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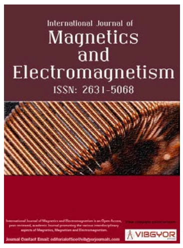
Some Results of the Study of Variations of Electromagnetic Fields Caused by Different-Rank Seismogeodynamic Processes and the Mode of Operation of Man-Made Objects



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Abstract

The data of the analysis of long-term studies of variations of electromagnetic fields on the territories of geodynamic polygons and technogenic objects are presented. It is revealed that local anomalies of the geomagnetic field in technogenic objects are associated with the operation mode and with the combined manifestation of different-rank geodynamic processes and seismicity. The issues of using these results in earthquake forecasting are considered. It also contains the results of a study of variations in the complex of electromagnetic fields at the Yangibazar magnetic-ionospheric Observatory. Daily, seasonal, and short-term anomalous variations of the pulsed electromagnetic field associated with earthquakes and other processes in the earth's crust are identified.

Keywords

Earthquake energy, Amplitude, Variations, Geodynamic polygon, Epicenter, Forecast, Pulsed electromagnetic field

Introduction

Seismic risk assessment and earthquake prediction are one of the most important global problems in the world. Complex deformometric, geophysical, hydrogeoseismological and other studies aimed at developing approaches to solving earthquake forecasting problems are continuing in many countries of the world.

Features of various forms of deterministic manifestations of seismotectonic processes, with the effects of cyclical seismic activity, migration of earthquake foci occurring on spatio-temporal scales, and energy exchange in the system of a multi-rank geological environment, play a significant role in the formation of precursors. Therefore, the study of spatial and temporal patterns of variations in deformometric, geophysical, hydrogeoseismological and other fields is an important task in solving the problem of earthquake forecasting.

Special attention is paid to identifying the features of the manifestation of the complex of earthquake precursors in different seismotectonic conditions, and studying the nature of the identified anomalous variations. When solving problems of

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earthquake forecasting, a detailed study of the features of the manifestation of electromagnetic fields associated with natural and man-made processes is particularly relevant in the current period of intensive development.

Among a wide range of harbingers, one of the most important places is occupied by the study of electromagnetic fields. This article discusses some of the results of long-term studies of electromagnetic, magnetic and electric fields conducted in Uzbekistan.

Among the electromagnetic precursors of earthquakes, the most promising, but still poorly studied, is the natural pulsed electromagnetic radiation of the earth's crust. Vorobyov AA (1970) [1], Nagata T (1968, 1972) and others wrote about the possibility of accumulation and discharge of electricity in the bowels of the Earth in the 70's of the last century.

In Uzbekistan, experimental work in the field was first organized at the Tashkent test site in collaboration with the Tomsk Polytechnic Institute. Anomalous variations of electromagnetic field (EMF) of the earth's crust associated with earthquakes were first recorded at the Tashkent test site in the tunnel of the Charvak reservoir. This method quickly spread to a number of other countries (USA, Japan, China, Greece, etc.).

Seven stationary EMR stations were opened at the Tashkent, Ferghana and Kyzylkum ranges. The pulse of the electromagnetic field, the dynamic characteristic of the field - the amount of motion that the electromagnetic field has in a given volume. Body placed in an electromagnetic field, under the influence of mechanical forces. The effect of the field on the body is associated with the absorption of electromagnetic waves by the body or a change in the direction of their propagation (reflection, scattering, refraction). When the body emits electromagnetic waves, in particular even light, the pulsed radiation of the body also changes. Since the momentum of a closed material system cannot change as a result of radiation, absorption, or reflection of electromagnetic waves (due to the law of conservation of the total momentum of the system), it follows that the electromagnetic wave also has momentum. The Analysis of the results of observations of electromagnetic radiation (EMR) is given in [Mavlyanov, et al. (1979) [2], Abdullabekov (1989), Gokhberg (1998), Khusomiddinov (1990), Moroz (2015), Yusupov (2016) [3], Yusupov (2018) [4], etc.].

The study of non-tidal changes in the magnetic field and their connection with modern seismotectonic processes is presented by many groups of authors and was considered at annual meetings [5-8] [Abdullabekov, Maksudov, Berdialiev, Tuichiev, Yusupov, 1973, 2011, 2018]. Deformation and slope observations at geodynamic polygons were analyzed with special care during the Tavaksay earthquake [Yarmukhamedov (1979)].

Seismic activation occurs synchronously in the southern and Northern Tien Shan. This is a proof of the morphological uniqueness of the Tien Shan. [Abdullabekov and Usmanova (2003)] Activations were observed in 1897-1916, 1934-1951, and 1971-1988. This means that strong earthquakes in the Tien Shan and Pamir (with M = 3.5-7.5) are cyclical for about 35 years. Cycles of activation of the Tien Shan seismicity occur synchronously with the strongest earthquakes between the Indian and Eurasian plates (Figure 1) [7].

Combined manifestations of anomalous variations of seismogeodynamic and technogenic nature were revealed at the Charvak polygon. This situation makes it necessary to conduct geomagnetic studies on the territories of man-made objects with high accuracy. In these territories, when determining the installation locations of stationary stations, it is necessary to take into account the presence of interference-generating objects, the magnitude of the horizontal and vertical gradients of the geomagnetic field. The results of geomagnetic studies on the territories of the Charvak reservoir, underground gas storage, and in the epicentral zones of strong earthquakes were interpreted in relation to the Yangibazar magnetic-ionospheric Observatory and those located near the above-mentioned objects or specially installed stationary stations.

Variations of the geomagnetic field at the Charvak polygon associated with earthquakes are studied. If stress-strain processes occur in any part (area) of the Earth several months or years before an earthquake, all the physical properties of rocks change in the center of the upcoming earthquake. As a result of tectonic movements in the earthquake center, the electrical conductivity, magnetic properties, and density of rocks change.

Results and Discussion

The first points of repeated geomagnetic observations in the area of the Charvak reservoir were

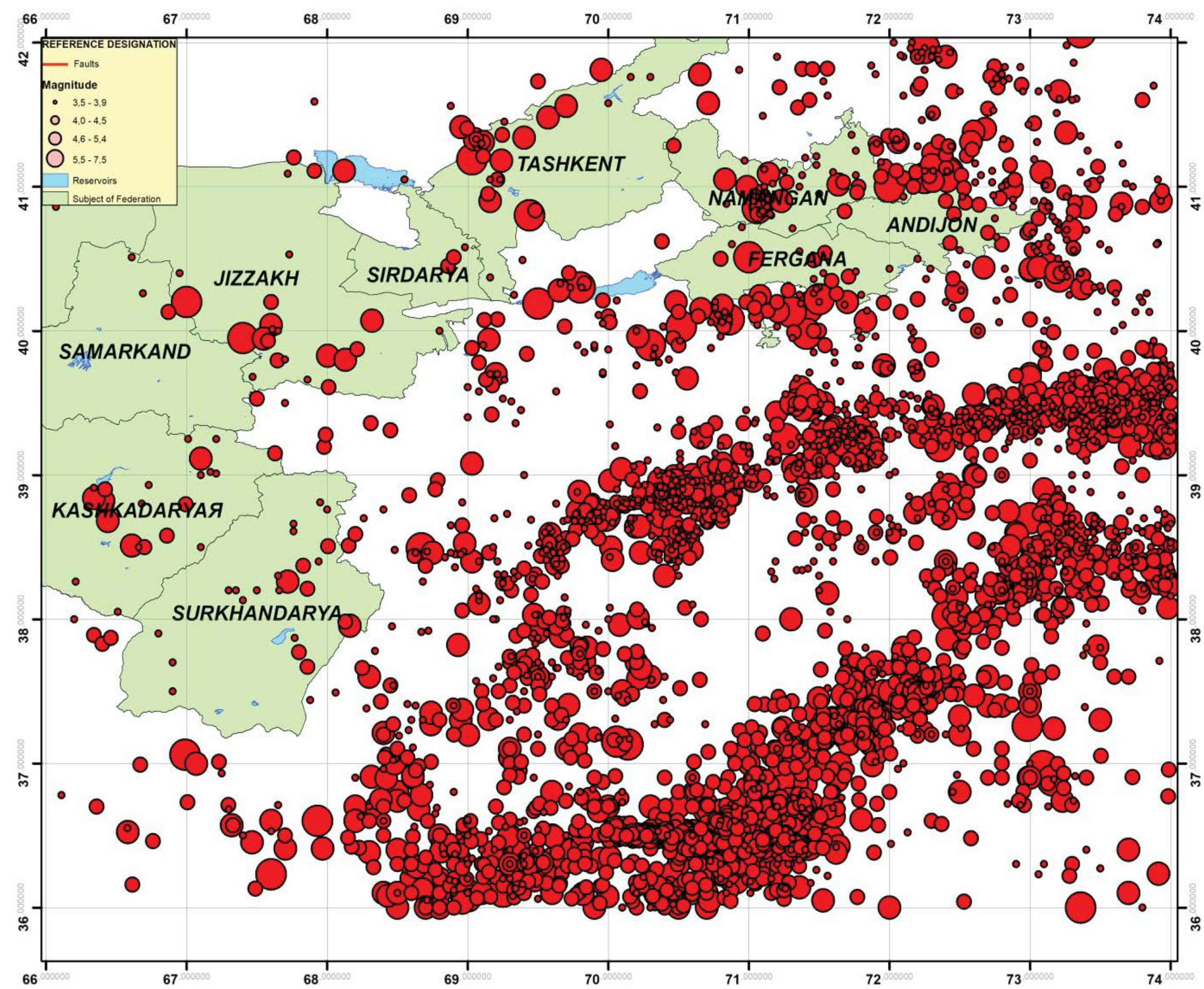

Figure 1: A fragment of the tectonic map of Eurasia and the epicenters of strong earthquakes in Central Asia (M = 3.5-7.5).

laid in December, 1973. The number of points in different years was different, and varied from 25 to 45 points. The number of measurement cycles per year also changed - from 2 to 8. In total, more than 170 measurement cycles were performed during the period of 1973-2020. The analysis of research results for 1973-2020 involved data from 45 points of repeated observations that were not damaged during this period. Measurements at the repeated observation points were made by proton-precession magnetometers T-MP, MV-01 synchronously with the magnetometer MPP-1 of the magnetic ionospheric Observatory "Yangibazar "and MV-01"Charvak". The accuracy of a single reading of magnetometers is 0.1 nTl. The results of geomagnetic studies are classified, systematic errors of reference stations are excluded, and field increments relative to 1 observation cycle are calculated using the following formula:

$$\Delta\Delta Ta = \Delta Ti \text{ cycle} - \Delta T1 \text{ cycle}$$

The results of the work of their predecessors clearly show that the study of the spatial structure of geophysical fields is one of the scientific directions of research in various applied problems of structural Geology, tectonics, metallogeny, geodynamics and seismotectonics. These studies play a special role in seismically active zones, since the discharge of tectonic stresses occurs, as a rule, in the zones of influence of active tectonic structures.

Changes in the energy and number of earthquakes over time. To model the seismic process, a database of seismological information on earthquakes in Eastern Uzbekistan was used, containing data from 1970 to 2020. Seismicity in the area under consideration was analyzed on the basis of instrumental observations, mainly over weak earthquakes, the number of which during the observa-

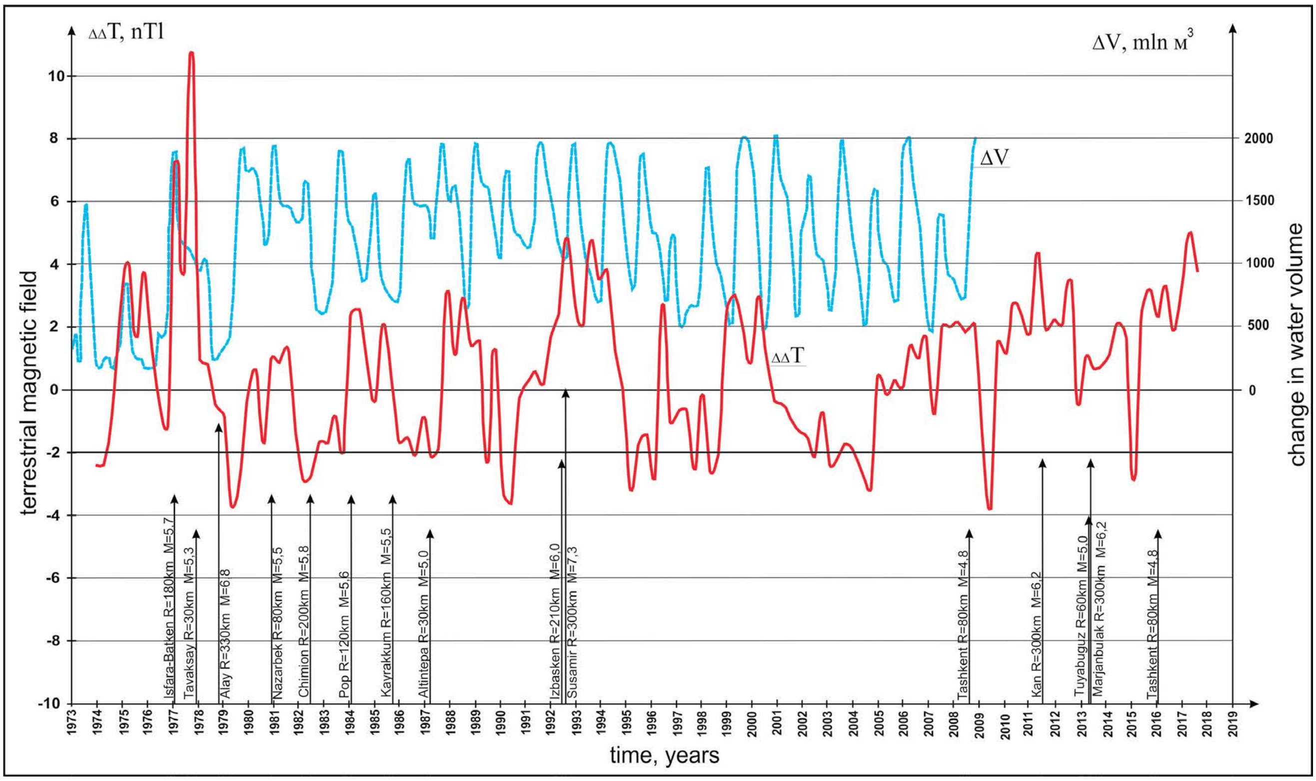

Figure 2: Anomalous changes in the geomagnetic field at the Charvak polygon associated with earthquake preparation processes and changes in the volume of water in the reservoir.

ΔΔV: Changes in water volume; ΔΔT: Changes in the geomagnetic field.

tion period was more than 32 thousand. Information about earthquakes contained the following data: year, month, date, time, coordinates, and K (class) Figure 2.

One of the main tasks of modern geophysical research in seismically active regions is to study the geological prerequisites for the occurrence of earthquakes of different strengths and to compile regional forecast maps of seismic hazard. The study of electromagnetic precursors of earthquakes is carried out by scientists in several leading scientific centers and institutions of higher education seismically active countries in the world, including: Xuemin Zhang, Xuhui Shen, F. D. Stacey, A. V. Shapiro, S. Polyakov, A. Shchennikov, Z. Tang, I. Podsklan, V. Kuznetsova, V. Maksymchuk, Mei Li, Handong Tan, Meng Cao, P. M. Davis, in Uzbekistan, the research of electromagnetic fields in different years conducted by G. A. Mavlyanov, V. I. Ulomov, K. N. Abdullabekov, S. Kh. Maksudov, S. Husamiddinov, E. Berdaliev, M. J. Muminov, A. I. Tuychiyev, S. O. Yakubov, O. M. Barsukov, N. M.Mutaliev, E. M. Mahkamdzhanov, M. T. Usmanova and others. Changes in the electromagnetic field were studied at geodynamic polygons and hydraulic structures in Kyrgyzstan (Turdukulov, et al. (2003)), in the United States of America, the time, place, and strength of earthquakes (Geller) were revealed using complex analysis of electromagnetic fields, and in Greece, anomalous precursor changes were detected before several earthquakes [Eftaxias (2000)].

The main results of geophysical research were as follows

The results of studies of changes in the electrical resistance of rocks (GC), telluric currents (TT), natural electric field (SES), atmospheric electricity (AE), natural pulsed electromagnetic field (EIEMP) and variations of the geomagnetic field are presented. In countries located in seismically active territories (Kazakhstan, Russia, Japan, China, the USA, Greece, etc.), studies of atmospheric electricity, telluric currents, electrical resistance of rocks, and natural pulsed electromagnetic radiation of the earth's crust are developed. In many countries of the world, these methods are used to study various electromagnetic phenomena, processes at man-made objects, as well as to predict earthquakes.

At The Institute of seismology, studies of earthquake precursors using a set of electrometric methods were carried out at the Tashkent, Fergha-na, and Kyzylkum geodynamic polygons, Charvak reservoir, Poltorak underground gas storage, Tamdybulak, Shirmanbulak, South Alamushuk, and the epicenter zone of the Gazli earthquakes.

In the Poltoratsky underground gas storage facility, the pressure changes over time as a result of gas injection and pumping from the reservoir with a capacity of 20-40 m, lying at a depth of 520 m in the vault and 720 m on the wings. Reservoir pressure of the reservoir itself is 6 MPa. Gas is pumped at a pressure of 9.5 MPa in summer and consumed in autumn and winter. According to the results of research, it was found that when the anticline structure is filled under high pressure, the gas displaces the host water, which increases the electrical resistance of rocks by 15-20%. In the winter months, the opposite is observed - due to gas pumping, the pressure decreases and the electrical resistance of rocks (ha) also decreases by 15-20%. Thus, the pressure varies from 6 to 9 MPa. These results show that the electrical resistance of rocks strongly reacts to changes in the environment and external influences, which can be used in modeling the processes of earthquake preparation in natural conditions on man-made objects.

A complete analysis of studies of observations of the electromagnetic field (EMI) is given in [Vorobyov (1970) [1], Gokhberg, et al. (1983, 1986, 1988) [9]]. The first studies of anomalous perturbations in the ionosphere were described by JG Birfeld in 1974 [9]. The EMR variation curves have a quasi-sinusoidal character with the maximum intensity of radiation occurring during the daytime and the minimum intensity at night. The characteristic cyclicity is broken a few hours before the most severe earthquakes occur. The analysis of the material makes it possible to conclude that electromagnetic emissions can reach the surface and gives grounds to assert that there is a fundamental possibility of detecting harbingers of electromagnetic anomalies. EMR anomalies occur over large areas and distances from the earthquake source. Moreover, in contrast to magnetic field anomalies, in this case there is no correlation between the amplitude of the anomaly and the parameters of the focus.

So, on the territory of the Yangibazar Magnetic and ionospheric Observatory, round-the-clock electrometric observations are organized with the help of a cluster center.

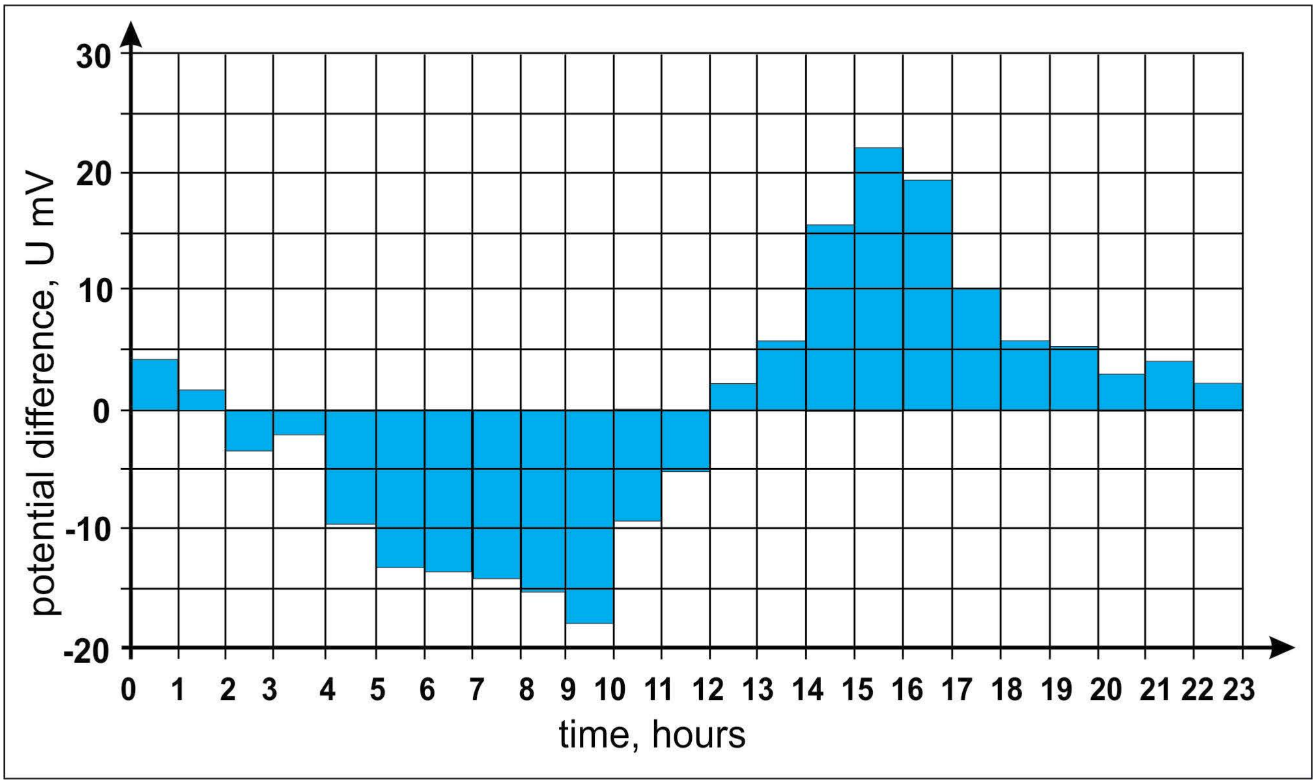

Figure 3: Average daily variations of pulsed electromagnetic radiation at the Yangibazar Observatory (local time) (2013-2015).

Figure 3 the average daily variations of EMR at the Yangibazar Observatory are shown calculated by averaging data from 365-day field intensity measurements. As can be seen from the Figure 3, the intensity of the field in the first half of the day is negative, and in the second - positive.

As an example, see Figure 3 shows graphs of the daily course of EMR at the Yangibazar Observatory for 2013-2015. Analysis of the graph showed that diurnal variations in background intensity occur at all times of the year, but their shape and amplitude are subject to seasonal changes. The shape of the daily course in the winter months is more smoothed and does not have clearly defined patterns. The night maximum is planned after midnight, at least during daylight hours (6-14 hours). During the transition to the spring-summer season, the shape of the daily course changes and is characterized by the presence of two maxima-afternoon (16 hours) and at night. The minimum intensity of EMR occurs in the morning (9-10 hours). The amplitudes of diurnal variations are greatest in summer and smallest in the winter months. In the spring and autumn months, they are approximately the same and are the average between summer and winter values. Summer EMR intensity values reach 4000-5000 pulses per hour, and in winter they are much lower. This indicates that the causes that determine the forms of diurnal variations of EMR are interregional in nature. The highest EMR intensity values are observed in the summer months (June, July), and the lowest in the winter months (January, February). Absolute values of seasonal variations are in the order of minimum-20 mV, and maximum-40 mV. Thus, the main regularities of regular variations of EMR are as follows: - daily variations of EMR are characterized by a minimum signal level in the morning hours of local time and a maximum (in winter) - at night. - Seasonal variations in EMI intensity are characterized by a maximum of EMI intensity in the summer months, and a minimum in the winter months. To analyze the relationship of variations in the background intensity of EMR with meteorological factors, we used data from the Kustovoy Center station.

In Figure 4 annual variations of pulsed EMR at

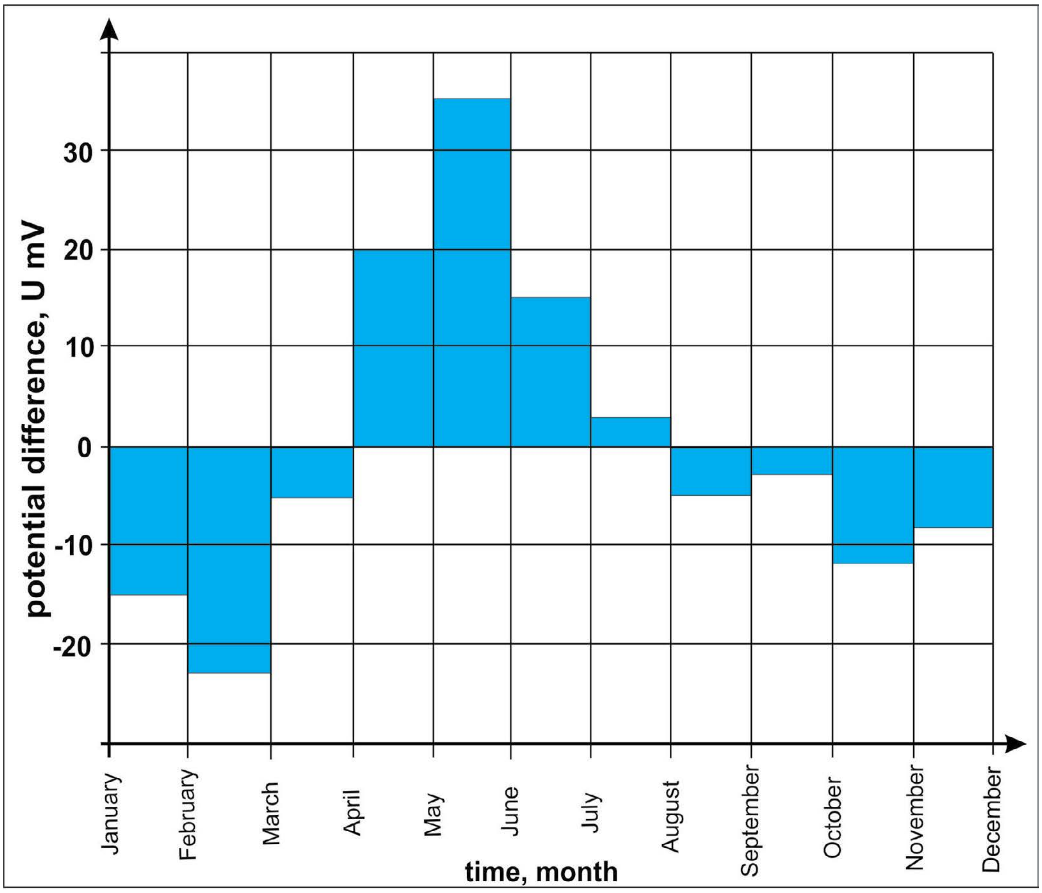

Figure 4: Seasonal variations of pulsed electromagnetic radiation at the Yangibazar Observatory (2013-2015).

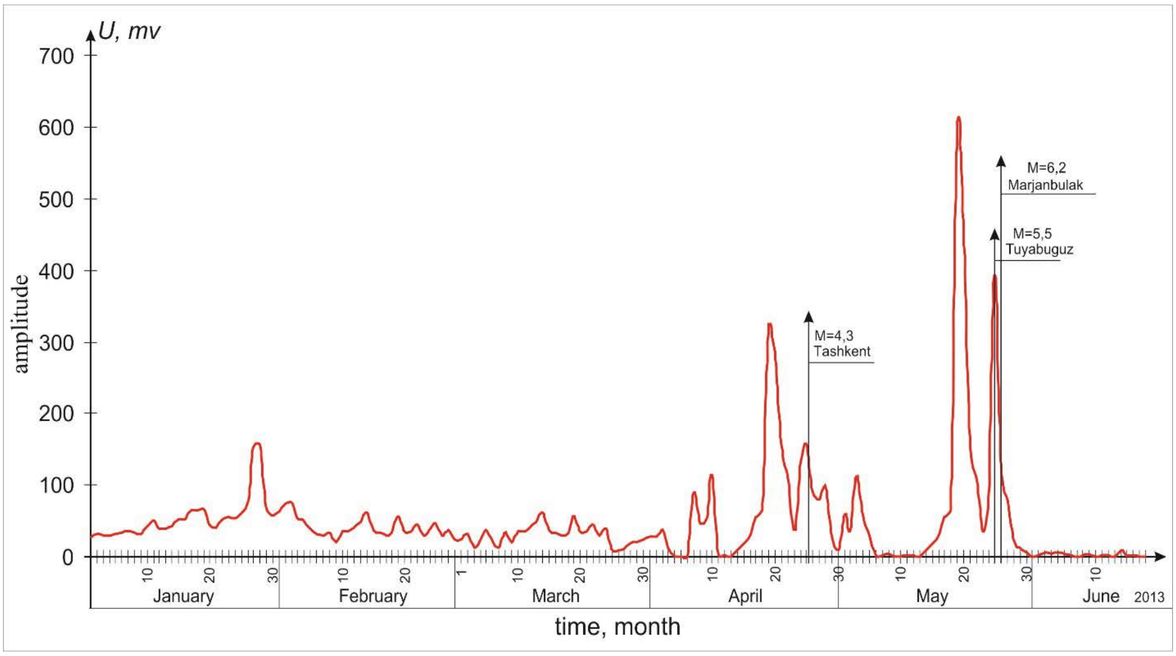

Figure 5: Anomalous changes in the pulsed electromagnetic field at the Yangibazar observatory associated with the Tuyabuguz and Marjanbulak earthquakes.

the Yangibazar Observatory are reflected. Thus, the intensity of EMR is high in the summer months, and low in the winter months.

Based on the results of statistical analysis of changes in the electromagnetic field pulses at the Yangibazar Observatory in 2013, it was found that strong changes are observed in the summer months relative to the winter months. But the average monthly schedule of changes differs from other months. These anomalous changes are compared with earthquakes in the region that occurred within a radius of LgR = 0.204 M + 1 km. The results of the analysis showed that the electromagnetic field from January to May 18 changed on average by 100-200 mV, and on May 20-25 it changed by 600-650 mV (Figure 5).

In Uzbekistan and other seismically active regions, numerous anomalous variations of EMR associated with earthquakes were identified in 1974-2017. The intensity of the amplitude of anomalies on normal weekdays increases from several tens to several hundreds, and even a thousand times. The results of continuous EMR observations at the Yangibazar magnetic ionospheric Observatory and variations in other regions are compared.

It was shown in [9] [Gokhberg MB, et al. (1980)] that even when the entire energy of an earthquake source with E = 10 j is transformed into electromagnetic energy, the EMR intensity on the daytime surface will be less than the background component. Therefore, the recorded anomalies are the result of the near-surface interaction of crustal blocks during their relative movement near the observation point and are determined by the physical properties of rocks, their material composition, and the nature of movement along the fault.

Numerous studies of variations in the geomagnetic field and its secular course are conducted in many countries. The average annual change at a certain point is taken as the secular course of the geomagnetic field. Short-term variations of the geomagnetic field should be taken into account when conducting geological exploration and predicting earthquakes using the geomagnetic method. Global and regional changes in the geomagnetic field are associated with processes in the deep layers of the earth, and local changes are associated with processes occurring in the shallow layers of the earth's crust.

The secular course of the geomagnetic field is studied at more than 200 magnetic observatories, at thousands of points of the secular course, as well as by space magnetic surveys.

The secular course of the geomagnetic field at stationary stations is determined by the following formula:

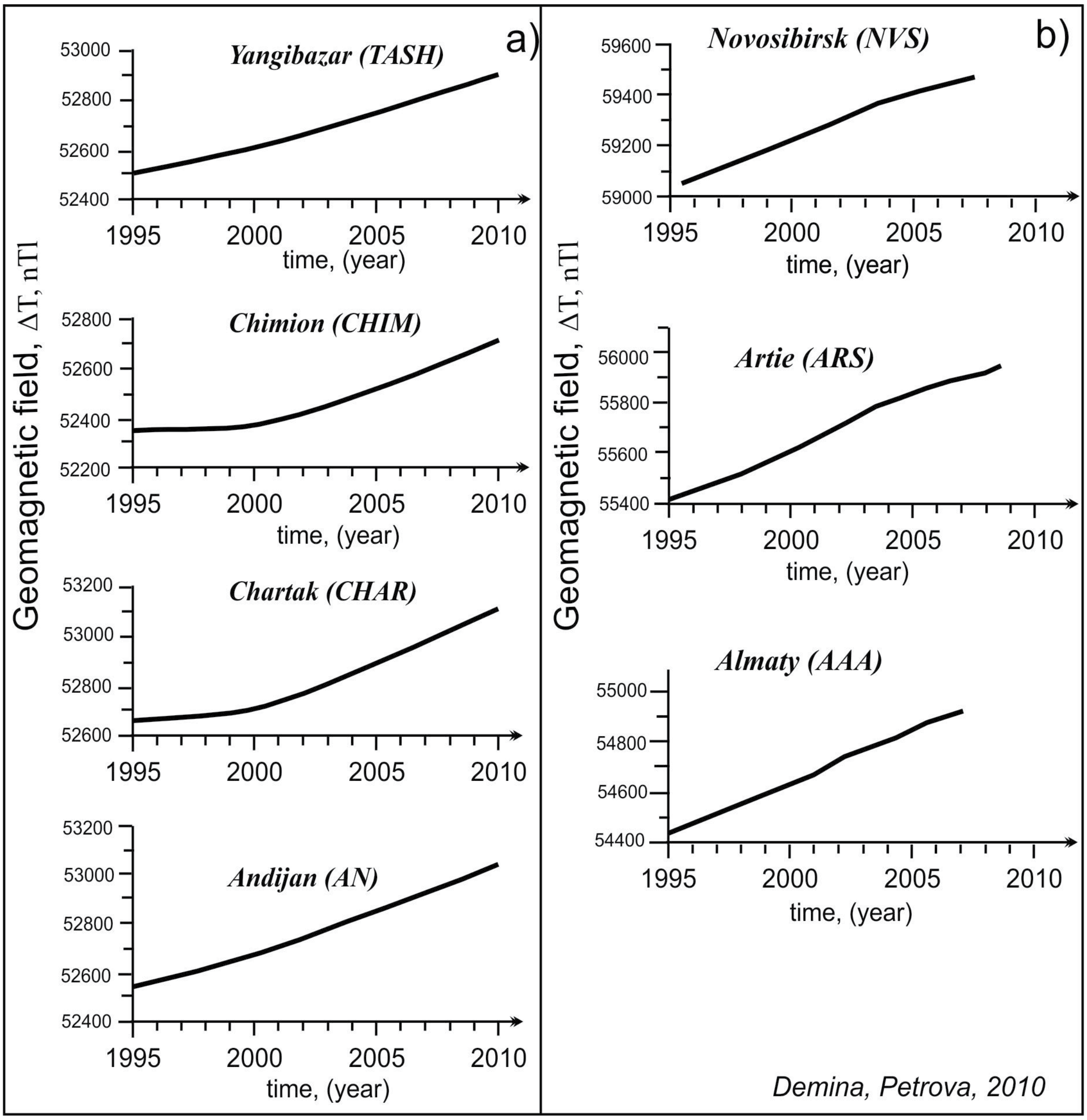

Figure 6: Observed secular changes in the geomagnetic field at stationary stations in Uzbekistan (a) and observatories in Russia and Kazakhstan; b) [IM Demina, AA Petrova (2010)].

$$\Delta T_{secular} = T2\text{-}T1, T3\text{-}T2, \ldots\ldots Tn\text{-}Tn\text{-}1 \qquad (1)$$

The values of the secular course of the geomagnetic field in Uzbekistan over the past 30-40 years were determined based on the results of long-term observations at the stationary stations "Andijan", "Chartak", "Chimion", "Khumsan", "Yangibazar", "Samarkand", "Tamdybulak", "Bukhara", "Shurchi". For a clear representation of the dynamics of the geomagnetic field since 1979, the values of the average secular course for every 5 years are given in the form of vectors.

Secular changes in the geomagnetic field are studied at geomagnetic observatories and stationary stations in Central Asia. The observed secular changes in the geomagnetic field in 1995-2010 at the stationary stations "Yangibazar", "Chimion", "Chartak", "Andijan" are compared with the secular changes observed at magnetic observatories located outside Uzbekistan - "Novosibirsk" (NVS), "Arti" (ARS), "Alma-ATA" (AAA). As a result of comparison, it is revealed that secular changes at the Yangibazar Observatory and stationary stations occur according to regional changes (Figure 6).

Conclusion

Thus, long-term research in Uzbekistan: Large-scale complex observations of variations in electromagnetic, electric and magnetic fields are organized to ensure the seismic safety of the population and the territory of the Republic; based on long-term monitoring of variations in electromagnetic fields on geodynamic polygons in Uzbekistan, anomalous changes caused by different-rank geodynamic processes, earthquakes, as well as man-made processes-the mode of operation of high-altitude reservoirs and oil and gas fields are identified.

Scientists believe that the anomalous changes are caused by the variation of the residual magnetism of rock due to excessive stresses. Hence the analysis of mean yearly data of the world network of magnetic observatories, together with a long series of measurements in test areas and at points of secular changes, has discriminated a slow variation of the magnetic field with an intensity of 50-70 nTl and a characteristic time of 15-20 years, having the linear dimensions of the first hundreds of kilometers. This type of variation has been explained in terms of tectonic processes in the active areas of the Earth’s crust and phrases of seismic activity in seismotectonic regions.

In conclusion was identified, the long-term research result of the variation of geomagnetic field around the Uzbekistan displays that the local geomagnetic anomalies regional related to the changes of magnetic dates of the observatory of the nearby regions (Novosibirsk (NVS), Artie (ARS), Almaty (AAA)) and (Yangibazar (TASH), Chimion (CHIM), Chartak (CHAR), Andijan (AN)) in Uzbekistan. The research variation geomagnetic field results in the area of Uzbekistan could be used in not only the modeling preparation process of earthquake and prediction of earthquake but also monitoring seismic activity near the faults zones and the Uzbekistan cities.

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References

1. Vorobyov AA (1970) On the possibility of electric discharges in the earth's interior. Geology and Geophysics 12: 3-13.

2. Mavlyanov GA, Ulomov VI, Abdullabekov KN, Khusamiddinov SS (1979) Studies of variations in the parameters of electromagnetic fields for earthquake prediction. Uzbek Geological Journal 5: 11-15.

3. Yusupov VR (2016) Investigation of anomalous variations of the earth's natural pulsed electromagnetic field. Geology and Mineral Resources, Toshkent 3: 51-53.

4. Yusupov VR (2018) Anomalies of geomagnetic field related to natural and technogenic events in Charvak area. Geodesy and Geodynamics 9: 367-371.

5. Abdullabekov KN, Maksudov S Kh, Tuichiev AI, Yusupov VR (2012) Anomalous variations of the geomagnetic field at the Charvak polygon of seismic nature. DAN RUz, Tashkent 4: 45-48.

6. Abdullabekov KN, Maksudov S Kh, Tuichiev AI, Yusupov VR (2012) Investigation of local variations of the geomagnetic field of technogenic and geodynamic nature in the area of the Charvak reservoir. Ecological bulletin, Tashkent 4: 11-14.

7. Abdullabekov KN, Yusupov VR (2014) Features of seismicity in different-rank tectonic structures. Reports of the Academy of Sciences of Uzbekistan, Tashkent 1: 43-46.

8. Abdullabekov KN, Maksudov S Kh, Tyychiev AI, Yusupov VR (2018) Local variations of the geomagnetic field of technogenic and geodynamic nature in the area of the Charvak reservoir. Exploration and protection of mineral resources, Moscow 5: 27-32.

9. Gokhberg MB, Gufeld IL, Dobrovolsky IP (1980) Sources of electromagnetic precursors of earthquakes. DAN SSSR 2: 323-328.

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