seismic attenuation of *S* waves from repeating microearthquakes that pass through a fault zone, including the source regions of M~2 earthquakes in the Bambanani gold mine, South Africa. South African gold mines, where induced earthquakes occur in the vicinity of mining faces due to stress concentration, are suitable fields for near-source observations because planned mining enables us to anticipate where and when large earthquakes will occur. The Bambanani gold mine has a network of geophones around a potential source area (a part of the Tanton fault) of normal faulting earthquakes. In laboratory experiments, it is well known that the amplitude of elastic wave repeatedly transmitted through a fault decreases prior to unstable sliding. However, there are few studies on natural faulting to show similar phenomena because it is difficult to set controlled wave sources and receivers at the proximity to the natural faulting source. Earthquakes whose seismograms are similar to one another are called repeating earthquakes, of which source locations and mechanisms can be regarded as identical. At the Bambanani gold mine, a few hundred of clusters of repeating microearthquakes were recorded by a geophone (basic sampling frequency of 2 kHz) that closely situated within 250 m from the Tanton fault. Two M~2 earthquakes occurred in February 4th 2003 and April 12th 2003 along the Tanton fault, and we focused on one of these clusters that contains 20 repeating microearthquakes (-1.5 ~ M ~ 0.0) from October 2002 to June 2003. We calculated the spectral ratios of *S* waves for the repeating earthquake pairs to estimate temporal changes of seismic attenuation in the fault zone, including the focal regions of the M~2 earthquakes. We found a decrease in the relative *S* wave amplitudes for frequencies higher than 100 Hz, after the M~2 earthquakes. In addition, we found a decrease in the relative *S* wave amplitude prior to the M~2 earthquakes for the same frequency range (> 100Hz). The decrease in the *S* wave amplitudes for higher frequencies cannot be explained by the change of frequency-independent Q^{-1}. It is suggested that small cracks or damage were formed in the focal regions of the M~2 earthquakes both before and after the M~2 earthquakes, and the attenuation increased in higher frequencies. The typical heterogeneity scale of cracks or damage was expected to be around or less than 14 m. This is the first study that clearly found the frequency-dependent increase in seismic attenuation of transmitting waves through a natural fault zone prior to earthquakes.

Key words: seismic attenuation; repeating earthquake; spectral ratio; South African gold mine

PRESENTER'S BIOGRAPHY

Nana Yoshimitsu I received my bachelor in science from Ritsumeikan University in 2008. Now, a master course student at Ritsumeikan University. My research interest is seismology, especially earthquake source process. I am a student member of Seismological Society of Japan.

Some possible electrical pre- and co-seismic phenomena and their examination with the use of fuzzy-logic and morphologic analysis algorithms

J. Zlotniki[1], A. Gvishiani[2], **M. Rodkin[2]**, S. Agayan[2], Sh. Bogoutdinov[2]

1. CNRS, University Clermon-Ferrand, France, jacques.zlotnicki@wanadoo.fr
2. Geophysical centre RAS, Russia, rodkin@wdcb.ru

ABSTRACT

The electric signals are believed to be a perspective in revealing of electrical pre-seismic phenomena (EPSP). The possibility of existence of EPSP has long been looked for, but it is still difficult to construct a theory that could describe the generation of EPSP and the characteristics of EPSP. It was also found that there is a shortage of techniques capable to identify and discriminate pre-seismic signals from noise. At the Corinth Gulf (Greece) polygon of DEMETER project seismic, electric and magnetic components are recorded at very high recurrence rate (up to 10 kHz). As a result a huge volume of data was accumulated. In result of examination of these data it was revealed that some electric signals appear around the time when the seismic waves go through the recording stations. Such signal can be clearly seen on electric channels after the proper processing procedure and removing of low frequency part of the signal. Moreover, in some cases, the electric signals seem to appear before time arrival of the seismic wave. It was also noticed that a pre-event spectral phenomenon occurs (in statistical sense) before strong changes in the electric and geomagnetic record value. It was shown that the relative input of low frequency variations has a tendency to increase before the strong change in electric and geomagnetic data. This little but statistically observable effect can be treated as an analog of the critical slowing down effect. This critical slowing down is a well known effect taking place in vicinity of bifurcation points (including phase transitions and a number of similar situations). Some similar critical slowing-down-like features were found to occur in the evolution of systems of very different nature approaching some instability in their behavior, i.e., for the systems nearby jumps occurrence. The character of the examined anomalies in monitoring data is rather complicated and the qualified experts are expected to carry out visual examination of data. Thus, for an examination of the huge amount of available data some automation (or facilitating) of expert visual data analysis should be used. Such automatic data processing should imitate work of the expert making analysis of data on the basis of personal qualitative criteria. The used algorithms of data processing (carrying out automated fuzzy pattern recognition and morphologic analysis) are elaborated on the basis of fuzzy-logics and statistics. Results of their application are presented and an effectiveness of the use of these algorithms in comparison with the well known mathematical methods is presented and discussed.

Key words: co-seismic geoelectrical phenomena, data mining

Rodkin Mikhail V.,
Chief Scientist, born September 11, 1954, Russia.
Geophysical Centre RAS, Molodezhnaya 3., 119296, Moscow, Russia +7 (495) 930-51-46, fax. +7(495) 9300506, rodkin@wdcb.ru
Graduated from Physical Department, Moscow State University (1977).
Ph.D. in Physics and Mathematics (Geophysics), Institute of Physics of the Earth, Moscow (1986).
Dr. in Physics and Mathematics (Geophysics), Institute of Physics of the Earth, Moscow (2003).
Author of three monographs ("Geodynamic Effects of Physical-Chemical Transformations in Solids" in co-authorship with V.A.Kalinin and I.S.Tomashevskaya, 1989; "Role of Deep Fluid Regime in Geodynamics and Seismotectonics", 1993; and "Heavy-Tailed Distributions: Application to Disasters Analysis" in co-authorship with V.F.Pisarenko, 2007) and more than 150 papers, including those published in PEPI; PAGEOPH; J. Geodynamics; J. Earthquake Prediction Research; Phys. Chem. Earth; Izvestiya RAS: Physics of the Solid Earth and Geography; Proc. of Russian Acad. Sci.; Geotectonics; Economics and Mathematical Methods.
Engaged in natural hazards statistics, earthquakes regime, physics of earthquake origin, algorithms of pattern recognition.