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ABSTRACT

of the dissertation for the degree of
Doctor of Philosophy

EFFECT OF MINGACHEVIR WATER BASIN TERRITORY ON SEISMICITY

Specialty: 2507.01- Geophysics, methods of geophysical prospecting of minerals

Field of science: Earth sciences

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GENERAL CHARACTERISTICS OF THE WORK

Relevance and development of the topic:

Intensive development of construction of residential buildings and industrial facilities in the country requires a thorough study of the degree of earthquake danger for individual cities, settlements and construction sites. The construction of hydraulic structures creates the need to address a number of issues related to their operation. The revitalization of the landslide process, especially in areas adjacent to hydraulic structures, requires the reworking of shores as a result of the deterioration of the reservoir, the elimination of the process of pumping rivers and siltation of shores with recycled products.

The study of the seismicity of the Mingachevir watershed, located on the southern slopes of the Greater Caucasus and the middle Kura basin, which is one of the most seismically active regions of Azerbaijan, is of particular importance in this regard. Obtaining detailed engineering and geological information about the area and forecasting dangerous geological processes is of great importance for the construction and operation of industrial and civil facilities.

The construction of the Mingachevir complex of hydro-technical facilities has led to the creation of large-scale reservoirs that create completely new conditions for the coast and coastal slopes. Increased seismic activity and destructive earthquakes in recent years, especially in the areas of large hydraulic structures, have made it necessary to establish and conduct a system of seismological monitoring in the Mingachevir reservoirs.

The study of natural and man-made processes in the geological environment by geophysical methods is the most pressing problem of today. In the study of seismic processes of geophysical methods, it is possible to study and predict the dynamics of this process by determining the seismicity as a result of its application and monitoring the change of geophysical fields over time.

Object and subject of research:

Influence of Mingachevir water basin and its level change on seismicity and exogenous geological processes of the area.

Research goals and objectives:

Study of the impact of changes in the water level in the Mingachevir water basin on the formation of artificial earthquakes in the region, the creation of dams to change the seismic situation..

1. Analysis of macroseismic and instrumental data on seismic events
2. Distribution of weak and medium earthquakes in space and time
3. Construction of earthquake epicenter mechanisms and assessment of stress-strain state of the environment
4. Carrying out seismotomographic works
5. Study of the impact of strong earthquakes on Mingachevir water basin
6. Study of tension situation in the territory of Mingachevir water basin on the basis of Pearson correlation coefficient.
7. To study the impact of changes in water levels on seismicity and exogenous geological processes in the area.

Research methods:

During the dissertation work on the basis of materials obtained in the zone of Mingachevir water basin on the basis of telemetry stations of the Republican Seismological Service Center, geological-geophysical fund materials of the Institute of Geology and Geophysics of ANAS, State Oil Company of Azerbaijan Republic Geophysics and Engineering Geology Production Association, Materials of the Ministry of Ecology and Natural Resources were used. The parameters of earthquakes that occurred during 1980-2017 were used in the implementation of the reports. Complex analysis of seismic and geological data was conducted in Antelope, ArcGIS10.1, Surfer, Fa_major, Moment Tenzor, MathLab and DIMAS programs.

The main provisions of the defense:

1. Formation of seismicity in connection with the operation of the Mingachevir reservoir, the dynamics of development of seismic conditions and the state of tension-deformation of the environment.
2. The impact of changes in the water level of the Mingachevir reservoir on the seismicity of the area and exogenous geological processes.

Scientific novelty of the research:

1. Analysis of the long-term seismicity of the Mingachevir water basin zone, as well as adjacent areas, showed that an increase in weak seismicity has been observed since 1956.

2. From my observations, I came to the conclusion that the violation of the water level balance in the Mingachevir reservoir affects the formation of weak earthquakes in these areas.

3. It has been determined that weak earthquakes occur at a depth of 12-34 km within a radius of 30 km from the center of the reservoir within 1-3 months after the completion of the reservoir filling, which confirms their man-made nature - directed seismicity.

4. Seismological and geodynamic surveys conducted around the Mingachevir water basin showed that 80 landslides were recorded in the direction of SW-NE of Bozdag slope, which lasted 7-12 seconds, at a depth of 18-50 m.

Theoretical and practical significance of the research:

The results of the study can be used to assess the potential seismic hazard around the Mingachevir Reservoir and other artificial reservoirs and to take measures to reduce seismic risk.

Approbation and application of the case:

Provisions and results of the dissertation at the conference of the Azerbaijan Association of Seismologists II Seismology and Seismic Risk Reduction Factors, Natural Disasters, the conference dedicated to the 100th anniversary of instrumental observations in Azerbaijan, the seminar of the 10th International School of Seismology (Baku, September 14-18, 2015) , Was presented at the conference on methods of processing and interpretation of seismic data (Baku, 2015), in the annual reports and scientific seminars of the RSCC under ANAS, at the General Republican seminar held at the Institute of Geology. 12 articles and 2 theses on the topic of the dissertation were published.

Name of the organization where the dissertation work is carried out:

The research work was carried out in 2003-2019 at the Republican Seismological Service Center under ANAS.

Structure and scope of work:

The dissertation consists of an introduction, four chapters, results, 88 references and appendices. It covers 159 pages, including

103 figures and 10 tables. The introduction to the dissertation is 4 pages with 7569 characters, the first chapter is 19 pages with 37814 characters, the second chapter is 13 pages with 23475 characters, the third chapter is 34 pages with 43632 The fourth chapter consists of 69 pages with 75217 characters, the results are 2 pages with 3412 characters and the list of 88 references used is 10 pages with 15762 characters. The volume of the dissertation consists of 159 pages of computer writing, the total volume is 206882 characters (191120 characters excluding the list of references and appendices).

The author expresses his deep gratitude to the scientific adviser, director general of the RSCC under ANAS, corresponding member of the Azerbaijan National Academy of Sciences, doctor of geological-mineralogical sciences, professor GC Yetirmishli for the opportunity and assistance provided for the dissertation work.

SUMMARY OF THE WORK

In the introductory part, the relevance of the topic, the purpose of the research, the objectives and the general characteristics of the dissertation are given.

The first chapter studies the features of the geological structure of the Mingachevir reservoir, the history of research in the Mingachevir region, man-made earthquakes, physical and geographical conditions, brief lithological and stratigraphic characteristics of the Mingachevir reservoir, geological conditions and tectonic faults in the Mingachevir area. The first researches in this direction In the years after the construction of the Mingachevir reservoir, a geophysical expedition led by KS Islamov worked. Separate information about the geological structure of the Mingachevir region can be found in the works of MM Bogdanov "Two intersections of the Main Caucasus Range" (1902) and VV Bogachev "Geological structure of the Arin district" (1919). Information about the geological structure of Mingachevir region was first given in 1905 on a map compiled by Professor NI Lebedev. Here are the sediments of the third period belonging to the Sarmatians. The research allowed to consider numerous options for the placement of the ridges of the high-resistance dam and to clarify the tectonics of the areas where the main option will be selected.

In 1915, for the first time in the book Water Inspection in the Caucasus, the issue of the possibility of building an irrigation dam in the Mingachevir Strait was raised. (only 7-8 m high, to irrigate the cotton fields of the Shirvan Plain), the issue of re-establishing the dam was raised in 1925, and the government of the Transcaucasian Socialist Federal Soviet Republic established a scientific commission to determine Azerbaijan's water resources. This commission considered the geological conditions of Mingachevir region favorable for the installation of an energy reservoir. In 1926, research was conducted in the Mingachevir Strait and the research yielded negative results.

In 1927-1928, the commission of the Labor and Protection Council, recognizing the inadequacy of the work carried out and the lack of laboratory research of the soil, decided to organize extensive hydrogeological research to justify the project of construction of a concrete dam 20-25 m high in Mingachevir. The work was carried out by the hydrogeological party under the leadership of SI Lukoshevich.

In geological research, geologists, V.A. Strakhov, M.E. Lavrov, V.V. Shishkin and others. Attended, general management prof. It was carried out by F.A. Savarensky. The purpose of the research was to justify the construction of a reinforced concrete dam with a support not exceeding 25 m in height.

As a result of research, the Bosphorus and its hydrogeology were discovered. SI Lukoshevich determined that there were very difficult geological conditions for the construction of the dam.

A schematic project was compiled on the basis of S.I. Lukoshevich's materials (Uprvadskhema 1939). During the drawing up of the scheme of the Kura-Araz basin in 1931, it was discovered that the value of the Mingachevir reservoir increases significantly as the number of supports increases. In this regard, it was proposed to build a new version of the dam with a height of 30 m in Mingachevir.[1],[2]

From 1932 to 1933, new and more detailed geological surveys were conducted to substantiate the "Greater Mingachevir" scheme.

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[1] Мячкин В.И. Процессы подготовки землетрясений. М., Наука, 1978, с. 232

[2] Мячкин В.И., Костров Б.В., Соболев Г.А., Шамина О.Г. Лабораторные и теоретические исследования процессов подготовки землетрясений. Изв. АН СССР, Физика Земли, 1974, №10, с. 107-112.

In 1956, J.M. Suleymanov published an article on the geological and hydrogeological conditions of the Mingachevir junction. This work gives a brief description of the geological structure of orohydrography and geomorphology of Mingachevir junction.

Geodynamic processes are strongly influenced by both internal (endogenous) and external (exogenous) events. The influence of "dam earthquakes" on the creation of artificial earthquakes is great. Such earthquakes were observed when the water level in the reservoirs created by the dams reached 80, 100, 120 m.

On August 1, 1975, a magnitude 7.0 earthquake shook the city of Ovril in the United States, attracting the attention of seismologists.

The study found that an arched Hover Dam was built on the border of Nevada and Arizona in 1935, 40 years before the Ovril Dam earthquake started.

The second chapter studies the hydrogeological conditions of the Mingachevir area, groundwater and exogenous geological processes. The area is poor in terms of groundwater distribution. Groundwater is found in the sediments of the Absheron, Agchagil and Baku floors. Absheron sediments are divided into three types according to their hydrogeological features:

1. Clay layers of sandstone with a certain thickness, consisting of sandstones and with a special hydrogeological regime.
2. Sand layers are observed in the composition of dry clay layers.
3. Intermediate aquifer consisting of clays and sandstones.

Depending on the tectonic point of view and the bedding conditions of the strata, the aquifers of the Mingachevir region are characterized by their specificity. Laboratory filtration coefficients of Absheron sediments are 0.069 m / day, and those of Upper Absheron sediments are 0.1728-0.773 m / day. These figures show that the Absheron-aged sandstones are characterized by very small water infiltration coefficients, and in some cases the increase in the filtration coefficient in these sediments is explained by their exposure to cracks as a result of tectonic movements.

Groundwater mineralization is almost high. Mineralization varies between 2-12 grams. Mineralization in the Mingechevir region is mainly due to sulfates and chlorides. In general, the mineralization of groundwater in the Mingechevir area is high and varies between 130-400 mg / eq. The groundwater in this area is mainly sulphate water, which is due to the excessive content of gypsum in the rocks in the area. The contact of aquifers with each other is disturbed in some places. As a result, groundwater is mixed and a new type of groundwater is formed.

As noted, the study area covers alluvial and deluvial-proluvial plains of southeastern edge of the Ganja-Gazakh foothill plain. Ground and pressurized aquifers are widespread within the plains.

In the hydrographic network of the area, along with the Kura River, the Kurakchay, Goranboy, Injachay and Alijanchay rivers of the Ganja-Gazakh plain, as well as the Upper Karabakh and Upper Shirvan irrigation canals attract theoretical attention. Entering the territory of Azerbaijan, the Kura River rises from the Agstafachay estuary to the plain through a shallow ravine and extends smoothly to the city of Mingachevir. Above Mingachevir, the river cuts the shallow gorge of the Bozdag range. A large Mingachevir reservoir with m3 of water has been built. The mineralization of water varies from 150 to 644 mg / l per year.

The thickness of the groundwater horizon varies from 15.2 m (Uchkhoz) to 29.7 m (Salahli). Consumption of wells during pumping is 19.9-179.9 / day, specific consumption is 0.07-0.43 1/cm, filtration coefficient of waterlogged rocks is 0.47-7.96 m/day, water permeability coefficient is 6.2-67, Varies in the range of 7 m^3/day.

In order to study the active landslide area on the right bank of the Mingachevir reservoir (Bozdag landslide area) and to monitor the landslide processes, the contours of the landslide area and the parameters of the landslide plane were determined based on the results of geophysical work carried out in 3 km^2 area. Thus, the landslide mass in this area occurs in the western part of the Karabakh canal, in the part of the relief lying at an angle of 60° and having a 15-20 m landslide mirror. The landslide is of an aceventive nature, caused by the sharp wetting of the landslide tongue with reservoir water and the leakage of atmospheric sediments on the cracks and fissure systems present in the watersheds of the Bozdag range. The lithological composition of the upper part of the section is also suitable for landslides.

The volume of field works for inspection purposes has been significantly reduced due to the use of the results of EGP monitoring and engineering geological works previously carried out in the Mingachevir reservoir area. In the landslide area on the right bank of the Mingachevir reservoir, 30 f.n., and in Yenikend and Shamkir reservoirs, electrical exploration regime observations were carried out (Fig. 1).

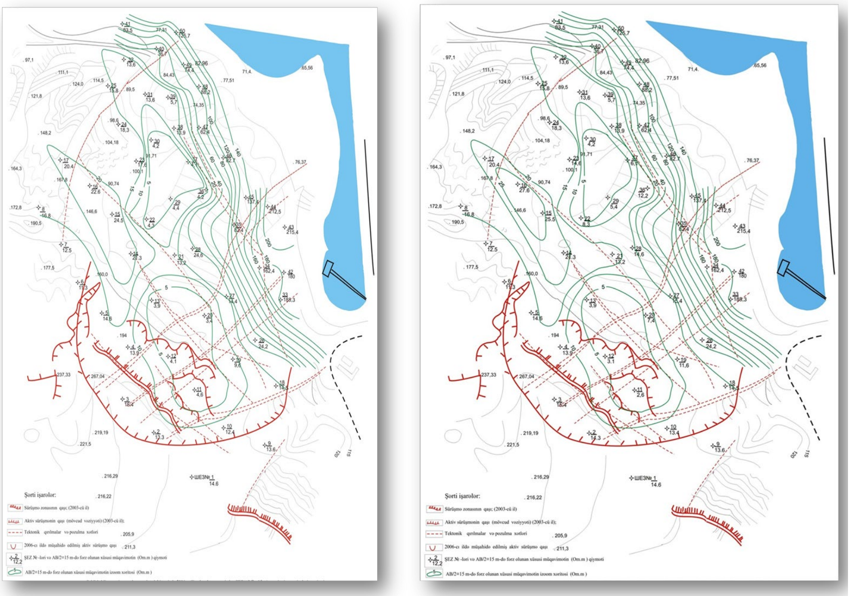

Figure. 1. Map of monitoring results of SEZ (AB / 2 = 15 m) in the dam part of Mingachevir reservoir for October and December 2006 (compiled by: R.F. Huseynov)

Based on the results of the monitoring network established for the landslide mass and surrounding areas, as well as for the established rappers, the map of isopotentials compiled in the Bozdag landslide area played a basic role in developing a methodology for predicting landslide processes. After the detection of active landslides and tectonic fault lines in the landslide zone by means of electric reconnaissance by profiles, monthly monitoring measurements were carried out and isopotential maps were compiled and analyzed. Only one active landslide occurred (30 October 2006) during the observation phase. As can be seen from the isopotential maps compiled for October and November, an intensive positive potential zone was formed in the eyebrow zone in the watershed of the landslide area in early October. The process progressed rapidly towards the end of the month and covered the entire landslide mass. According to the visual route inspections carried out at this stage, the landslide continued to increase in size and the new active landslide identified 200 m below it. It coincided with the time of the landslide when the positive positive isopatential area covered more than 50% of the landslide area. During the 10 days before the landslide, new intensive crack zones appeared in the direction of the landslide. It should be noted that an increase in seismic activity was observed in the Mingachevir seismically active zone during the landslide.

In 2019, Salamov A.M.Bozdag landslide area on the right bank of Mingachevir reservoir was studied by electric exploration methods. As a result of geophysical surveys, a previously unknown refractive error in the direction of NMG-CS was revealed. It is assumed that this violation is the main point of the main fracture area. The main angle of descent of the landslide plane is marked 8 °, and the landslide surface passes through various rocks that are inclined along the slope, passing through the contact of different layers of different lithological compositions. Therefore, according to the classification, landslides belong to mixed landslides[3].

The third chapter analyzes seismicity, macroseismic data, epicenters of earthquakes, seismotomographic studies in the Mingachevir watershed, and P wave velocities at different depths. The Mingachevir water basin and adjacent areas are characterized by seismic activity as other regions of Azerbaijan. According to the general seis-

[3] Саламов А.М., Габибов Ф.Г., Саламов Ф.А. Исследования оползневых процессов на правобережной части Мингечаурского водохранилища методами электроразведки Вестник Волгоградского государственного архитектурно-строительного университета. Серия: Строительство и архитектура. Вып. 3(76). 2019, с. 40-49

mic zoning map, the territory of Mingachevir belongs to the zone of 6-7 points, the recurrence of such earthquakes occurs on average once every 100 years. The analysis of the spatial-temporal distribution of earthquake epicenters and other features of the seismic process provides additional information about the structure of the fracture network and the main boundaries of the Earth's crust.

It is to carry out research to get a complete picture of the modern seismicity of the area as a whole. 40.60 ° to 41.10 ° N for the study area. and 46.50 ° -47.40 ° N. taken. The main topic is the study of seismicity, earthquakes and their macroseismic manifestations (Fig. 2).

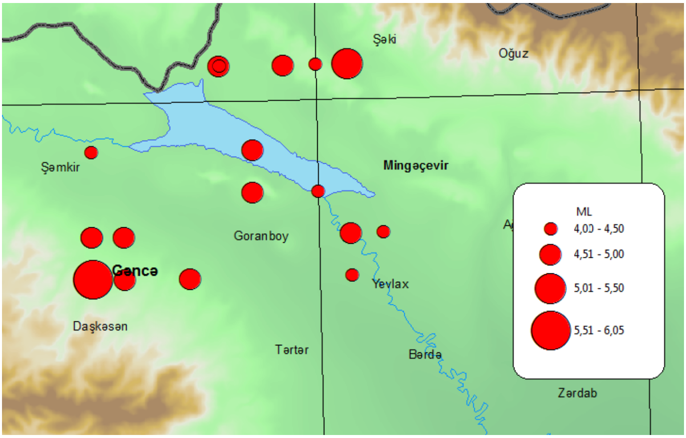

Figure. 2. Map of epicenters of earthquakes with magnitude 4.0 near Mingachevir water basin during 1900-2017

The territory of Mingachevir seismogeodynamic landfill completely covers the Mingachevir seismotectonic block. According to the general seismic zoning map of the country, the maximum intensity of earthquakes in this region is 8 points, and the maximum period of recurrence of earthquakes is 1000 years. Although no destructive and catastrophic earthquakes were recorded directly in this block during the historical period, a number of earthquakes with the intensity of I0 = 9-10 points occurred in the neighboring seismotectonic blocks. The average strength of earthquakes in the Mingachevir seismotectonic block is estimated at 6-7 points.

Considering the long-term seismicity of the Mingachevir zone, as well as adjacent areas, the study of the seismicity of the area can be divided into two stages:

The first stage covers the period from 1950 to 1950 before the construction of the Mingachevir water basin. The data available in these years are based on macroseismic data. A map of the epicenters of the earthquakes has been compiled. As can be seen from the picture, only 11 earthquakes occurred in the area (Fig. 3).

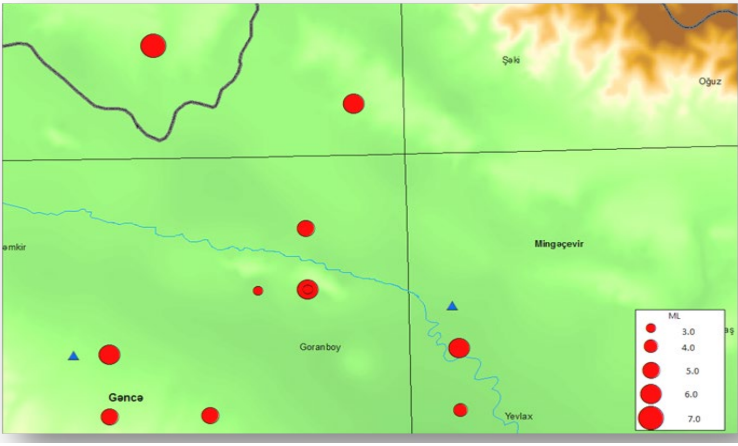

Figure. 3. Map of epicenters of Mingachevir region and adjacent territories for 1900-1954

The second stage covers the period after the construction of the Mingachevir water basin. Covers the period from 1954 to the present. In 1962, a seismological expedition led by K.Sh. Islamov worked here in Mingachevir, where it was discovered that there were local and weak earthquake foci, mainly in the sedimentary layer. During the operation of this expedition, 25 local tremors with S-P=1.0-1.5 were recorded at Mingachevir station.

The survey area is limited to 40.60°-41.20° latitude and 46.20°-47.40° longitude and covers the area of the Mingachevir reservoir and adjacent areas.

In recent years (since 2003), the study of the seismicity of the Mingachevir area requires the systematization and analysis of new seismic data obtained on the basis of highly sensitive stations. Improving the accuracy of seismic parameters, a more qualitative analysis of the distribution of seismicity in the area, allows to determine the relationship of earthquake epicenters with fault zones and to isolate active areas. Thus, the map of the epicenters of earthquakes that took place during 1954-2017 (Fig. 4) showed that 1290 ml=0.1-5.2 earthquakes occurred in that area.

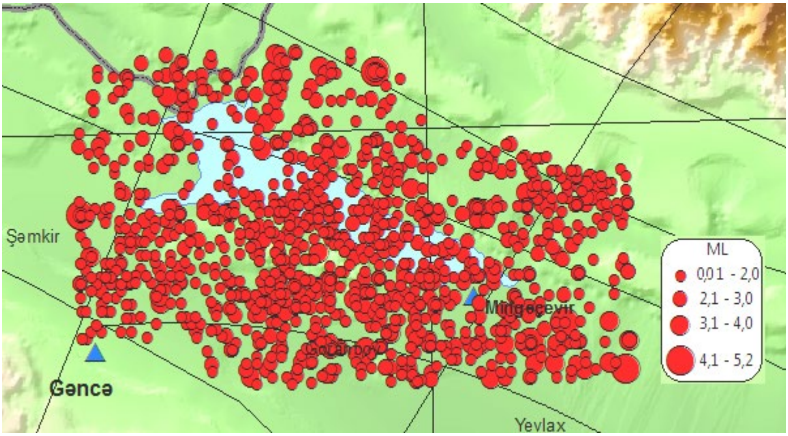

Figure. 4. Map of epicenters in the territory of Mingachevir for 1954-2017 (N = 1290)

Based on the analysis of macroseismic and instrumental data, it was determined that along with strong earthquakes, weak earthquakes occur in the territory of Mingachevir reservoir. Studies show that the number of weak earthquakes has increased in this area, which causes small cracks in the Mingachevir reservoir. This is not only a strong earthquake, but also can lead to the ecological danger of the Mingachevir reservoir.

Seismological profiles were constructed to study the depth distribution of earthquake epicenters. The figure shows the cross-section of the I-I profile, which coincides with the longitudinal depth fracture in the direction of NW-SE (Fig. 5). As can be seen, the mass of earthquake hypocenters (earthquake foci) is selected mainly in the middle part. In the seismogenic zone, the main foci are located at a depth of 10-40 km, at an epicenter distance of 20-120 km.

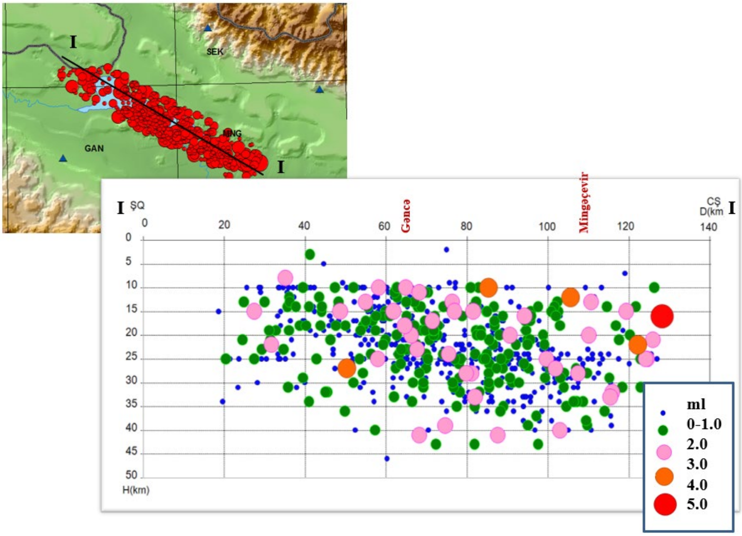

Figure. 5. Seismological section of I-I profile of Mingachevir water basin area (2003-2017)

The main part of the earthquakes is concentrated in the fracture zone intersecting in different directions, in the central part of the active Ganjachay-Alazan and Arpa-Samur transverse fractures of the profile. The consolidated layer is clearly visible. The surface of the foundation extends horizontally from north-west to south-east, and in the south-east there is a tendency for the surface of the foundation to gradually decrease to 15 km. Most of the depths of earthquakes vary between 10-35 km. It should be noted that relatively strong earthquakes are located in the central part at a depth of 10 to 40 km with ml = 3.0-4.0. The Mokho border has an arched shape, the depth of the central part is 35 km and the maximum load is 45 km. At the border of the earth's crust, especially in its upper layers, there are a large number of cracks and heterogeneity. The weak earthquakes recorded are due to the increase in these cracks.

Based on the analysis of the mechanisms of earthquakes that occurred in 2003-2017, the types of tectonic movements in the Mingachevir water basin zone were identified. Mainly break-up and breakdown movements were found. Analysis of the schematic map of the compression and tensile axes of these earthquakes showed that the tensile orientation axes are located in the direction of the main WSW-ENE and WNW-ESE, however, the compression orientation axes are found in the direction of SSW-NNE. Thus, the territory of Mingachevir water basin as a compression zone

It should be noted that the Middle Kura mega-zone is divided into the following structural zones from north to south.

1. The Chatma-Acinour zone is composed of oligocene-fourth nolas and formed in the valax fold phase, has a scaly-plus structure with anticlines and southward inclinations. In addition, the amplitude of displacements decreases from 25-20 km in the west to 10-6 km in the east.

2. The Jeyranchol zone is located to the west of the Middle Kura bend and is mainly Upper Pliocene-Quaternary, composed of Miocene sediments in some places.

In the general background of the bend, there are three activity bands in the arches, which are complicated by fracture-lift-overlap violations.

The fourth chapter analyzes the impact of the filling of the Mingachevir reservoir on seismicity and its interaction with changes in water level and seismicity in the reservoir over time.

The rise in water levels in the reservoir usually reaches its maximum intensity in 5 months - from March to July, as well as in May-June. In August, the water level begins to fall: first slowly, and then faster. Level fluctuations are insignificant in January-March. Rising water levels in spring and summer are caused by sediments in the reservoir, as well as by water from the Kura, Iori and Alazani rivers.

The decrease in the water level in the reservoir during the autumn-winter period is due to the average water level on the one hand, and the operating mode of the reservoir operating on the energy schedule on the other hand.

The peak of river water in the Mingachevir reservoir in spring is the result of the interaction of two factors - the melting of snow in the mountains and spring precipitation. The gradual increase of spring water begins in March. Thus, the average duration of floods is

2.5 to 3 months. The onset and end of the floods coincide in the three rivers. In addition, the artificial accumulation of water for irrigation affects the flow regime. The consumption of the measured pumps also varies depending on the change in water consumption. In order to determine the relationship between the filling of the reservoir and the increase in seismicity, the entire area of 605 km2 marked on the annual maps of the epicenters was studied in detail.

The change in the annual totals of earthquakes from 1980 to 2017 was considered and it was observed that the number of earthquakes has been increasing since 1981, when the reservoir was filled to the level of 79.5 m, and in 2010 the water level in the reservoir was 83, When it reaches 5 m, it reaches its maximum. Quarterly totals of earthquakes are well correlated with rising water levels. We considered the relationship between the change in water level in the reservoir over time and the magnitude of earthquakes (Fig. 6).

Between May 2008 and March 2009, an average of 31 earthquakes occurred, as shown in Figure 7. In October 2008, during the rising water level, there were 6 earthquakes with a magnitude of ml = 3.6-1.6. When the water level reached its maximum of 80.5 m, the water level began to gradually decrease to 78.2 m. During this time, there were 18 earthquakes with a maximum magnitude of ml = 3.8.

In 2010, the water level in the Mingachevir basin rose from 78-79 meters in March and 82-83 meters in May, and in May there were floods due to the increase in the amount of water released from the basin and the rising water level in the Kur River. The analysis of seismicity conducted during that period showed that in February, March, April and July, August and September, 21 earthquakes with a magnitude of 1.2-3.0 occurred in the Mingachevir water basin.

The water level began to rise in March 2011, gradually increasing to 82 m in June. Subsequently, a gradual decrease and an increase in seismic activity in the study area were observed. Between August 2011 and April 2012, there were 46 earthquakes.

It should be noted that weak seismicity has increased in this area in recent years (ml ≥ 0.5 in 2010-2013). Most of these earthquakes (75%) are concentrated in the southern part of the study area.

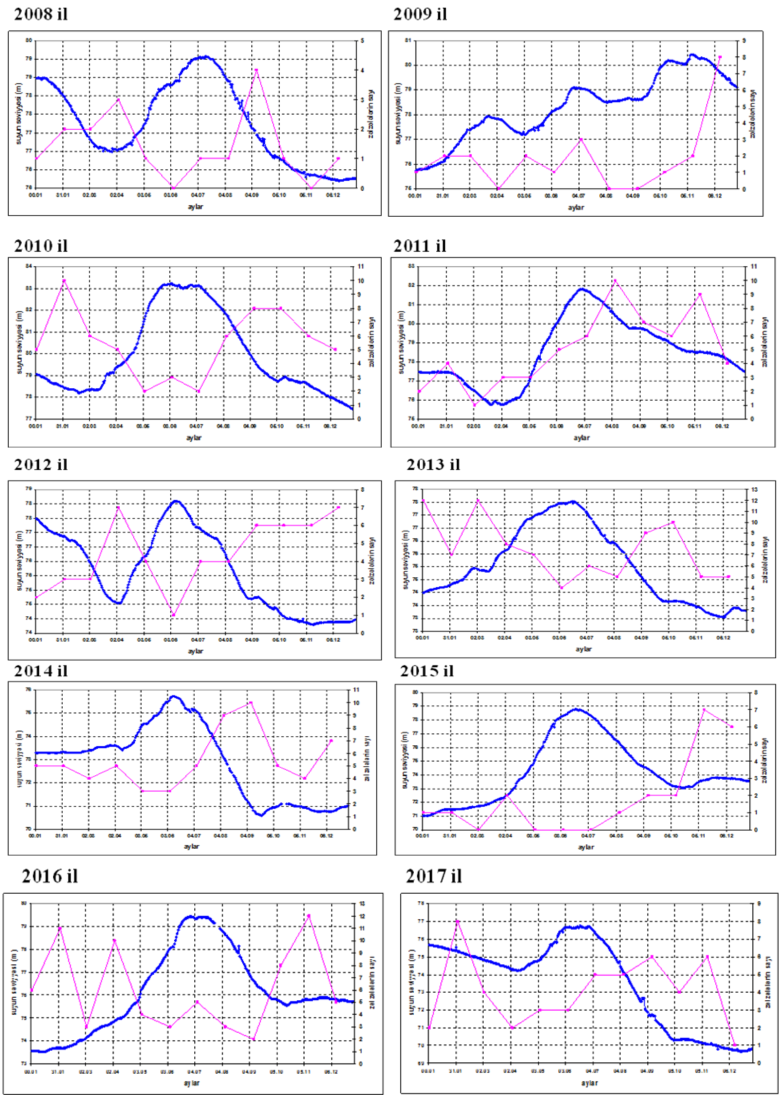

Figure. 6. Histogram of water level and number of earthquakes in the reservoir[4]

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[4] Исламова Ш.К., Влияние Мингячевирского водохранилища на сейсмическую активность района., Azərbaycan ərazisində seysmoproqnoz müşahidələr, Bakı, 2012. 207-212 s.

Figure 7 shows the time distribution of water level and number of earthquakes in the reservoir in 2014 (water level - 70.60-75.78 m). In 2014, 104 tremors were recorded in the territory of Mingachevir water basin.

Thus, the filling of the reservoir directly affects the occurrence of weak earthquakes in the Mingachevir reservoir area and adjacent areas. It was found that periodic changes occur every 5-6 years, and the maximum water level is observed from 2012 onwards and is maintained until 2017.

Thus, the filling of the reservoir directly affects the formation of weak earthquakes in the Mingachevir reservoir area and adjacent areas. The water level in the reservoir usually rises for 5 months - from March to July. In August, the water level begins to fall: first slowly, and then more rapidly (from 80-78 m to 74-73 m). In January-March, water level fluctuations are small. As a result of falling water levels in the water basin, an increase in artificial seismicity is observed in the area.

As a result of singular spectral analysis of the number of seismic events and water level change data by months and analysis of signals through functions (empirical mod decomposition - EMD), a method of determining the time-space parameters of directed seismicity related to changes in water level in reservoir areas was developed. developed. Statistical analysis of the time dynamics of instrumental seismicity in the Mingachevir reservoir filled in 1953 during 2010-2018 was carried out in the research work. Depending on the magnitude (MC = 1.6), only 269 events were selected in the Mingachevir reservoir at a maximum distance of 30 km from the center and at a depth of 54 km for 9 years. Therefore, in order to obtain information on the dynamics of seismic activity in the region, we used statistical methods every month to find the relationship between time dynamics and the effect of water level on the seismicity of the area in the Mingachevir reservoir. For this purpose, we applied the following methods: singular spectral analysis and division of signals into functions (empirical mode decomposition - EMD).

In cases where seismicity is not as intense as, for example, around the Mingachevir dam, the study of time series of monthly (or even annual) number of events can provide important information about seismic processes. In fact, a stricter time resolution (month or year) shortens time series, while a more precise time resolution (hour or day) lengthens them. However, in the second case, the time series will have a zero value more than the first; therefore, it is extremely important to consider both the temporary solution and the size of the time series. In our study, we analyzed the time series of the number of monthly earthquakes occurring in the Mingachevir area, at a depth of less than 55 km, with a magnitude greater than or equal to 1.6. Figure 7 shows a comparison of the average monthly water level and the monthly number of events. We can observe that the water level changes with an annual frequency that decreases during the first 5 periods.

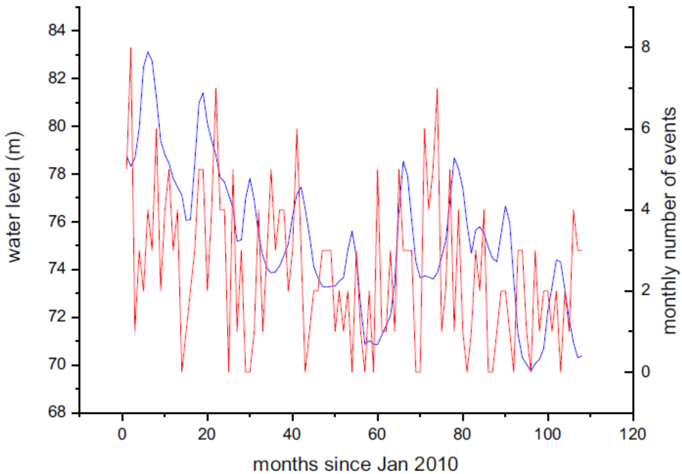

Figure. 7. Graph of change of water level and average values of earthquakes by months (time magnitude ≥ 1.6)

Thus, the slope of the water level increases slightly over the next two periods, the maximum level remains almost unchanged. Looking at the number of events on the moon, it seems that seismic activity increases after the water level reaches a maximum. This behavior is more pronounced in the early stages of the water level. However, such a correspondence between water levels and seismic activity peaks is less clear. Most likely, the tendency to increase the number of earthquakes every month corresponds to the tendency of the water level to decrease in the first 5 years and then increase. These results suggest that there may be a link between changes in water levels and seismic activity. In addition, since the water level is clearly modulated by the annual frequency, it is very important to see if the seismic activity is modulated at the same frequency; in this case, the water level can be considered as one of the factors causing seismic activity in the open reservoir.

For this purpose, we will apply three independent time series analysis methods to the number of monthly earthquakes: correlogram-based periodogram and two distribution methods, singular spectrum analysis (SSA) and empirical mode decomposition - EMD.

The SSA method is based on the conversion of a one-dimensional time series into a multidimensional one using a parametric transition procedure, followed by the application of the principal component analysis (PCA) method to a multidimensional time series. In this case, the obtained multidimensional trajectory is investigated using a series expansion and reconstruction (approximation) in terms of selected key components. The purpose of the method is to divide the time series into interpretable additive components. Theoretical results allow to give a meaningful interpretation of specific values, their values and factor vectors under certain conditions and to justify the selection of elementary matrices for each of them.

Figure 8 shows a correlogram-based periodogram of the number of monthly earthquakes and water levels. Although the water level shows a very clear peak representing the main frequency in 1 year, the number of monthly earthquakes does not show a clear peak.

Thus, in the presented research work, the regularities between instrumental seismicity ($0.5 \leq Ml \leq 3.5$) recorded in the Mingachevir area (Azerbaijan) from January 2010 to December 2018 and its changes in the water level in the reservoir were studied. It was determined that in recent years, most earthquakes with a local magnitude of $0.5 \leq Ml \leq 3.5$ in the Mingachevir area occur at a depth of 34 km within a radius of 30 km from the center of the reservoir at intervals of 1-3 months after the completion of filling the reservoir. confirms directed seismicity.

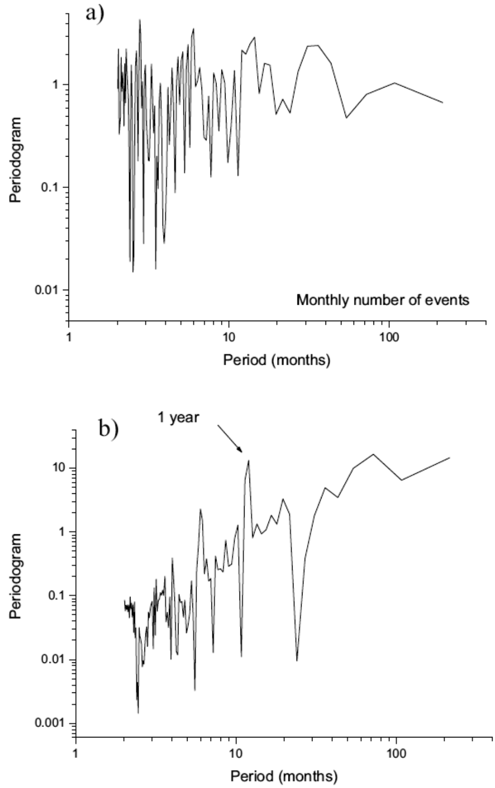

Figure. 8. Correlogram of the monthly periodogram of the number of earthquakes (a) and water level (b)

It is known that in 1985, 1987, 1989, 1996, 2000 and 2006 landslides occurred on the right bank of the Mingachevir reservoir - on the borders of the Bozdag range.

In order to study the effect of the hydrostatic effect on the activation of landslides within the boundaries of the study area, we used the energy released as a result of earthquakes and landslides in 1985, 1987, 1989, 1996, 2000 and 2006. A comparative analysis of the level change was performed (Fig. 9-10).

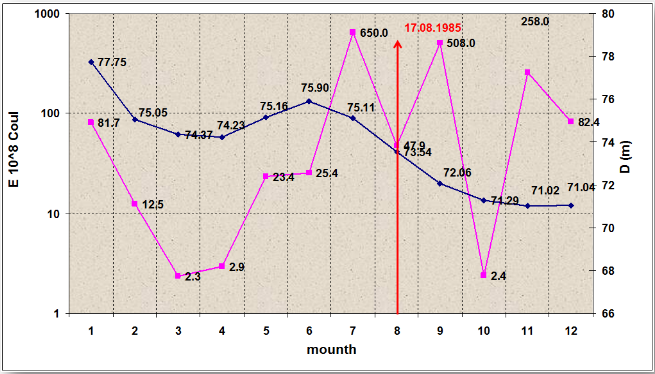

Figure. 9. Schedule of activation of landslide processes as a result of energy released during earthquakes caused by water changes in Mingachevir water basin during 1985

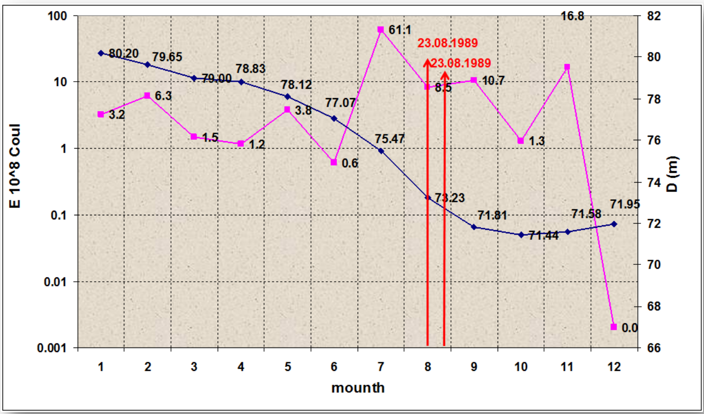

Figure. 10. Schedule of activation of landslide processes as a result of energy released during earthquakes caused by water changes in Mingachevir water basin during 1989

The following results were obtained on the basis of seismological, engineering-seismological, geophysical (gravimetric, magnetometric) and geodynamic (GPS and Tiltimeter) studies conducted in the landslide area around the Mingachevir water basin in 2014. The process of landslides in this area began in early July. Landslides in the area were recorded at the Mingachevir seismic station in the form of seismic vibrations different from earthquakes. Vibrations of different frequencies occur day and night in the landslide zone from traffic, construction works and other sources near the landslide site and subject the area to constant vibrations. The boundary of the landslide plane and the moving area of the gray mountain slope in the direction of SW-NE were determined in the zone. Gravimetric data show the presence of landslide geodynamic movement at a depth of 52 meters in the area of profiles I and II, where the study was conducted. Investigated to a depth of 50 m: 18-30 m depth of the sliding surface in profile 1; 12.5-22.5 m in profile 2; It can be said that it corresponds to 12-21 m in profile 3. Investigated to a depth of 100 m: in the central parts of the seismic profile No. 2a, mainly 6-11 m depth, 16-49 m on the north-western edge and, accordingly, 38-75 m depth on the southern edge, according to the landslide surface. it can be said; In seismic profile No. 4, 12-23 m from the top surface, as well as on the north-western side of the profile, depths of 50-88 m can be assumed as a sliding surface.

In the first days in the landslide zone, the horizontal movements were generally directed in the direction of the landslide, but then gradually shifted in the direction of the landslide. In the following period, the general tendency of landslide movement was in the direction of Shm-ShmSh. During the last 3 months, the displacements have been dancing in the direction of NE - SW. In general, actions in the direction of EMS prevailed. In recent years, the prices of horizontal displacement have gradually decreased. Vertical movements with amplitude of 1-2 mm were observed in the landslide area. At the foot of the hill, the south side collapsed. Although the surface bends as a result of vertical movements, it periodically returns to its equilibrium position. After about two and a half months in the landslide zone, the amplitudes of vertical movements weakened and in recent days decreased by 2-3 times. In general, the process is about to shut down.

RESULTS

1. Establishment of Mingachevir water basin in 1954 affects the formation of artificial earthquakes and changes in the seismic situation of the area.
2. Earthquakes in the Mingachevir water basin zone, as well as in the adjacent areas during 2003-2017, mainly occur in connection with the Kura, Geokchay, Ganjachay-Alazan and Arpa-Samur faults. The hypocenters of earthquakes are located at a depth of 10-30 km and occur mainly in the granite-basalt layers. Analysis of the distribution of seismic energy and the number of earthquakes released in the last 14 years shows that since 2009 there has been an increase in activity every year.
3. Based on the analysis of the mechanisms of earthquakes that occurred in 2003-2017, break-up and fall-type movements were identified.
4. Analysis of the schematic map of the compression and tensile axes of these earthquakes showed that the tensile orientation axes are in the direction of the main WSW-NE and WNW-ENE, however, the compression orientation axes are found in the direction of SSW-NNE. The territory of Mingachevir water basin is characterized as a compression zone.
5. The values of the Pearson correlation coefficient, which shows the relationship between the number of earthquakes and the average annual water level, vary between 0.4-0.5. The maximum values of the coefficient (0.73-0.82) are observed in 1985, 1996, 2006 and 2010.
6. Filling of the reservoir directly affects the formation of weak earthquakes in the Mingachevir reservoir area and adjacent areas. The water level in the reservoir usually rises for 5 months - from March to July. In August, the water level begins to fall: first slowly, and then more rapidly (from 80-78 m to 74-73 m). In January-March, water level fluctuations are small. As a result of falling water levels in the water basin, an increase in artificial seismicity is observed in the area.
7. From January 2010 to December 2018, the regularities between instrumental recorded seismicity ($0.5 \leq Ml \leq 3.5$) in the Mingachevir

area (Azerbaijan) and changes in the water level in the reservoir were studied. It was determined that in recent years, most earthquakes with a local magnitude of $0.5 \leq Ml \leq 3.5$ in the Mingachevir area occur at a depth of 34 km within a radius of 30 km from the center of the reservoir at intervals of 1-3 months after the completion of filling the reservoir. confirms directed seismicity.

8. In 2010, the water level in the Mingachevir water basin rose from 78-79 meters in March and 82-83 meters in May, and in May there were floods due to the increase in the amount of water released from the basin and the rising water level in the Kur River. The analysis of seismicity conducted during that period showed that in February, March, April and July, August and September, 21 earthquakes with a magnitude of 1.2-3.0 occurred in the Mingachevir water basin.
9. On the basis of seismological and geodynamic surveys carried out in the landslide area that occurred between 03.07-10.12.2014 around the Mingachevir water basin, the moving area of the Gray mountain slope in the direction of WS-NE was determined. 19 weak earthquakes (ml = 0.6-2.5) and a total of 80 landslides were recorded around the water basin. The depth of the landslide surface varies between 18-50 m.

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Plaintiff's personal work

[2, 3, 7, 9, 12] works were performed independently, [1, 4, 5, 6, 8, 10, 11, 13, 14] in the works the plaintiff participated in problem setting, calculations, interpretation of results.

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