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SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN

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SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN

SEISMICITY OF THE TERRITORY OF AZERBAIJAN IN 2019

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Introduction

Spatial and temporal communication patterns of seismically active zones contain important information about the seismic process and it is necessary to use it to study this process. The study of seismicity during instrumental observations plays an important role in the statistical search for earthquake warnings as part of the problem of medium and long-term earthquake forecasting [23]. As is known, the study of seismic processes in the source shows the diversity of seismotectonic movements in a homogeneous geotectonic structure. In the seismic source of the Earth, different types of seismic movements are recorded in this or that region, which can be considered as seismotectonic movements.

The territory of Azerbaijan is part of the seismically active zone of the Alpine-Himalayan fold. There have been many strong earthquakes with magnitude of ml≥5.

Analysis of the seismic studies results of the southern slope of the Azerbaijani part of the Greater Caucasus in recent years shows that there is a tendency for seismogenic zones to spread along the borders of all-Caucasian structures.

Recently, the Kura basin and the seismicity of the Greater Caucasus have been associated with the movement of transverse faults.

Seismic analysis shows that the hypocenters of earthquakes are often located in the upper part of the Earth's crust, which indicates the stress deformation in the sedimentary layer of the Earth's crust [12, 24].

The purpose of the article is to study the seismic regime, the regularity of the distribution of earthquake epicenters, the dynamics of seismic processes in the source zones in the territory of Azerbaijan Republic on the basis of earthquakes in 2019 also to identify active parts of depth faults and seismically active areas. [1-9].

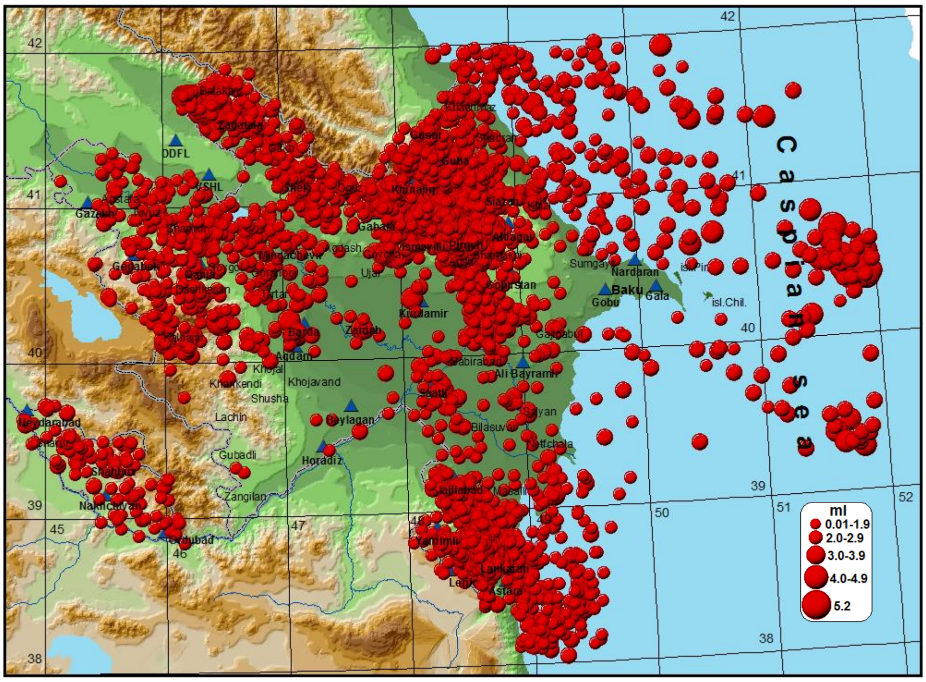

Figure 1. The map of earthquakes epicenters of Azerbaijan in 2019.

Seismicity of the territory of Azerbaijan

In 2019, seismic analysis of the territory of Azerbaijan have been conducted on the basis of 40 digital data. During the year, 13,818 earthquakes were recorded by RSSC. Of these, 5442 are local (Azerbaijani territory), 1825 regional and 2188 remote earthquakes. At the same time, 2948 weak shocks (recorded by a single station), 1405 explosions, 7 landslides and 3 volcanoes were recorded.

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The map of the earthquakes epicenters in Azerbaijani territory has been created (Figure 1). As can be seen from this map, the vast majority of tangible earthquake sources are located at the junction zone of the Kura Plain and the southern slope of the Greater Caucasus.

In 2019, 81 earthquakes with a magnitude of ml≥3.0 were recorded in the territory of Azerbaijan and 25 of them are tangible earthquakes. The epicenters map of these earthquakes with a magnitude of ml ≥3.0 have been created (Figure 2).

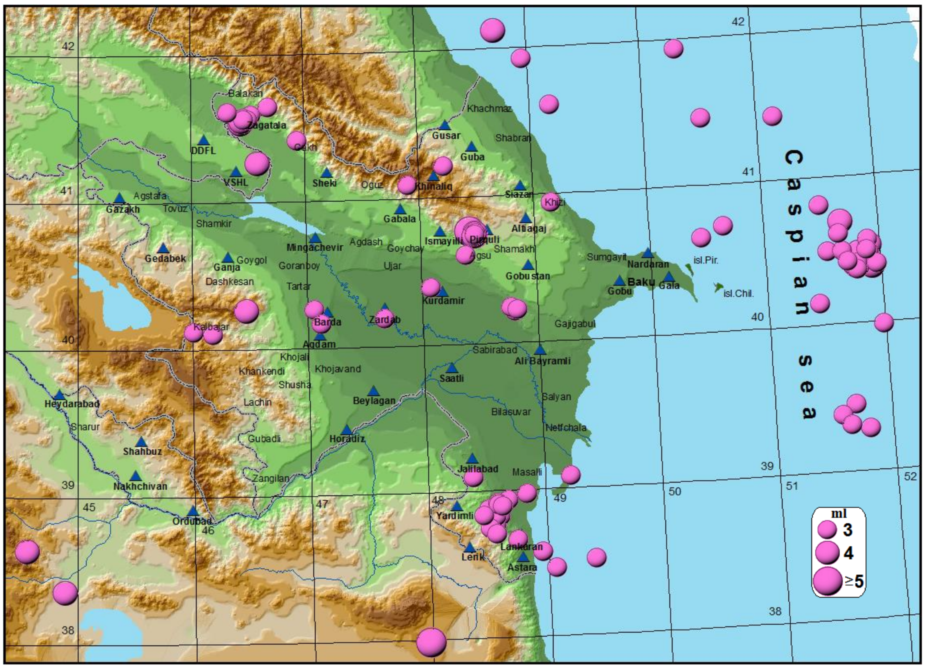

Figure 2. The map of earthquakes epicenters with magnitude of ml≥3.0 in the territory of Azerbaijan during 2019.

Compared to 2018, the number of earthquakes in 2019 has increased and the amount of released seismic energy has decreased. Thus, the number of earthquakes was 4081 in the territory of Azerbaijan in 2018, the amount of released seismic energy $\sum E = 42.7 \cdot 1011C$, the maximum magnitude 5.5, the number of earthquakes was 5442 in 2019, the amount of released seismic energy $\sum E = 31.9 \cdot 1011C$, the maximum magnitude 5.2.

Analysis of the number of earthquakes and released seismic energy over the last 9 years (Figure 3) shows that the amount of released seismic energy since 2010 has been gradually increasing. In 2012, the amount of released seismic energy reached a maximum level. This is due to the occurrence of strong earthquakes (ml = 4.0 ÷ 5.7) in the territory of republic. It should be noted that after the strong earthquakes in 2012,the relative calm was observed in 2013. During 2014-2016 years, a series of strong earthquakes have been occurred:, Zagatala earthquake with magnitude of ml=5.6 and 5.7 in 07.05.2012; Balakan earthquake with magnitude of ml=5.6,14.10.2012 (felt J_0=7 point in the source), Ismayilli earthquake with magnitude of ml=5.3, 07.10.2012, Caspian earthquake with magnitude of ml=5.0, 10.01.2014, Hajigabul earthquake with magnitude of ml=5.7,10.02.2014, Zagatala earthquake with magnitude of ml=5.3, 29.06.2014, earthquakes in Caspian Sea with magnitude of ml=5.6, 07.06.2014, a series of earthquakes in Gabala on 29.09 and 04.10.2014 with magnitude of ml_{max} = 5.5; Oghuz earthquake with magnitude of ml=5.9, 04.09.2015 and Imishli earthquake with magnitude of ml=5.6, 01.08.2016. Earthquakes have been felt at the epicenter with an intensity of 6-7 points [11, 15, 24].

In 2012, compared to 2011, the amount of released seismic energy have been increased 25 times. It is determined that the amount of released seismic energy in 2013 decreased by about 28 times compared to 2012. The increase in the number of earthquakes since 2010 is most likely due to the operation of new stations in 2009-2013. The number of earthquakes in 2014 increased compared to 2013 and the amount of released seismic energy was 25 times higher. The number of earthquakes in 2015 was higher than in 2014, and the amount of released seismic energy was relatively small. In 2016, compared to 2015, released seismic energy decreased by 3 times. The number of earthquakes in 2017 was higher than in 2016, and the released seismic energy was about twice as high [1-9]. The number of earthquakes in 2018 is small, and the amount of released seismic energy is twice less than in 2017. In 2019, a decrease in released seismic energy with a high number of earthquakes was recorded.

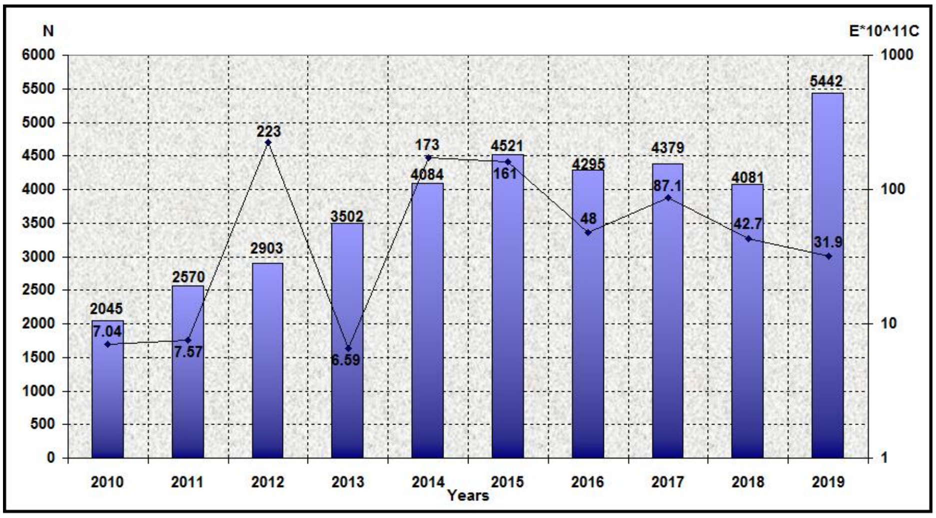

Figure 3. The histogram of the number of earthquakes and the distribution of released seismic energy in the territory of Azerbaijan in 2010-2019.

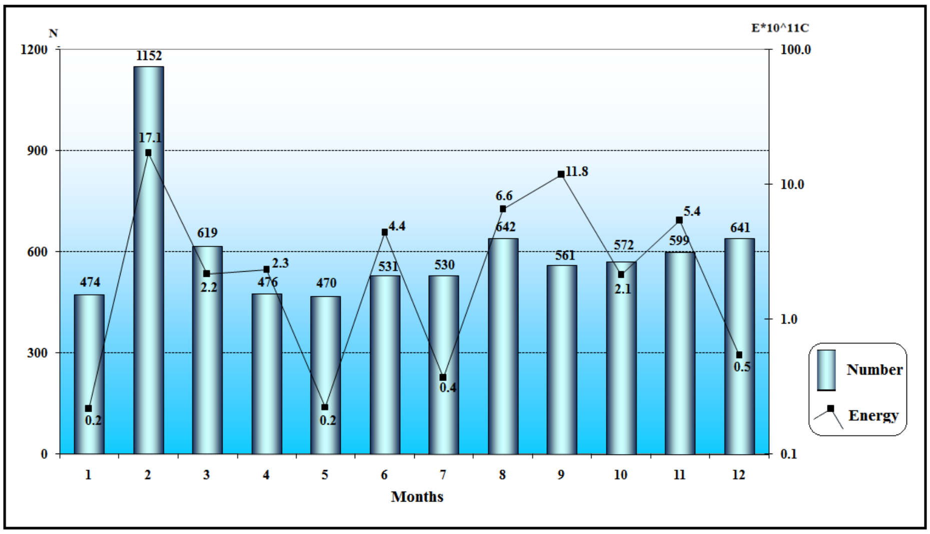

Figure 4. The histogram of the number of earthquakes in Azerbaijan and adjacent areas in 2019 and the distribution of seismic energy by months.

The histogram of the number of earthquakes in Azerbaijan and adjacent areas and the monthly distribution of released seismic energy is shown below (Figure 4).

Analysis of the number of earthquakes in Azerbaijan and adjacent areas and the distribution of released seismic energy by months shows that the released seismic energy was higher in February, August, September and November. This is due to earthquakes of magnitude 5.2 in the country. The number of earthquakes in February was higher than in other months. This is due to the aftershocks of the earthquake, which occurred in ml = 5.2.

During 2019, in the territory of Azerbaijan in 1952 with a depth of ≤10 km, 2664 with a depth of 10 <h≤20 km, 1329 with a depth of 20 <h≤30 km, 724 with a depth of 30 <h≤40 km, 383 with a depth of 40 <h≤50 km , h> 507 earthquakes with a distance of 50 km were recorded. The analysis of the distribution of earthquakes by depth shows that 40% of them occurred at a depth of 10-20 km.

Zagatala-Balakan seismically active zone

Zagatala seismically active zone is located in the north-western part of the Azerbaijani part of the Greater Caucasus. Its eastern border can be considered as a conventional ascent to Zagatala-Shamkhor. North, west and south-south Dagestan and western Georgia are surrounded by potentially strong seismic zones. The area of the Zagatala seismically active zone covers an area of 3,500 km^2 in Azerbaijan.

The structural elements of the geological structure of the Zagatala zone are associated with the central Tfan anticlinorium of Zagatala-Kovdagh synclinorium and Vandam anticlinorium of Alazan-Ayrichay faults. From the north, west and south-south, Dagestan and western Georgia are surrounded bypotentially strong seismically active zones.The area of the Zagatala seismically active zone covers an area of 3,500 km^2 in Azerbaijan territory.

The structural elements of the geological structure of the Zagatala zone are associated with the central Tfan anticlinorium of Zagatala-Kovdagh synclinorium and Vendam anticlinorium of Alazan-Ayrichay faults. Because the Alazan-Ayrichay faults expand to the north direction of the area, these faults cover the Vendam anticlinorium [10].The first information about the earthquake in this area dates back to 1250 year. From 1894 to 1982 years, 19 earthquakes with a magnitude of ml> 4.7 occurred in the Zagatala-Balakan zone. Over the past 15 years, several strong earthquakes (> 5.0 ml) have been recorded in this area and 2019 year is no exception.

During 2019, seismicity in Zagatala was higher than the background level. From the tectonic point of view, the Zagatala-Balakan seismically active zone is located in the north-western zone of the Azerbaijani part of the Greater Caucasus. In 2019, the territory of Zagatala was more active than in 2018. The earthquake with the highest magnitude in Zagatala was ml = 4.9. This earthquake occurred on 10August at 11:35 local time in Zagatala district, 18 km south-west of Zagatala station. The intensity of earthquake at the epicenter was6 points and was 5-3 points in the surrounding areas.

A map of the earthquake epicenters occurred in Balakan-Zagatala, Sheki and Gabala districts (fig. 5) have been created. As can be seen from the map, earthquakes are located in the intersection zones of the depth faults with different directions.

In contrast to 2018, in 2019 year there is an increase in earthquakes with a magnitude of ml≥3.0.An earthquake with a magnitude of ml = 4.9 occurred within a sedimentary layer at a depth of 5 km.The hypocenters of earthquakes in Balakan-Zagatala, Sheki and Gabala districs are located at a depth of 2-20 km.Earthquakes with a magnitude of ml≤3.0 occurred within a sedimentary layer at a depth of 7-11 km.An earthquake with magnitude of ml=3.3 in the Gakh district was recorded at a depth of 36 km.The earthquake sources were located in the zone of impact of Vendam and Sharur-Zagatala depth faults.

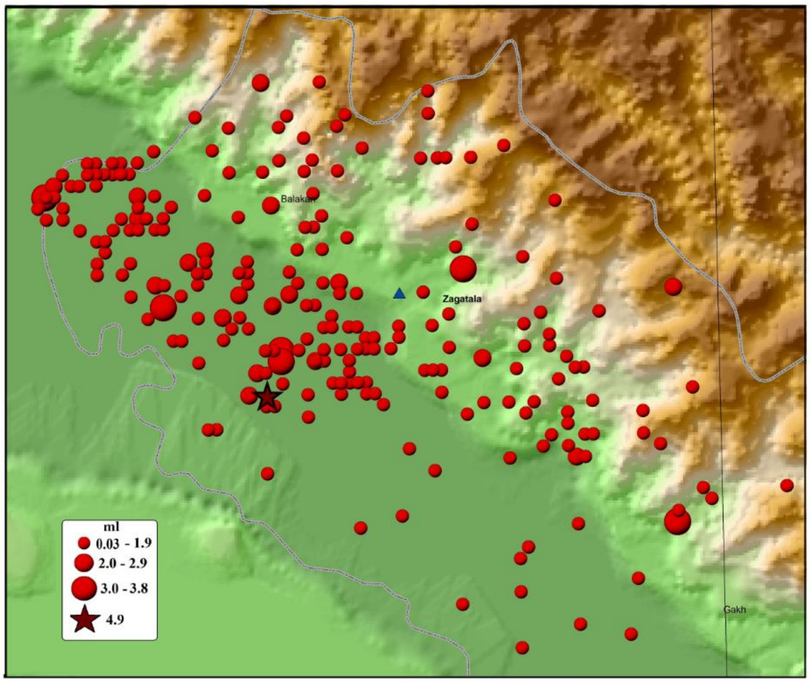

Figure 5. Map of the earthquake epicenters occurred in Balakan-Zagatala, Sheki, Gabala districts.

As can be seen from the analysis of the monthly distribution of released seismic energy and the number of earthquakes occurred in the Zagatala zone in 2019 year, the seismicity at the beginning of the year is below the background level.

The increase in the number of earthquakes began in July and lasted until September. In August, a sharp increase in released seismic energy is observed. The high released seismic energy is due to the occurrence of an earthquake with a magnitude of ml = 4.9.Since October, there has been a decrease in the number of earthquakes and the amount of released seismic energy. Also the seismicity dropped below the background level.

Shamakhi-Ismayilli seismically active zone

The Shamakhi-Ismayilli seismogenic zone is located in the south-eastern part of the Greater Caucasus and is characterized by a complex stepped-block structure. [16]

The Shamakhi-Ismayilli seismogenic zone is known as the zone of the strongest earthquakes in the Caucasus of Azerbaijan and is characterized by high seismic activity.

The strongest earthquake in the last 15 years occurred on October 7, 2012, 17 km south-east of the Ismayilli seismic station ($15^{h} 42^{m}$) local time [13, 22]. The magnitude of the earthquake was estimated at ml = 5.3, and the intensity at the epicenter was estimated at 6 points. The magnitude of the earthquake was ml = 5.3 and the intensity at the epicenter was estimated at 6 points.

It should be noted that, the strongest event was recorded in territory of Ismayilli district during 2019 year. This strongest earthquake with a magnitude of ml = 5.2 in this zone occurred on February 5, at 23:31, 11 km west of Pirgulu station. The intensity of the earthquake was 6 points at the epicenter and was 5-3 points in the surrounding areas.

In order to study the spatial distribution of seismicity, a map of the epicenters of earthquakes that occurred in February in the Shamakhi-Ismayilli zone has been created.

In the north-east of the country, migration of earthquake epicenters in the meridional direction (Pirgulu-Mugan) is observed.In order to study the geodynamic conditions of the Shamakhi-Ismayilli zone in 2019, a seismological section with the north-west, south-east direction (Fig. 7.) has been created on the I-I profile.

The intersection extends along the impact zone of Tairdjalchay-Salyan orthogonalis faults in the area where the epicenters of the Shamakhi-Ismayilli zone are more densely located[16].

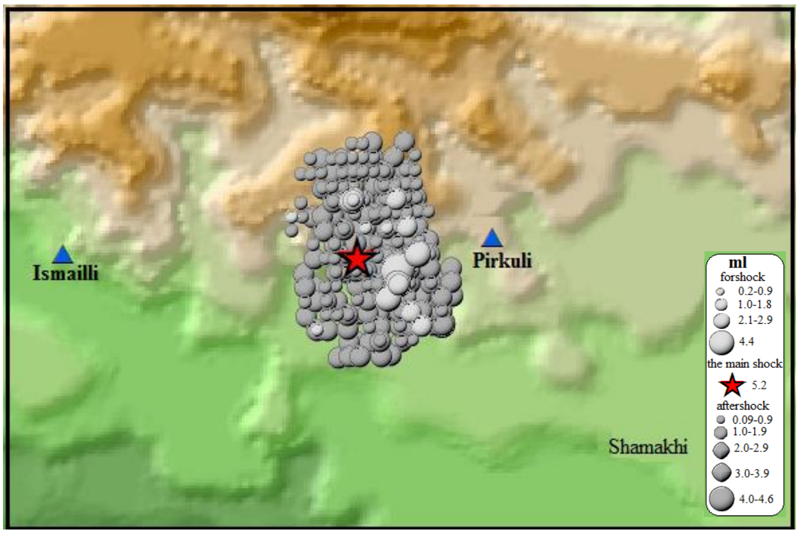

Figure 6. Map of epicenters of foreshock and aftershocks of Ismayilli earthquake with magnitude of ml = 5.2.

As can be seen from the intersection, weak seismicity is observed in the north-west direction.In the background of weak seismicity, an intangible earthquake with a magnitude of ml = 3.3 has been recorded in the territory of Guba district.The increase in the number of earthquakes in the Ismayilli-Aghsu area is recorded. Shocks mainly with magnitude of ml≤1.0 have been occurred .The source of the strong earthquake with a magnitude of ml = 5.2 occurred on February 5, is particularly noteworthy.Note that, the forshock with a magnitude of ml = 4.4 was recorded before the strong earthquake. The earthquake occurred 8 km south-west of Pirgulu station in Aghsu and it was felt by about 5 (five) point at the epicenterand 4-3 (four-three) points in the surrounding areas.An increase in the earthquakes with a magnitude of ml ≥3.0 have been recorded in this zone. They were mainly distributed at a depth of 2-25 km. In the north of the Shamakhi-Ismayilli active zone, hypocenters with a depth of up to 10 km are located within the sedimentary layer. The main shock was distributed at a depth of 8 km and earthquakes with a magnitude of ml≥ 3.0 were at a depth of 9-13 km. The earthquakes occurred between the Dashgil-Mudrasa and Vendam depth faults.

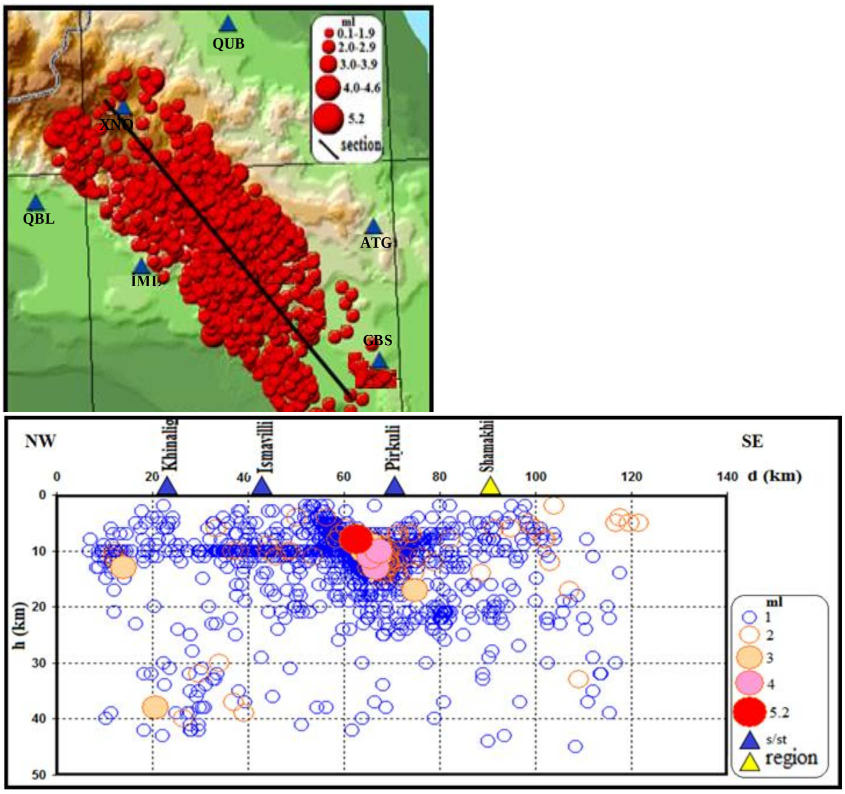

Figure 7. Seismological section of Shamakhi-Ismayilli seismogenic zone on the II-II profile.

After the strong earthquake on February 5, 2019, the aftershock process became quite active, 104 aftershocks were recorded during the first day after the main shocks (Fig. 8.). There were 19 forshocks and 413 aftershocks before the earthquake. 6 forshocks and 367 aftershocks were recorded by Pirgulu station.

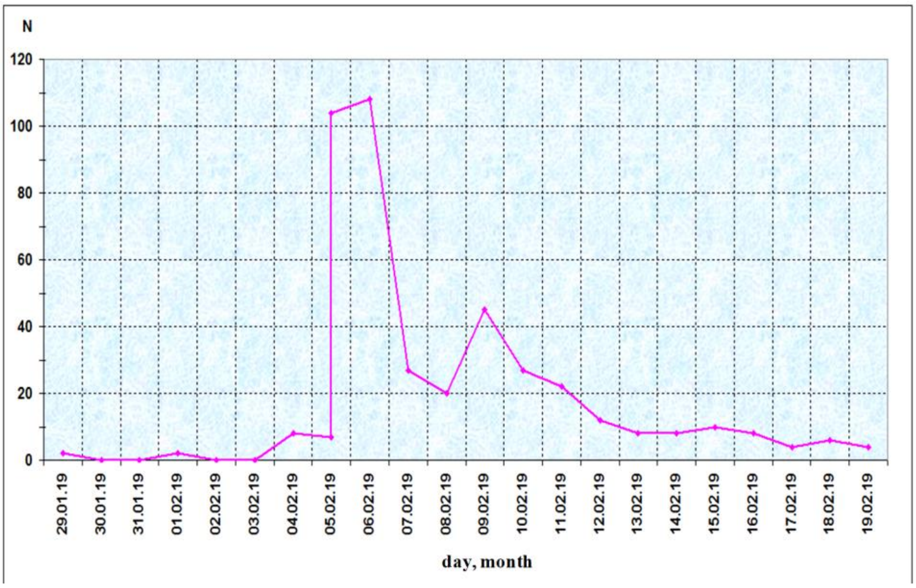

Figure 8. Histogram of the distribution of foreshocks and aftershocks by the earthquake of February 5, 2019.

Statistics of the aftershocks in the source zone shows that the number of shocks has decreased since February 19.In 2019, seismicity in the Shamakhi-Ismayilli zone was below the background level at the beginning of the year. The number of earthquakes and released seismic energy since February has been high. This is due to the strong shock and its aftershocks. In other months, the number of earthquakes and released seismic energy is lower than in February.

Talish seismically active zone

The Talish mountain system, as in previous years, is characterized by high seismic activity. In 2019, compared to 2018 year, seismicity in the Talish zone was at the background level. The magnitude of earthquake with the highest magnitude in this zone was ml = 3.7. The earthquake was recorded on February 5 at 17:24 in local time in Lerik region, 24 km east of Yardimli station. The intensity of the earthquake was about 4points in the epicenter and up to 3 points in the surrounding settlement.

In order to study the distribution of earthquake source on depth in the Talish zone,the seismic section has been created on profile IV-IV passing in the direction of North-South.The profile is in the meridional direction (Fig. 9).

As can be seen from the section, the main sources are in the seismogenic zone at a depth of 10-40 km.The reflected border is clearly visible at a depth of 10 km.As can be seen from the section, earthquakes with a magnitude of ml≥3.0 were distributed at a depth of 11-35 km. The main part of the earthquakes is concentrated in the fault zone intersecting in different directions, in the central part of the active Astara-Derbent orthogonal and longitudinal Talish and Front Talish faults of the profile.

Analysis of the number of earthquakes in the Talish zone during the year and the distribution of the released seismic energy by months shows that the number of earthquakes is high every month. Thus, more than 100 shocks have been recorded every month.

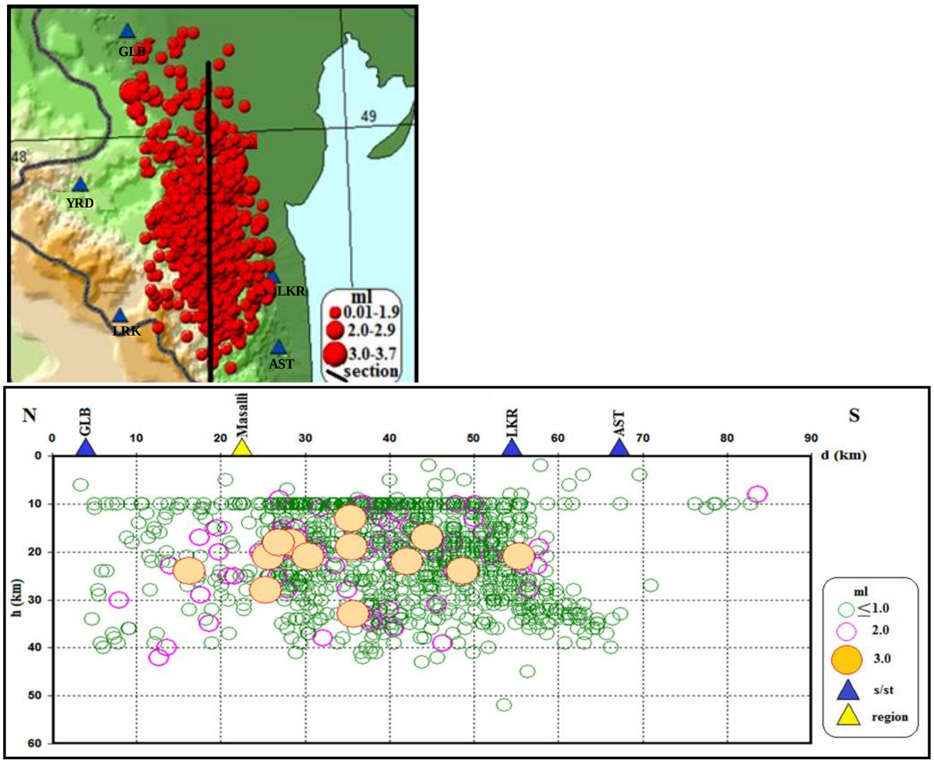

Figure 9. Seismological section of Talish mountain zone on IV-IV profile.

Caspian Sea water area

In 2019, compared to previous years, the seismicity of the Caspian Sea was higher than the background level.Analysis of the number of earthquakes and the amount of released seismic energy over the last 9 years (Fig. 11) shows that the amount of released seismic energy in 2010-2013 is stable.The number of earthquakes in 2014 was higher than in 2013, and the amount of released seismic energy was 23 times higher.This is due to strong earthquakes with magnitude of ml ≥5 occurred in the Caspian Sea.The number of earthquakes in 2015 was higher than in 2014, and the released seismic energy in 2015 decreased by 2 times compared to 2014.The number of earthquakes in 2016 was higher than in 2015, and the released seismic energy was 7 times less. While stability was observed in the released seismic energy from 2016 to 2018 years, in 2019 the released seismic energy was twice more.

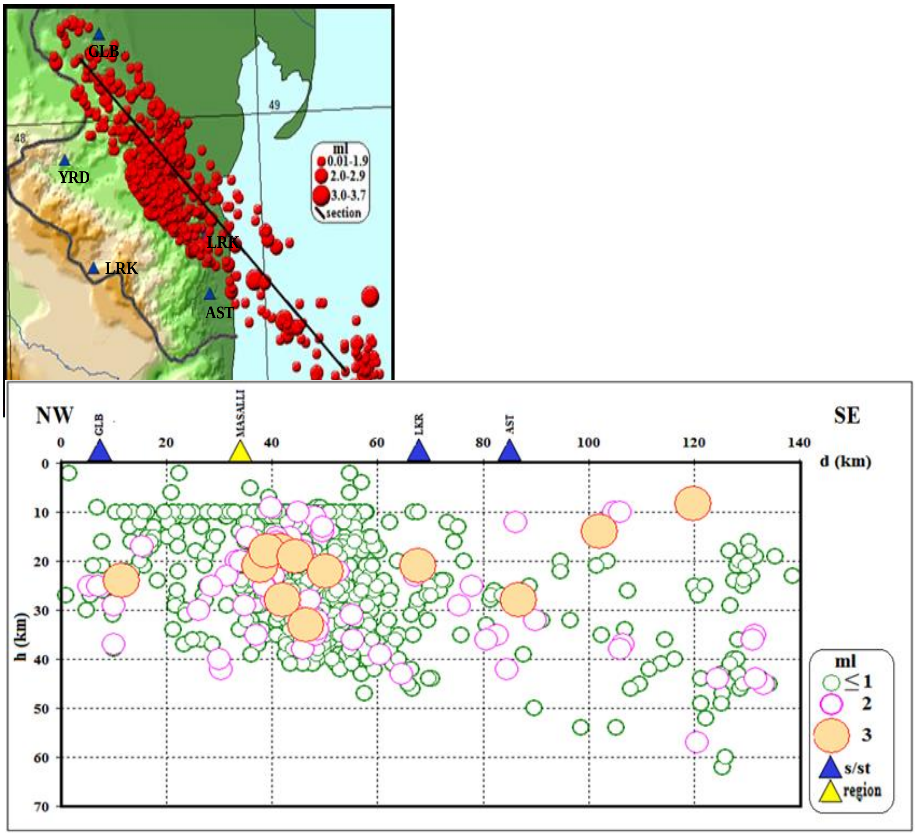

Figure 10. Seismological section of Talish mountain zone on V-V profile.

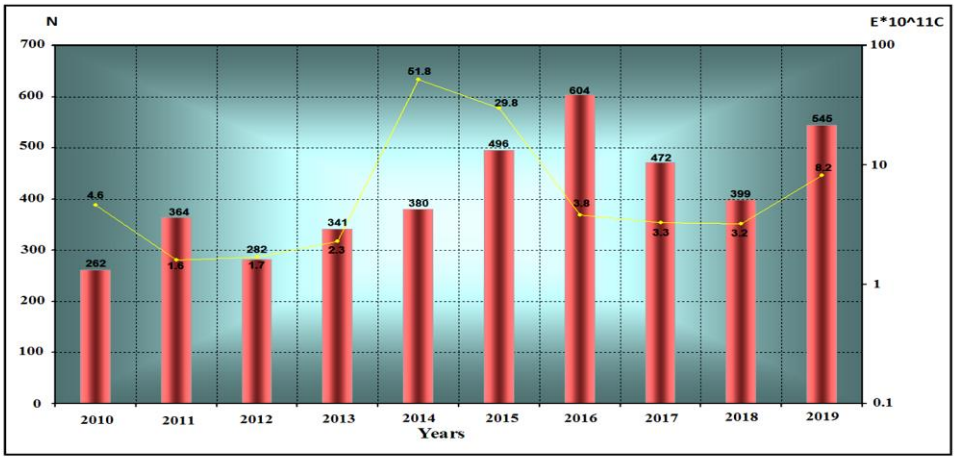

Figure 11. Histogram of the number of earthquakes in the Caspian Sea and the released seismic energy by years during 2010-2019.

The analysis of the number of earthquakes occurred in the Caspian Sea in 2019 and the distribution of released seismic energy by months shows that the number of earthquakes in March, August and October was higher than in other months. The high released seismic energy in June and October is due to earthquakes with magnitude of ml≤4.8.

In 2019, 36 earthquakes with a magnitude of ml ≥3.0 occurred in the Caspian Sea. The highest magnitude earthquake recorded in the Caspian Sea was ml = 4.8, h = 68 km. The earthquake was not felt.

A series of weak shocks occurred in the northern coastal area of the Caspian Sea at a latitude of 41 degrees and was observed in the Makhachkala-Turkmenbashi depth fault zone.

In order to study the depth distribution of earthquakes in the northern part of the Caspian Sea, a seismic transect on profile VI-VI in the north-west, south-east direction has been compiled (Fig. 12).Earthquakes with a magnitude of ml≤2.0 occurred in the north-western part of the section. Throughout the transect, the hypocenters are at a depth of 2-62 km.The earthquake with the highest magnitude recorded in the North Caspian Sea was ml = 4.7. The earthquake was felt up to 3 points near the coast. It occurred at a depth of 62 km. If we look at the central part of the Caspian Sea, there is an increase in earthquakes with a magnitude of ml=3.0 ml. Earthquakes with a magnitude of ml ≤4.8 were at a depth of 28-62 km.Superficial sources are also observed in the Caspian Sea.

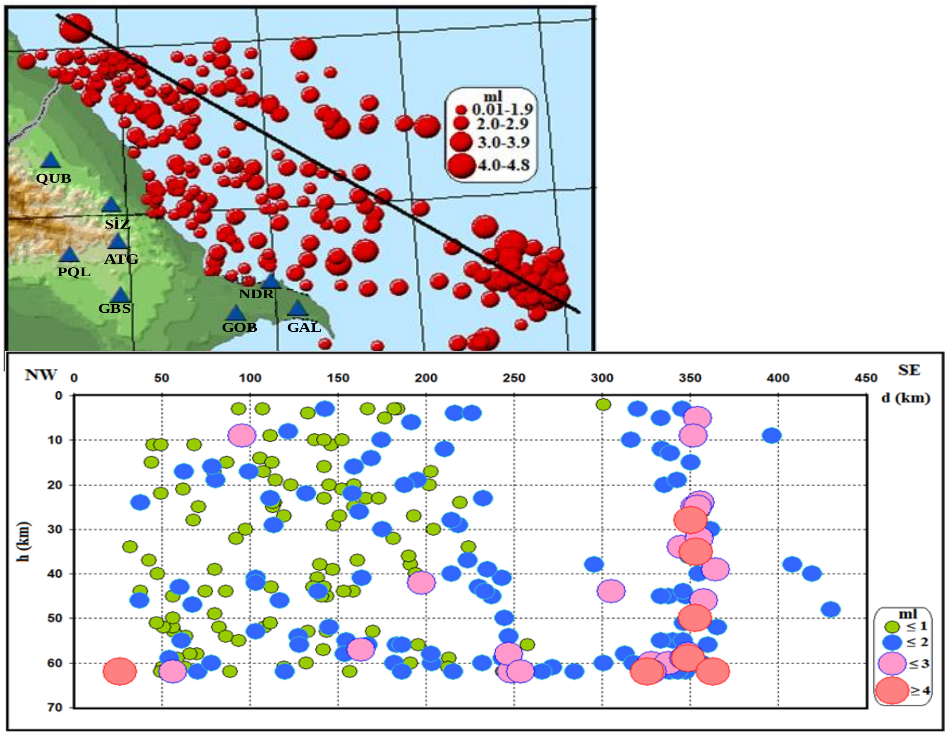

Figure 12. Seismological section of the northern part of the Caspian Sea on VI-VI profile.

In order to study the depth distribution of earthquakes in the Central Caspian basin, a seismological section on profile VI-VI (Fig. 13) was created. The profile passes in a north-south direction. As can be seen from the section, earthquakes with a magnitude of ml≥2.0 occur in the Central Caspian Sea. Most of the earthquakes were at a depth of 28-62 km. An earthquake with a magnitude of ml = 4.8 was recorded at a depth of 62 km.

Seismic activity of Azerbaijan and adjacent territories in 2019

The analysis of the seismic activity of the researh area was selected from the catalog of earthquakes that occurred in 2019 and it was carried out on the basis of recorded earthquakes.

In 2019, activity was high on the south-eastern slope of the Greater Caucasus - Zagatala-Balakan (A_{10} = 1.6-2.0), Shamakhi-Ismayilli (A_{10} = 1.6-2.0), Talish (A_{10} = 1.6-2.0).Seismic activity was weak in the south-northern part of the Lesser Caucasus (A_{10} = 0.6-1.0). At the same time, the seismic activity is (A_{10} = 0.6-1.0) in the north of the Caspian Sea (A_{10} = 0.9-1.6) , in the center of Caspian Sea, (A_{10} = 1.0-1.7) in the southern part of the active areas, (A_{10} = 0.6-1.8) in the zone of Iran (Tabriz) (Figure 14).

Study of earthquake source

In order to study the stress and deformation areas of the Earth's crust, the mechanisms of earthquake sources, the dynamic parameters of earthquake sources, the conditions of their formation and the analysis of stress areas of the Earth's crust have been carried out.Thus, the source mechanism of 60 earthquakes (ml≥3.0) have been analyzed in 2019 (Figure 15).The solution of the source mechanisms of earthquakes has been carried out in two ways: 1) by the method of inversion of waveforms (ml> 5.0) (Time-Domain Moment Tensor INVerseCode (TDMT INVC)) [19, 20, 21]; 2) based on the initial arrival times of the waves (ml> 3.0).

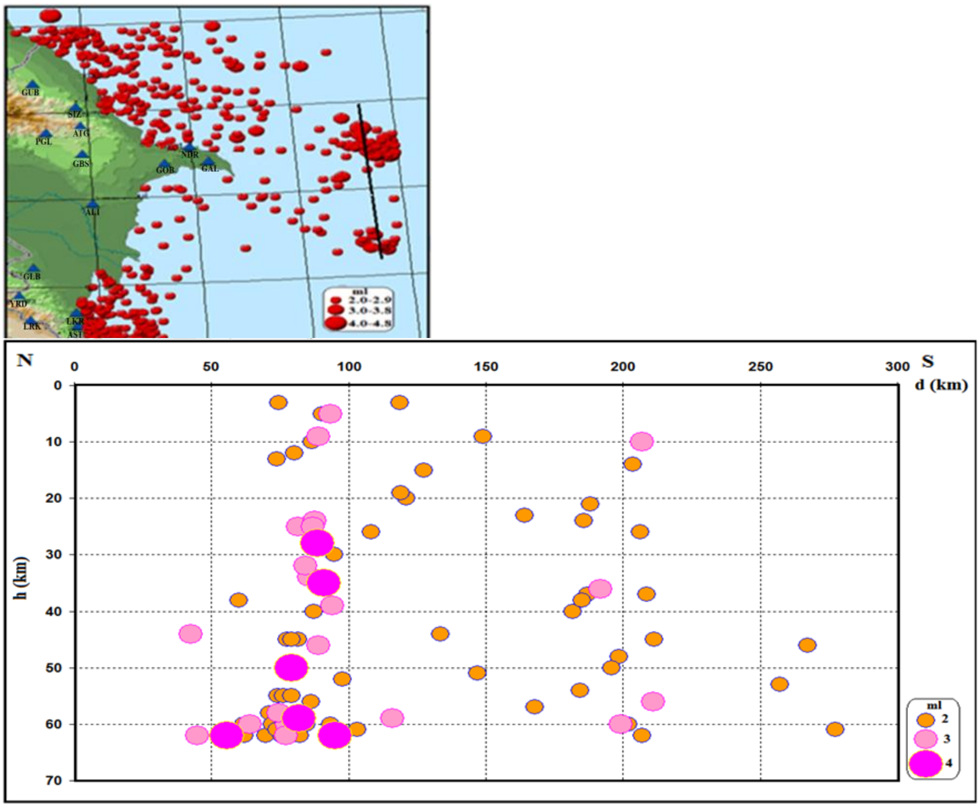

Figure 13. Seismological section of the central part of the Caspian Sea on VII-VII profile.

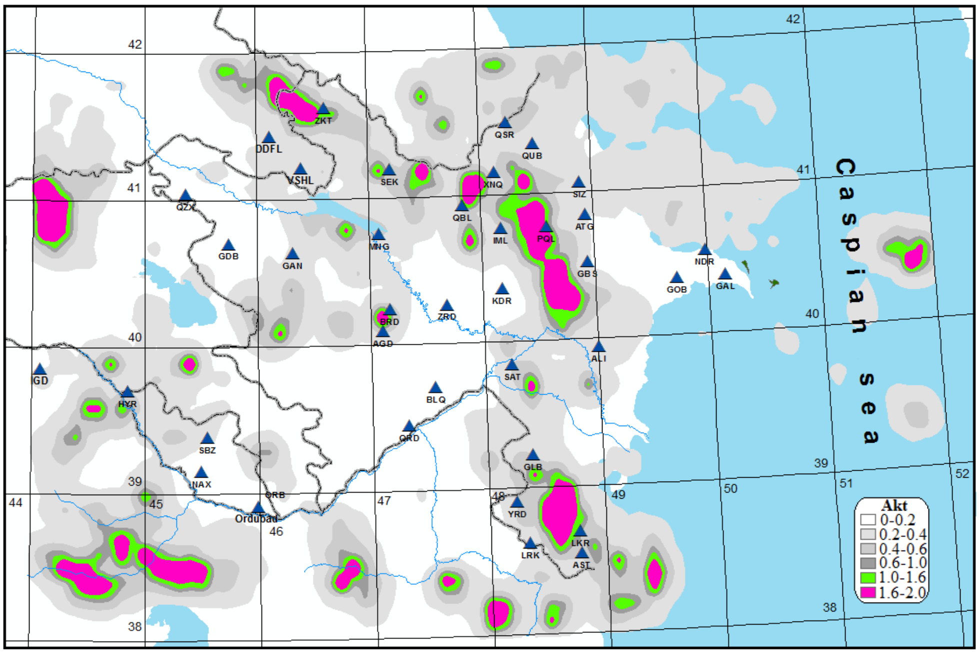

Figure 14.The seismic activity map of Azerbaijan and adjacent territories during 2019.

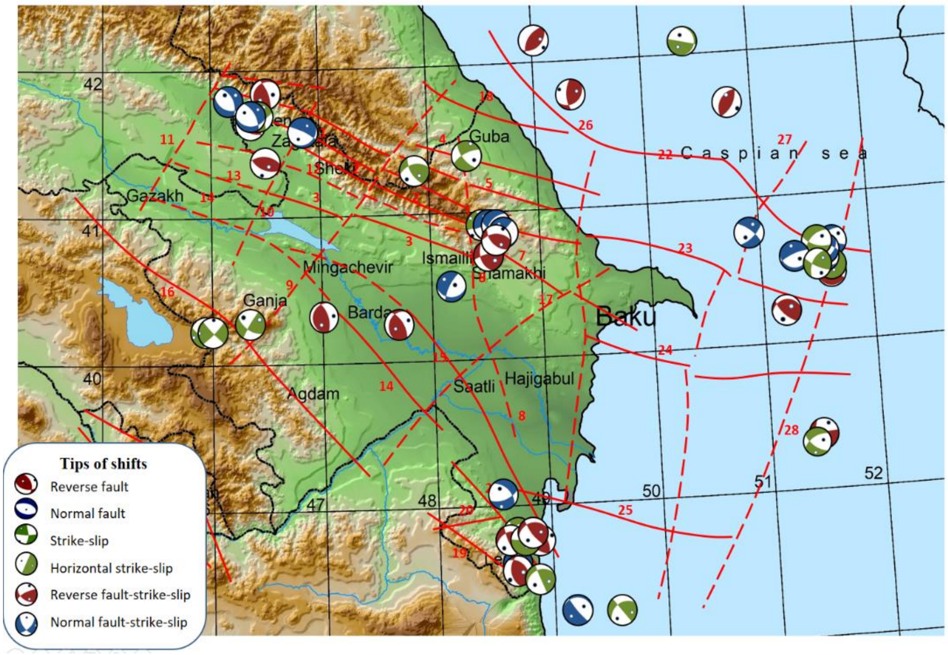

Figure 15. The mechanisms of earthquakes source with a magnitude of ml≥3.0 in 2019
(Compiled a faults map: [17, 18]).

Faults: 1-Dashgil-Mudrasa, 2-Vendam, 3-Gokchay, 4-Siyazan, 5-Zangi-Kozluchay, 6-Germian, 7-Adjichay-Alyat, 8-West-Caspian, 9-Arpa-Samur, 10- Gandjachay-Alazan, 11-Gazakh-Signakh, 12-North-Adjinour, 13-Iori, 14-Kura, 15-Mingachevir-Saatli, 16-Bashlibel, 17-Palmir-Absheron, 18-Akhti-Nugedi-Kiliziali, 19 - Talish, 20 - Yardimli, 21 – Front Talish, 22 - Central-Khazar, 23 - Absheron-Balkhan, 24 - Sangachal-Ogurchi, 25 - Chikishler, 26 - Yashma flexure, 26 - Gizilagaj, 27 - Shakhovo-Azizbeyov, 28 - Garaboghaz -Saphidre.

As mentioned above, the strongest earthquake with a magnitude of ml = 5.2occurred on February 5 at 23:31:37 local time in the Ismayilli region.The orientation of the axis of compression of the earthquake (P) and the axis of tension (T) are oriented horizontally (PL = 4, PL = 7). For the first and second nodal constants, an acute angle of incidence (DP = 82 º, 87 º) was identified (Fig. 16). The magnitude of the strike-slip in the fault (SLIP=8-177) indicates that the right-side displacement is predominant and corresponds to the fault of the Western Caspian.The earthquake source located in the sedimentary layer, almost as far as the Alps on the border of the foundation. It should be noted that at 13:24:51 on the same day an earthquake (Ml = 3.7) occurred in the Talish area.

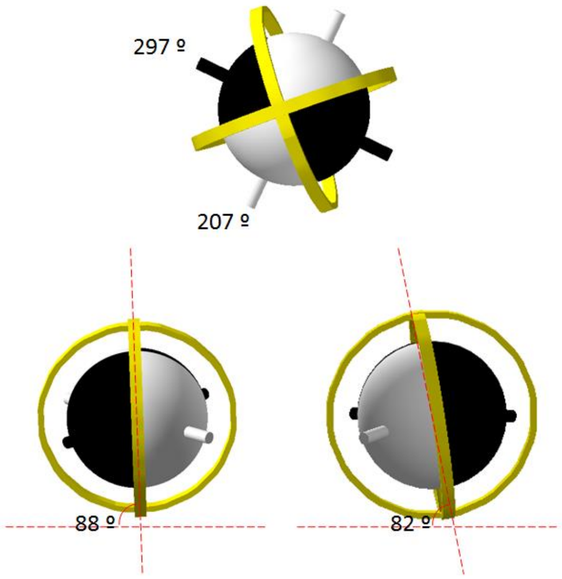

Figure 16. The source mechanism of the earthquake that occurred on 05.02.2019 at 23:31:37 in the territory of Ismayilli with a magnitude of ml = 5.2.

After that earthquake, the mechanisms of 6 aftershocks have been analyzed: (05.02.2019 ml=4.4, 05.02.2019 ml=5.2, 05.02.2019 ml=3.4, 05.02.2019 ml=3.0, 06.02.2019 ml=3.9, 09.02.2019 ml=2.9) – 6 earthquakes. As a result of the analysis, it was determined that two types of angles of incidence were recorded for both nodal planes. 1) acute angles of incidence (DP = 82-90) , and flat (DP = 17-41) angles. The values of strike-slip in the source indicate the occurrence of right-lateral horizontal strike-slip-reverse type movements and consistent with the Western Caspian, Aghsu and Vendam faults.

Analysis of the source mechanism of earthquakes in the area showed that during the year the activity of the Geokchay fault was at a depth of 13-17 km, the acute angle of incidence was 43-53 º, the Vendam fault was at a depth of 11 km, the angle of incidence was 47 º, the West-Caspian fault was at a depth of 8-13 km, the angle of incidence was 77-87 º. Thus, as a result of the orientation of the compression and extension axes, the depth distribution sections of the Lode-Nadayi coefficient have been created (Fig. 17). It was determined that the earthquakes were caused by compressive stress.

On August 10, 2019 at 11:35-07 local time, an earthquake with a magnitude of ml = 4.9 has been recorded in the territory of Zagatala, 18 km south-west of Zagatala station.The orientation of the axis of earthquake of the compression (P) is close to the vertical (PL = 55 º), the axis of tension (T) is close to the horizon (PL = 15 º).An acute angle of incidence (DP = 67 º) was identified for the first nodal constant and a flat (DP = 39 º) acute angle of incidence was identified for the second nodal constant (Fig. 18).The value of displacement in the source (SLIP = -57 º - (- 142) º) indicates that the normal fault - left lateral strike-slip fault type movements is dominated. During the year, the activity of faults in the Zagatala zone is mainly observed at a depth of 5-6 km, an acute angle of incidence 33 º-39 º and an acute angle of incidence 54 º-59 º at a depth of 9-11 km.

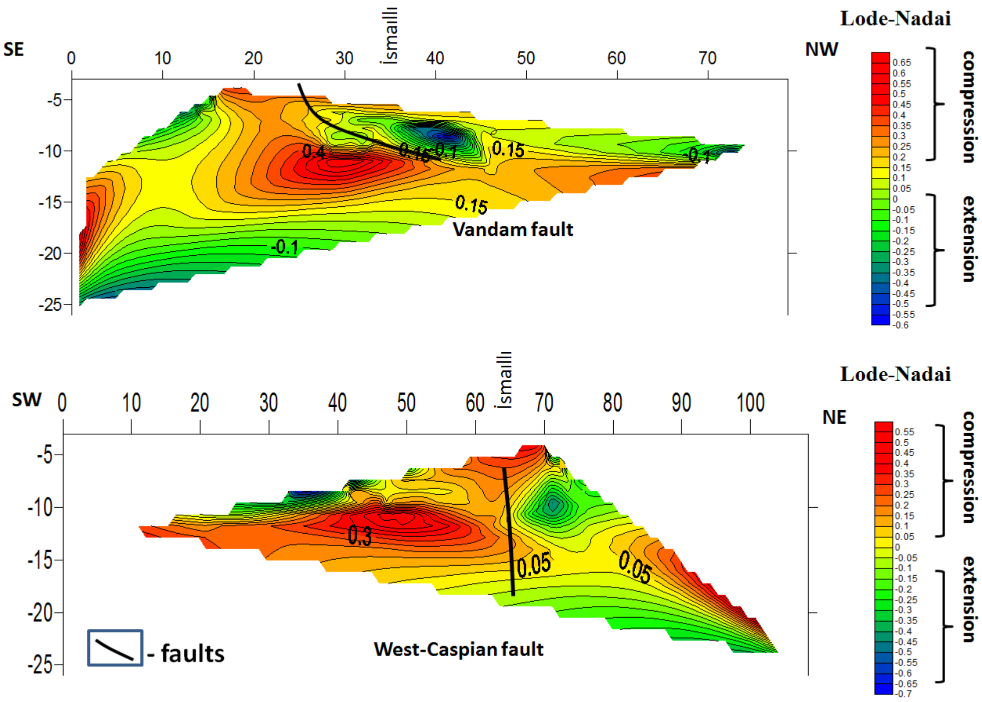

Fig. 17. Depth distribution scheme of Lode-Nadai coefficient along Shamakhi-Ismayilli seismogenic zone for 2018-06.02.2019.

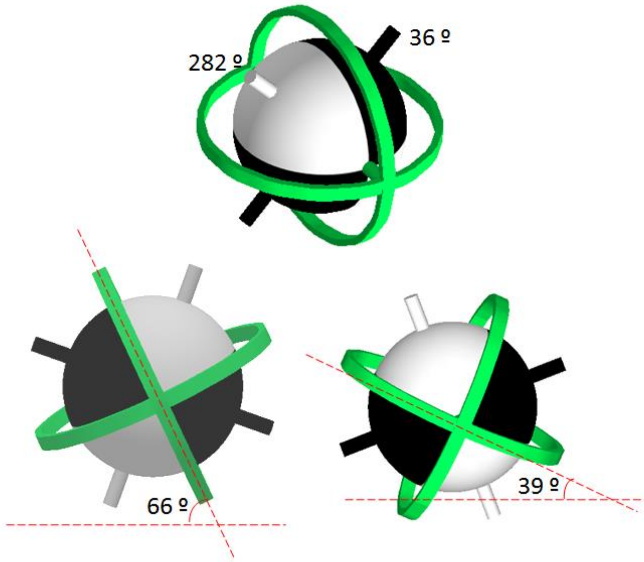

Fig.18. The mechanism of the earthquake source that occurred on August 10, 2019 at 11: 35-07 in the territory of Zagatala district.

It is known that the area of tension in the Middle and Lower Kura basin is characterized by tension (expansion), but the analysis of recent years shows the formation of strike-slip type movements in the area.Thus, on March 16, 2019 at 08:34 local time, an earthquake with a magnitude of ml = 3.3 was recorded in the territory of Zardab, 8 km south of Zardab station. The orientation of the axis of earthquake of the compression (P) is close to the horizon (PL = 23º), and the orientation of the axis of stress (T) is close to the vertical (PL = 51º). An acute angle of incidence (DP = 74 º) was determined for the first nodal plane, and a flat (DP = 33º) angle of incidence was determined for the second nodal plane. The value of strike-slip in the fault (SLIP = 60º-150º) indicates that the faults on the basis of the NP1 nodal plane propagating in the direction of NW-SE is dominated by left-sided displacement type movement and is consistent with the longitudinal fault of the Kura.

The area of tension in the Talish region is characterized by horizontal compression in the direction of SW-NE. It was determined that the reason for the increase in seismic activity in the region is mainly Talish, Front Talish, Yardimli and Astara faults. Right-sided displacement coincides with the Astara-Derbent fault. It should be noted that the Talish fault has an angle of incidence 27º-38º at a depth of 20-32 km and an angle of incidence 82º at a depth of 13-18 km.

As mentioned above, on February 5, 2019 at 17:24:51 local time, an earthquake with a magnitude of ml = 3.7 was recorded in Lerik region, 24 km east of Yardimli station. The intensity of the earthquake was about 4 points in the epicenter and up to 3 points in the surrounding areas. The direction of the earthquake's compression axis (P) is close to the horizon (PL = 15 º), and the direction of the tensile stress axis (T) is close to the vertical (PL = 56). A sharp drop (DP = 66 º) for the first nodal plane and a flat (DP = 38 º) angle of incidence for the second nodal plane were determined. The value of displacement in the source (SLIP = 121 º -39 º) indicates the predominance of reverse – strike-slip type of faults on the basis of both nodal planes propagating in the direction of NW-SE, and is consistent with the Talish longitudinal faults.

The mechanism of 25 earthquakes with a magnitude of ml ≥3.0 in the Caspian Sea has been analyzed. The central and northern part of the Caspian Sea was mainly active, and the activity was associated with the Central-Caspian, Apsheron-Balkhan and Garabogaz-Safidra faults [14]. The histogram of the percentage distribution of the mechanisms of earthquakes in the Caspian Sea shows that 60% of earthquakes are characterized by normal fault- strike-slip type movements (Fig. 19). The analysis of earthquakes showed that in the Caspian Sea, mainly at the intersection of the Makhachkala-Krasnovodsk and Shakh-Azizbayov fault zones, at a depth of 10-65 km. Activation of the Central Caspian fault at depths of 5-20 and 50-60 km is observed and is characterized by strike-slip. The Gızılaghaj fault was observed mainly at the depth of 40-65 km with the strike-slip type movements.

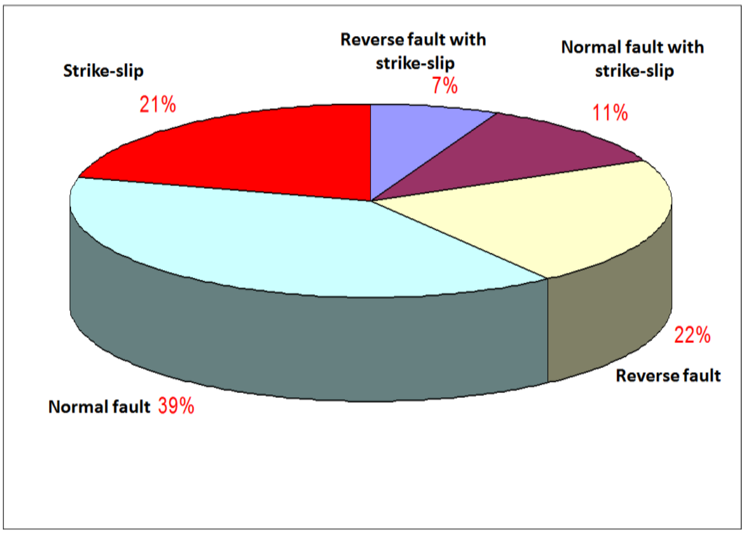

Fig. 19. The histogram of distribution of the earthquakes mechanisms occurred in the Caspian Sea by percentage.

On June 5, at 16:33-07 local time, an earthquake with a magnitude of ml = 4.8 was recorded in the Caspian Sea. The direction of the earthquake's compression axis (P) is close to the horizon (PL = 36 º), and the direction of the tensile stress axis (T) is close to the vertical (PL = 54 º). For the first nodal plane, a sharp drop (DP = 81 º) and for the second nodal plane, a flat (DP = 9 º) angle of incidence have been determined. The value of displacement in the fault (SLIP = 92 º -79 º) indicates a predominance of reverse- thrust -left lateral strike-slip type movement and isconsistent with the Central Caspian fault.

On June 7, at 09:27-13 local time, an earthquake with a magnitude of ml = 4.7 was recorded in the Caspian Sea. Earthquake was felt up to 3 points near the coast. The direction of the earthquake's compression axis (P) is close to the horizon (PL = 33 º), and the direction of the tensile stress axis (T) is close to the vertical (PL = 49 º). An acute angle of incidence (DP = 82 º) was determined for the first nodal plane, and a flat (DP = 23º) angle of incidence was determined for the second nodal plane. The value of displacement in the source (SLIP = 69 º -158 º) indicates a predominance of reverse- left lateral strike-slip - thrust type movement.

Conclusion

The epicenter zones of most earthquakes in the south-western part of the Greater Caucasus are located mainly in the foothills of the Vendam structural zone. The activation is also observed along the Dashgil-Mudrasa, Talish, Front Talish longitudinal, Akhvay, Gabala-Imishli (Chakhirli-Gabala), Tairdjalchay-Salyan orthogonal, Sharur-Zagatala transverse depth Sangachal Ogurju, Central Caspian, Agrakhan-Krasnovodsk faults.

In 2019, there were 25 tangible (ml = 2.6-5.2) earthquakes.It was determined that the number of earthquakes in 2019 was higher than in 2018, and the amount of released seismic energy was reduced. Thus, the number of earthquakes in Azerbaijan in 2018 is 4081, the amount of released seismic energy is ∑E = 42.7 • 1011C, the maximum magnitude is ml = 5.5, the number of earthquakes in 2019 is 5442, the amount of released seismic energy is ∑E = 31.9 • 1011C, the highest magnitude was ml = 5.2.

The activity was high on the south-eastern slope of the Greater Caucasus: in the Zagatala-Balakan zone (A_{10} = 1.6-2.0), in the Shamakhi-Ismayilli zone (A_{10} = 1.6-2.0), in the Talish zone (A_{10} = 1.6-2.0). The seismic activity was weak in the south-northern part of the Lesser Caucasus (A_{10} = 0.6-1.0). The active areas corresponds to the prices: in the north (A_{10} = 0.6-1.0), center (A_{10} = 0.9-1.6), southern part of the Caspian Sea (A_{10} = 1.0-1.7), in the Iran zone (Tabriz) (A_{10} = 0.6-1.8).

Thus, in 2019, the area of tension is characterized by extansion and the solution of the mechanisms of the earthquakes source shows the occurrence of reverse, normal fault and horizontal strike-slip. Based on the analysis of the earthquake sources, it was found out: 46-60 km on the Central-Caspian fault (61º-90º angle), Talish fault at a depth of 20-32 km, the angle of incidence 27º-38º and at a depth of 13-18 km the angle of incidence 82º, the activity of Geokchay fault at a depth of 13-17 km, the angle of incidence is 43º-53º, the activity of the Vandam fault is at a depth of 11 km, the angle of incidence is 47 º, the activity of the West Caspian fault is at a depth of 8-13 km, the angle of incidence is 77-87 º.

On the basis of data obtained as a result of the compression and extansion axis of the earthquake source mechanisms, it was determined that the compression axis are directed mainly in the direction of the NEW-SE in the Zakatala-Balakan zone, in the direction of the NE-SW in the Shamakhi-Ismayilli, Middle and Lower Kura basin and in the Talish zone.The extansion axis are oriented in the direction of NW-SE in each seismically active region.

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QUANTITATIVE ASSESSMENT OF SEISMIC HAZARD IN THE AZERBAIJANI PART OF THE SOUTHERN SLOPE OF THE GREATER CAUCASUS

T.Y.Mammadli[1], T.I. Jafarov[1]

The territory of Azerbaijan, which is part of the Alpine fold system, is characterized by quite high seismic activity. According to its geological structure and seismic features, the area can be divided into several large zones: the southern slope of the eastern part of the Greater Caucasus, the Kura basin, the northern slope of the Lesser Caucasus, the Gusar-Davachi basin, the Caspian Sea.

The map of epicenters of strong (M≥5,0) earthquakes [1; 2; 3; 4] from 427 year to the present, is an indicator of high seismic activity in the territory of Azerbaijan (Fig. 1).

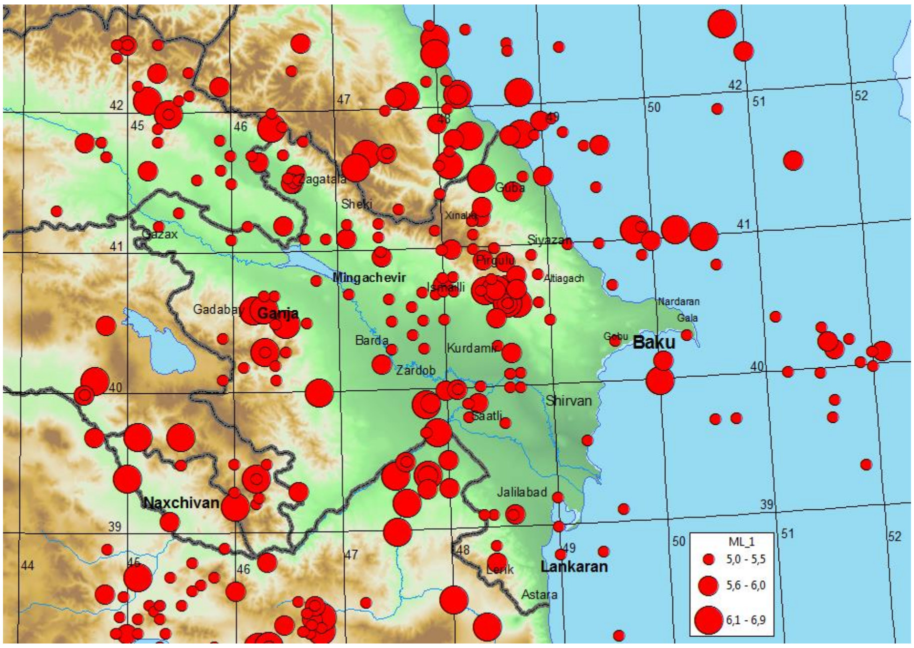

Fig. 1. The epicenters map of strong (M≥5,0) earthquakes occurred in Azerbaijan and adjacent areas during 427-2019 years.

Analysis of the spatial distribution of thousands of weak and medium-magnitude earthquakes (an average of 600-800 shocks are recorded each year) registered in the country shows that the earthquakes are unevenly distributed (Fig.2). The vast majority of these earthquakes occur on the southern slope of the eastern part of the Greater Caucasus. Studies show that seismic shocks are unevenly distributed within this zone [5, 6].

They are concentrated in some places and in the remaining areas, few of them are noted. Analysis of the spatial distribution of strong earthquakes (M≥5) shows that they occur mainly in areas where weak earthquakes are concentrated. Strong earthquakes in this region (M≥5.0) occur at shallow depths (10-15 km) and this affects the effect of their manifestation on the Earth's surface, especially in the Pleystoseyst zone. The strongest earthquakes in the eastern part of the Greater Caucasus occurred in the Shamakhi region (Fig. 1). The magnitude of some of them varies between 6.0 ÷ 6.9 points. These earthquakes have been felt at the epicenter with an intensity of up to 9 point on the MSK-64 scale [1]. The city of Shamakhi was repeatedly destroyed and there were numerous casualties. In other parts of the region, earthquakes with a magnitude of > 6.0 have not been recorded [2, 3, 4]. However, earthquakes with magnitude of 5.0-6.0 have been also quite strong at the epicenter, earthquake with magnitude of 7 according to the MSK-64 scale. The last time such a strong earthquake (M = 5.7) occurred in Zagatala in 2012, many houses were damaged, there have been a number of wrecks, fortunately there were no casualties.

One of the most important problems facing seismology is the seismic zoning of areas and the most important conditions for the correct compiling or specification of a seismic zoning map of great social, economic and ecological significance is a realistic assessment of the location and seismic potential of seismic

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zones, which can be the epicenter of a strong earthquake. For this purpose, extensive research is usually carried out, including a complex and detailed study of the depth structure of the Earth's crust, modern geodynamics, regional seismicity, seismotectonics. As a result of these studies, seismically active structures that are sources of seismic hazards, seismic effect caused by structures and extinction properties depending on the distance, parameters of seismic regime of these active structures are determined, the maximum possible level (point) of seismic impact is assessed in each part of the studied area. The seismic zoning map of the territory of Azerbaijan (mapping of the area according to the level of seismic hazard) has been repeatedly compiled by the method called “seismotectonic” or “genetic”. The last such map is the “Temporary seismic zoning map of the Republic of Azerbaijan” compiled in 1991 [7] (Fig. 3). As can be seen from this map, the southern slope of the Greater Caucasus - approximately from the meridian of the city of Gobustan (formerly Maraza) to the border with Georgia - is characterized by high intensity (8 and 9 points on the MSK-64 scale) seismic hazard.

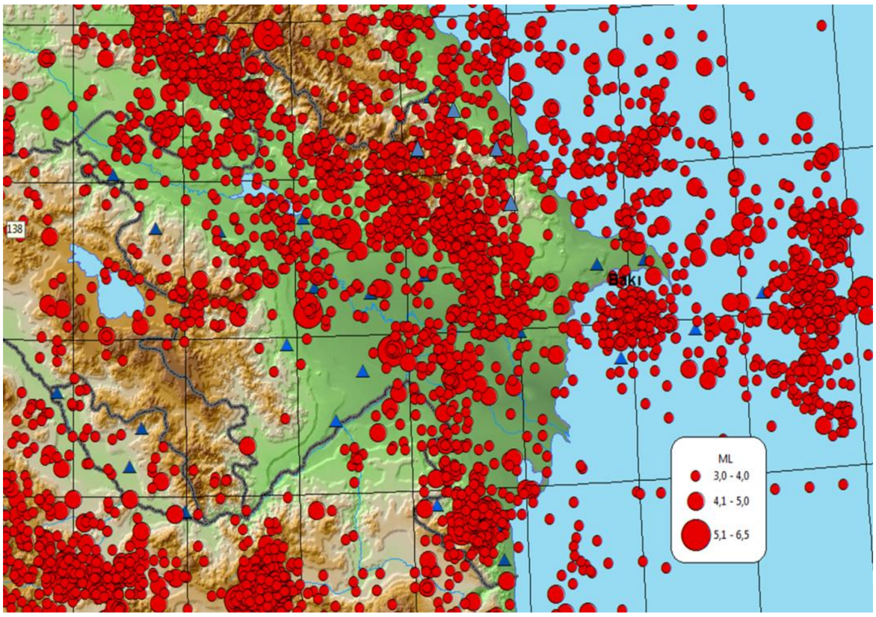

Fig.2. The epicenters map of earthquakes with magnitude of ≥3,0 occurred in Azerbaijan and adjacent areas during 1980-2019 years.

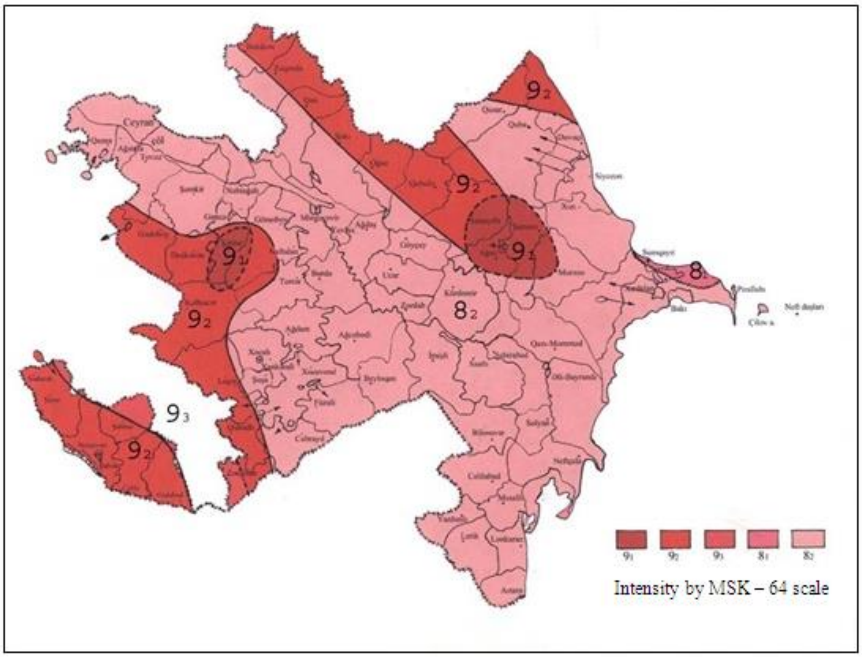

Fig.3. Map-scheme of temporary seismic zoning of the territory of Azerbaijan (1991).

In addition to the "seismotectonic" or "genetic" method mentioned above, the seismic hazard is also estimated by the probability method. In this case, the seismic hazard is expressed in terms of peak ground acceleration (PGA) caused by the earthquake, and this method allows to quantify the probable seismic hazard. The calculation is carried out in the following stages:

1. The earthquake source and its characteristics are determined. Depending on the geological nature of the source, it can be considered as a field, line or point.
2. Seismic parameters (repetition) and probability models are evaluated for each seismic source. The model is usually based on the Gutenberg-Richter dependence.
3. The extinction model of ground vibrations is selected on the basis of the extinction coefficient, which reflects the change of ground vibrations depending on the magnitude of the earthquake and the distance from the source.
4. Seismic hazard is quantified taking into account the influence of the above three factors.

Large depth faults determined by geological-geophysical methods in the study area were accepted as earthquake source zones. It is believed that earthquakes are evenly distributed in these fault zones, and there is a possibility of an earthquake at any point within the fault zones. Ground movement in the study area is modeled on the basis of earthquakes of known magnitude and extinction coefficients on known ground conditions. The formulas Boore and Atcinson [9], Campbell and Bozorgnia [10] were used in our studies. Calculations were made on rocks with transverse wave velocities of 760 m / s and the seismic effect of the ground equal to the value of acceleration. The research was performed in the following sequence:

1. Active depth faults in the territory of Azerbaijan were selected. It was found that the strong earthquakes that occurred in the Azerbaijani part of the southern slope of the Greater Caucasus and are likely to occur in the future are associated with the deep faults of Vandam and Adjichay-Alyat (Fig. 4).
2. The seismic source zones (SSZ) model have been compiled (Fig. 5).
3. The earthquakes with magnitude of ≥4.0 within zone 4 were selected.
4. The values of activity parameters *a* and *b* were calculated for source zones numbered 1 and 2, which able to create a seismic hazard in the study area. The seismic characteristics of zones (SSZ) are shown below:
5. The earthquakes with magnitude of ≥4.0 within zone 4 were selected.

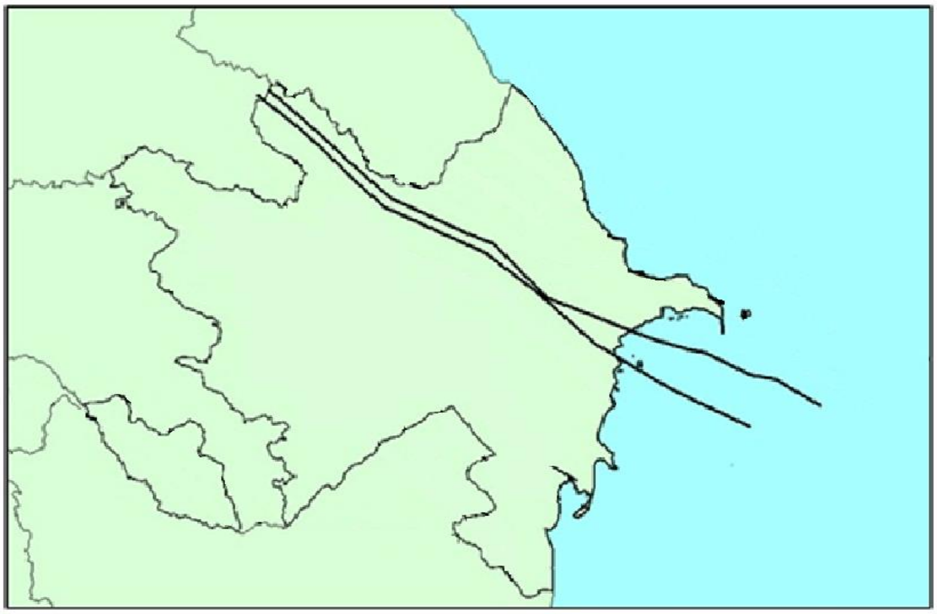

Fig.4. Layout scheme of the Vandam and Adjichay-Alyat deep faults passing through the Azerbaijani part of the southern slope of the Greater Caucasus.

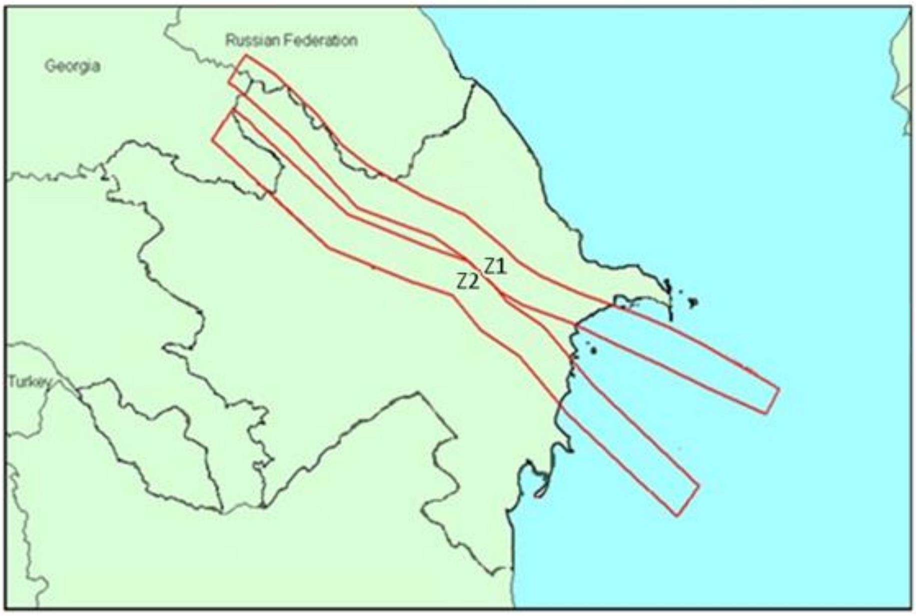

Fig.5. The model of the seismic source zones (SSZ) in the Azerbaijani part of the southern slope of the Greater Caucasus.

SSZ	Mmax	Mmin	Depth		Coefficient b	Activity on Mmin
			Hmin	hmax		
Zone 1	7.0	4.0	2.5	70	-1.215	2.77
Zone 2	6.0	4.0	3	49	-1.449	2.22

The seismic hazard in the study area was assessed using the EZFRISK software package and maps were compiled using the MapInfo program. Hazard maps have been compiled based on the values of the peak ground 5% acceleration (PGA) of earthquakes at intervals of 475 and 2475 years (with a probability of more than 10% for 50 years and more than 2% for 50 years) (Fig. 6 and Fig. 7).

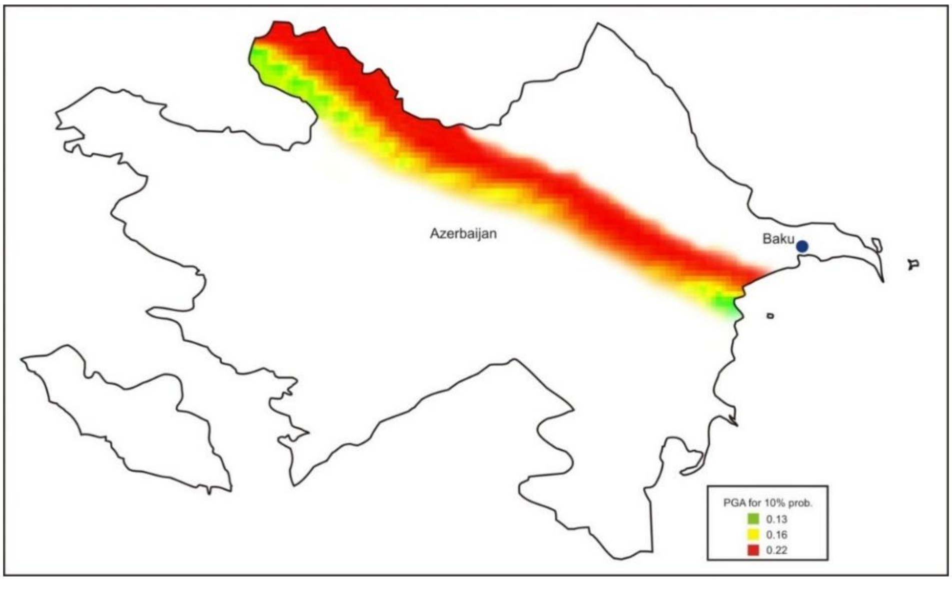

Fig.6. Peak Ground Acceleration (PGA) values over a 475-year recurrence interval (10% probability over 50 years).

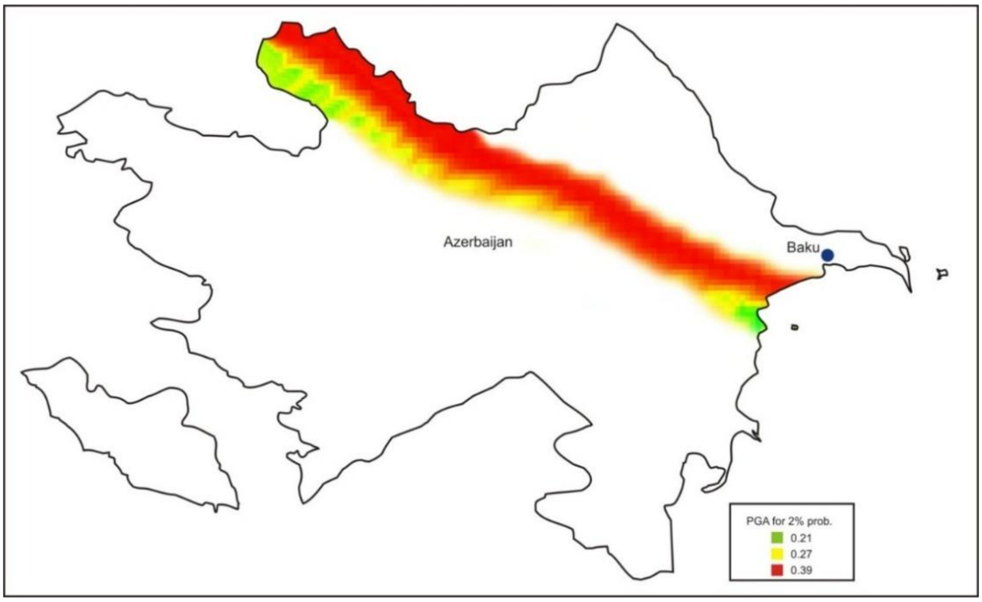

Fig.7. Peak Ground Acceleration (PGA) values for a 475-year recurrence interval (2% probability over 50 years).

According to these maps, the value of the maximum soil acceleration in the study area varies between 0.13-0.22g according to the 475-year recurrence period and 0.21-0.39g according to the 2475-year recurrence period.

Conclusion

In the temporary seismic zoning map-scheme of the territory of Azerbaijan compiled by the method called "seismotectonic" or "genetic", the intensity of seismic hazard in the Azerbaijani part of the southern slope of the Greater Caucasus is estimated at 8 and 9 on the MSK-64 scale.

The value of the peak ground acceleration of the soil in this area varies between 0.13-0.22 g according to the recurrence period of 475 years, and 0.21-0.39 g according to the recurrence period of 2475 years.

Acknowledgments

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FEATURES OF GEOMAGNETIC EFFECTS OF SEISMOGEODYNAMIC CHANGES IN THE TERRITORY OF AZERBAIJAN

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A.N.Mammadova[1], A.F.Alıyeva[1]

Before the strong earthquakes in seismically active regions of the world, it has been identified that the geomagnetic field of the Earth's crust is changed abnormally and anomalous seismomagnetic effect of the geomagnetic field has been observed before Machusiro (1965-1967), Akita (1970), Zangazur (1968) earthquakes. The seismomagnetic effect has been observed before the earthquakes in the territory of Azerbaijan [1].

The formation of the geomagnetic field and the observed changes are mainly related to the physical and mechanical processes occurring in the layers of the magnetic flux formed in the Sun and the Earth: magnetosphere, ionosphere, atmosphere, tectonosphere. Many researchers believe that the seismicity caused by geodynamic stress is directly related to geomagnetic changes [2, 5, 6, 8, 9].

Observations show that electromagnetic and geomagnetic fields have been observed as anomalous seismomagnetic effects before the earthquake as one of the warning factors of the earthquake [2, 6, 10, 11, 12, 15].

So far, the regularity of the seismomagnetic effect and other warning factors, such as short-term, instantaneous forecast, has not been confirmed. Early warning of an earthquake is estimated: 1-long-term; 2-medium-term and 3-short-term. The long-term warning factor, based on geological studies, given the tectonic structure and seismicity of the area, suggests that there will be a strong earthquake during 10-100 years. Medium-term warning factor, based on data obtained by seismological, geophysical and geodetic devices, estimates that there will be a strong earthquake in 1-10 years on the basis of anomalous physical and mechanical changes observed over time. The short-term warning factor should be based on very accurate information. The coordinates of the earthquake source, the magnitude of the earthquake and the time range from several hours to a week should be prognosed. False prognoses have a devastating effect on people's psychological state and it causes economic damage.

As one of the warning factors, the signs of abnormal electromagnetic variation are considered more convincing than other predictive factors, and regular magnetometric regime observations are carried out in many seismically active regions of the world [7, 11, 13, 14].

Changes in the magnetic field over time have been studied in Azerbaijan since the 1980's. It is the detection of anomalous changes in the magnetic field - the seismomagnetic effect - under the influence of geodynamic energy accumulated in the epicenters of geodynamic processes, tectonic faults [2, 3, 5, 6, 7]. At present, magnetometric measurements are carried out by the magnetometry department of the Republican Seismic Survey Center of ANAS at the 6 permanent points and at Sheki-Shamakhi, Near Kura-Talysh prognostic sites once a month (Fig. 1).

During the studies, the variability of the geomagnetic field, the changing characteristics of the seismomagnetic effect are studied under the influence of earthquakes with magnitude of $M \geq 4$. By analyzing the obtained data, the regularity of changes in the geomagnetic field due to earthquakes in geodynamic-stress zones is analyzed.

The purpose of the work is to monitor changes in the magnetic properties of rocks in the geological environment associated with the processes occurring in earthquake sources with modern devices and to analyze the variations of the magnetic field, to detect the seismoanomal effect and to determine the criteria for it.

Abnormal magnetic field changes caused by internal physical and mechanical processes and geodynamic stresses accumulated at the epicenter are studied as warning factors of earthquakes in time and space [3, 11]. Characteristic magnetic field changes are observed mainly before strong earthquakes. The researches have been carried out with proton-type magnetometers G-856, manufactured by the US Company Kinemetrics. The recording of the voltage T, which is the full vector of the magnetic field, is registered continuously (24 hours).

The experience of previous work and comparative analysis of data obtained at landfills in China, Uzbekistan, Russia, Kyrgyzstan and Tajikistan and other regions of the world, provide a basis for the prospects of magnetometric observation method as one of the warning factors of earthquakes. This method is used to study the anomalous seismomagnetic effect of the T-vector module by observing it simultaneously, both at the base station and at the measuring point. The essence of the method of comparative analysis is that the $\Delta T \sim f(t)$ dependency graphs are created on the geomagnetic field stress T observed synchronously. The ΔT obtained based on synchronous observations between the two points is recorded as an increase in the useful signal and

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stress field. Then the graphs of the series ΔT ~ f (t) are created during the year and the nature of the variations ΔT, the detection of the seismomagnetic effect and its regular variability are evaluated. During the study, seismic effects were selected at the measurement point and the effect formed by these earthquakes of the magnetic field variations has been studied [2, 6, 7].

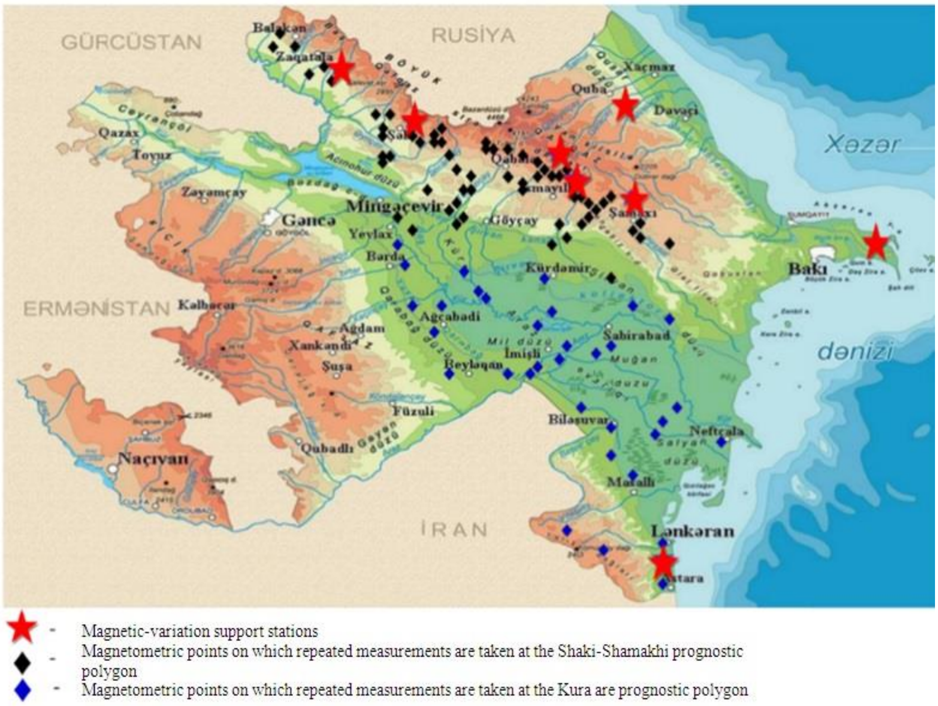
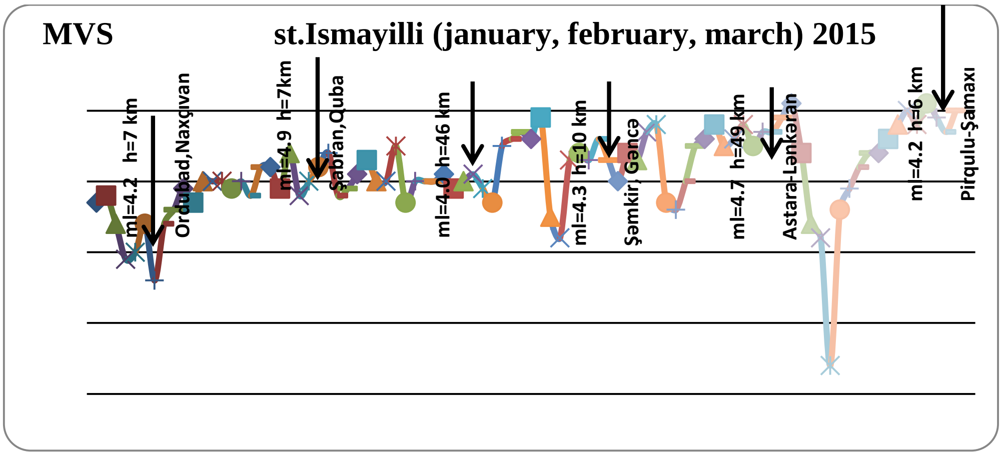


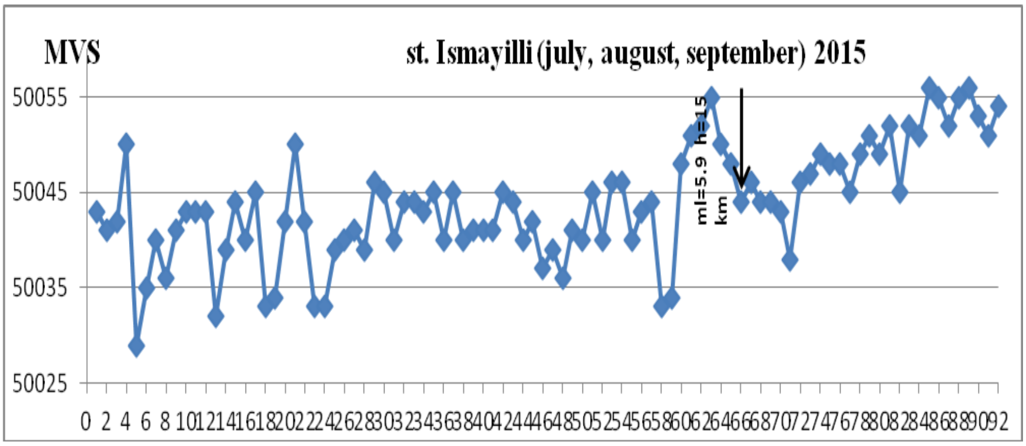
Figure 1. Scheme of magnetometric observation points where RSSC conducted studies in the territory of Azerbaijan.

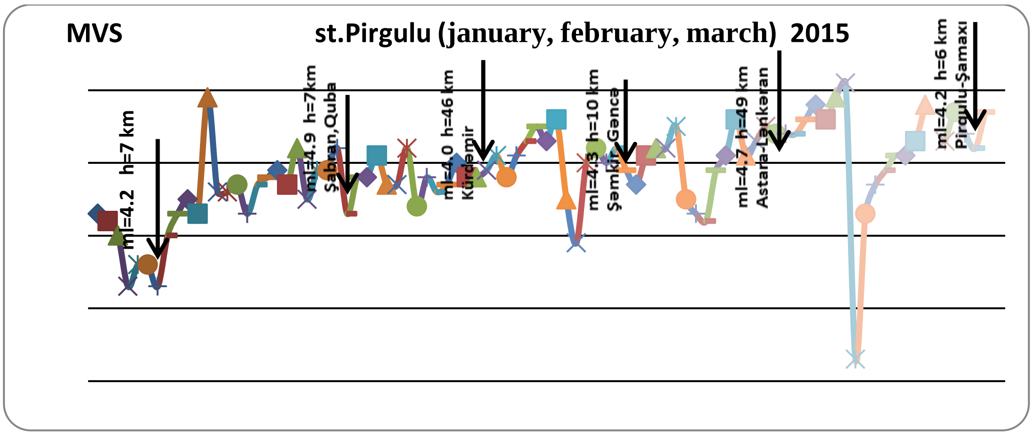
During the occurrence of earthquakes, the distribution area of the seismic magnetic effect has been calculated by the formula $R=10^{0.5M-1.27}$ km. The statistical quantity is ρ=0.87 in this area. This shows the cause-and-effect relationship between the seismomagnetic effect and earthquakes, and the relationship of seismomagnetic effects to the seismotectonic condition. It is accepted that the changes on T stress before earthquakes with magnitude of M≥ 4 are manifested in graphs, often in the form of bay-shaped. Such anomalous changes can be positive or negative, depending on the mechanism of the earthquake (compression, tension) [2, 4, 5, 7].

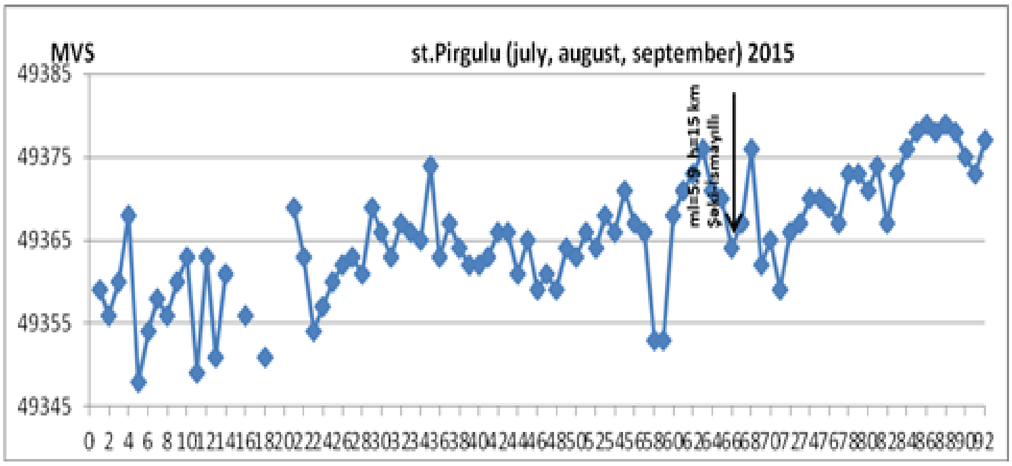
A comparative analysis method was performed to overcome ionospheric “barrier” factors and electromagnetic induction from observed T voltage field variations. As a result, $\Delta T (t) = Tm (t) - T_o (t)$, where Tm (t) -t at all stations and T_o (t) -t at the base station is taken as the value of the observed field stress [4, 6, 7]. Stationary geomagnetic observations have been carried out at Zagatala, Sheki, Ismayilli, Pirgulu, Lankaran and Absheron Peninsula-Nardaran Magnetometric Variation Stations (MVS) during the day since 2003 in registration regime. Based on these observations, T ~ f (t) graphs have been created and a comparative analysis of earthquakes has been conducted. During the analysis, earthquakes with magnitude of M≥4 were selected. Taking into account the epicenter distance of the selected earthquake from the observation point, the depth of the epicenter, the anomalous observation period of the seismomagnetic effect, the intensity of the magnetic change and its shape have been observed in the graph. For example, the graph of magnetometric observations in 2015 shows changes in the anomalous seismomagnetic effect of an earthquake (Fig.2).

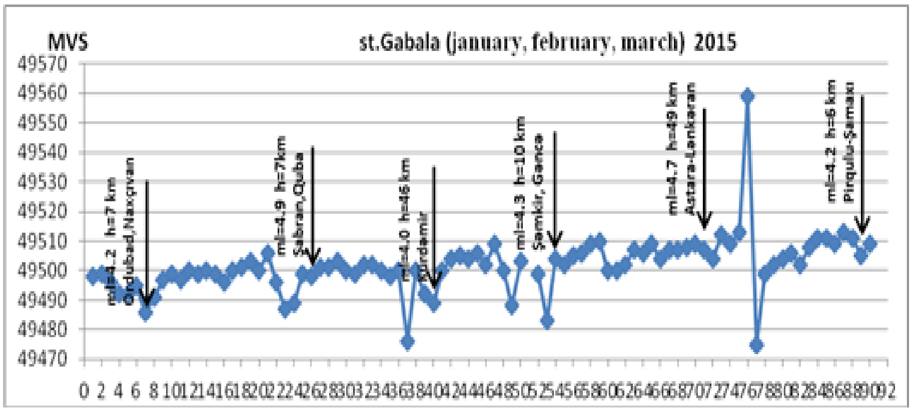
Abnormal magnetic changes, which are considered to be related to earthquakes, sometimes last from 2-3 days to 25-30 days. The large amplitude of anomalous magnetic changes is 30-40 nTl and sometimes more. As can be seen from the graph, anomalous changes in the geomagnetic field are sometimes observed even when no earthquakes is recorded. In our opinion, such cases are associated with other, unpredictable geodynamic processes occurring in the Earth's crust.

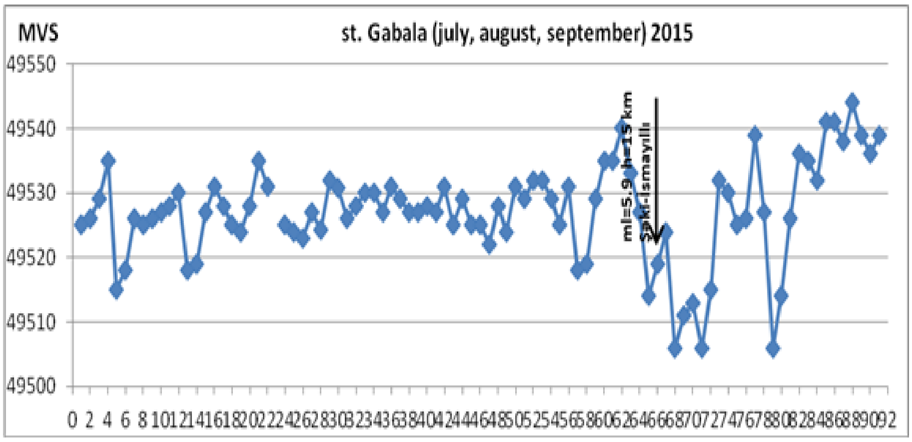

MVS
st.Ismayilli (january, february, march) 2015
ml=4.2 h=7 km
Ordubad,Naxçıvan
ml=4.9 h=7km
Şabran,Quba
ml=4.0 h=46 km
ml=4.3 h=10 km
Şamkir, Gəncə
ml=4.7 h=49 km
Astara-Lankaran
ml=4.2 h=6 km
Pirqulu-Şamaxı

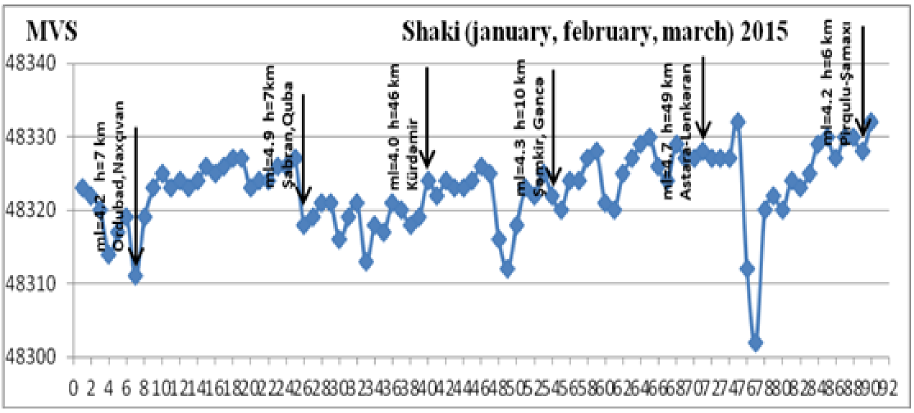

MVS
st. Ismayilli (july, august, september) 2015
50055
50045
50035
50025
ml=5.9 h=15 km

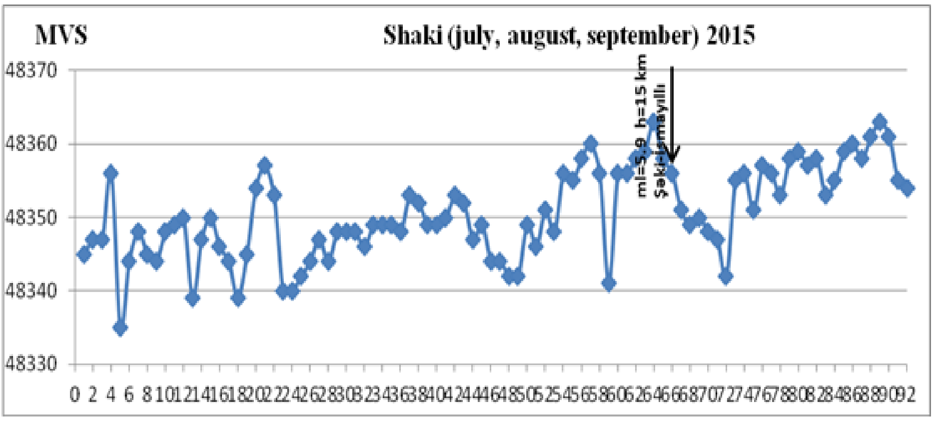

MVS
st.Pirgulu (january, february, march) 2015
ml=4.2 h=7 km
ml=4.9 h=7km
Şabran,Quba
ml=4.0 h=46 km
Kürdəmir
ml=4.3 h=10 km
Şəmkir, Gəncə
ml=4.7 h=49 km
Astara-Lənkəran
ml=4.2 h=6 km
Pirqulu-Şamaxı


MVS
st.Pirgulu (july, august, september) 2015
49385
49375
49365
49355
49345
ml=5.9 h=15 km
Şəki-İsmayıllı


MVS
st.Gabala (january, february, march) 2015
ml=4.2 h=7 km Ordubad,Naxçıvan
ml=4.9 h=7km Şabran,Quba
ml=4.0 h=46 km Kürdəmir
ml=4.3 h=10 km Şəmkir, Gəncə
ml=4.7 h=49 km Astara-Lənkəran
ml=4.2 h=6 km Pirqulu-Şamaxı


MVS
st. Gabala (july, august, september) 2015
ml=5.9 h=15 km Şəki-İsmayıllı


MVS
Shaki (january, february, march) 2015
ml=4.2 h=7 km Ordubad,Naxçıvan
ml=4.9 h=7km Şabran,Quba
ml=4.0 h=46 km Kürdəmir
ml=4.3 h=10 km Şəmkir, Gəncə
ml=4.7 h=49 km Astara-Lənkəran
ml=4.2 h=6 km Pirqulu-Şamaxı


MVS
Shaki (july, august, september) 2015
ml=5.9 h=15 km Şəki-İsmayıllı

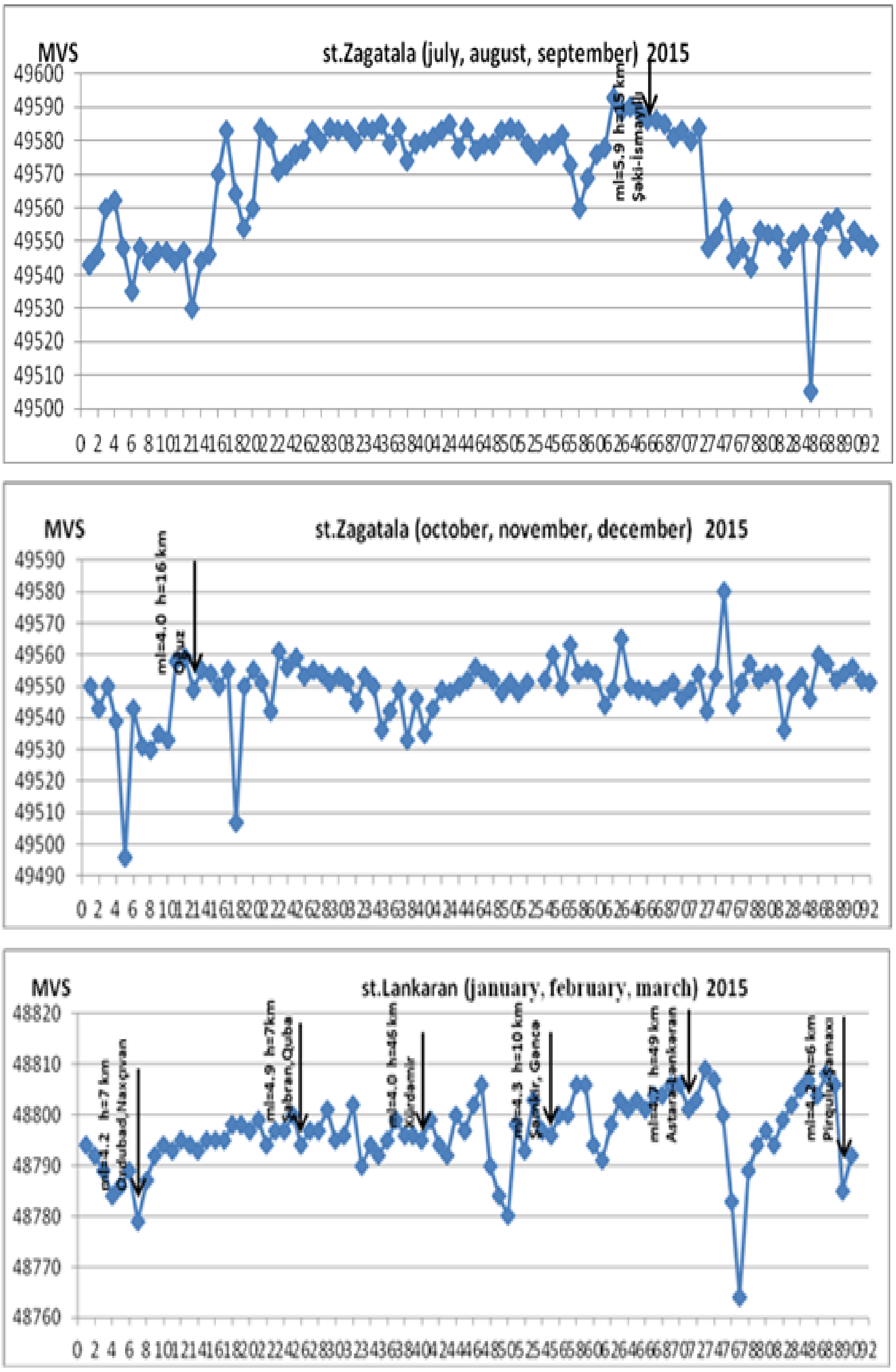


Figure 2. The graphs of magnetometric observations conducted in the territory of Azerbaijan in 2015 and changes in the anomalous seismomagnetic effect associated with earthquakes

In order to clarify the criterion for changing the seismomagnetic effect, we tried to explain the characteristics of the change in the seismomagnetic effect associated with earthquakes of M≥4.0 from the epicenter in the main layers of the Earth at different times. The hypocenters of earthquakes in the territory of Azerbaijan during 2003-2020 years have been observed 66% at a depth of 0-20 km, in the sedimentary layer; 21% at a depth of 20-35 km, in the granite layer, 12% at a depth of 35-60 km, in the basalt layer (Fig. 3). No earthquakes were recorded in the upper layers of the mantle, in the asthenosphere.

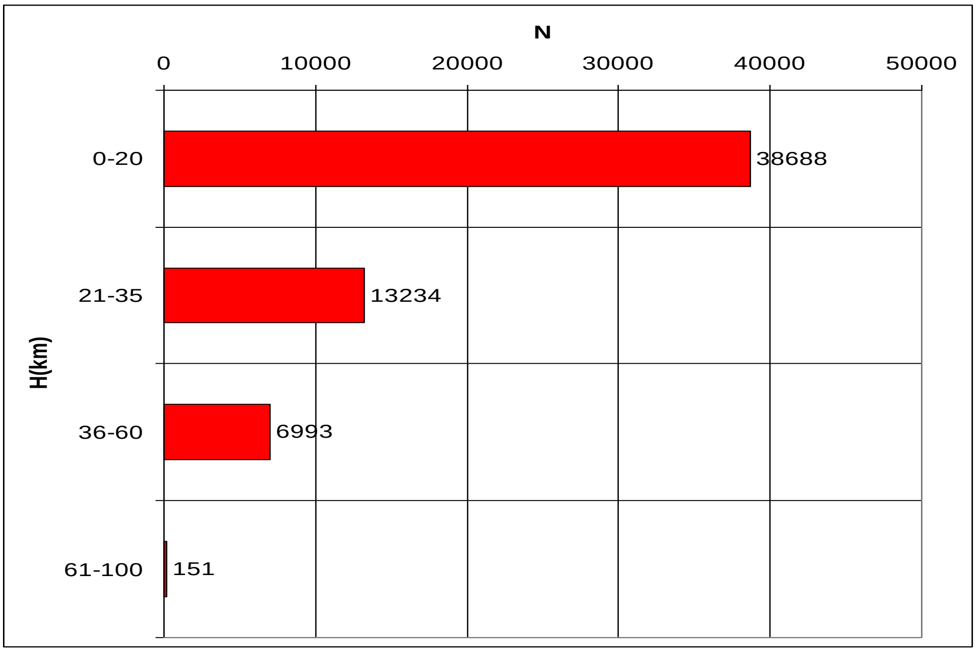


Figure 3. Graph of depth distribution of hypocenters in the South Caspian and onshore areas of Azerbaijan (Compiled by: H.O. Valiyev, S.E. Kazimova).

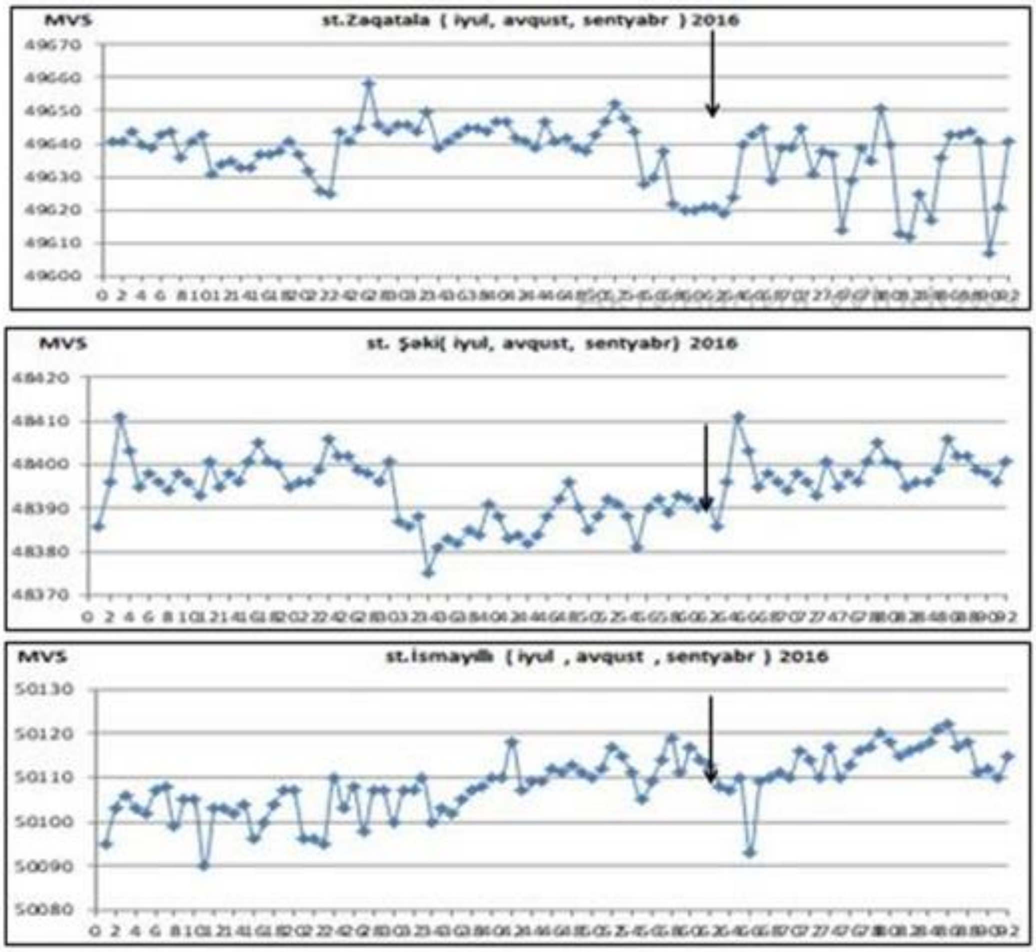
In the Caspian Sea basalt layer at a depth of 60-65 km, geodynamic activity is higher than in other areas. During the study, taking into account the depth of the epicenters and the presence of the epicenter in which layer of the Earth, it was observed how the geomagnetic field and seismomagnetic effect are formed at the magnetometric observation points (Fig. 4). The seismomagnetic effects of several earthquakes in the Earth's crust have been observed in the analyzed magnetometric data as follows.

In the Imishli zone, on 01.08.2016, the seismomagnetic effect of an earthquake with a magnitude of 5.6, the depth of the epicenter was in the granite layer and occurred at a depth of 28 km in Zagatala and Sheki points, began to form 8-10 days ago and was 20-30 with an bay-shaped minimum. It was extinguished 15 days after the earthquake. Seismomagnetic effect is observed in Ismayilli point, but it is not separated in a characteristic form.

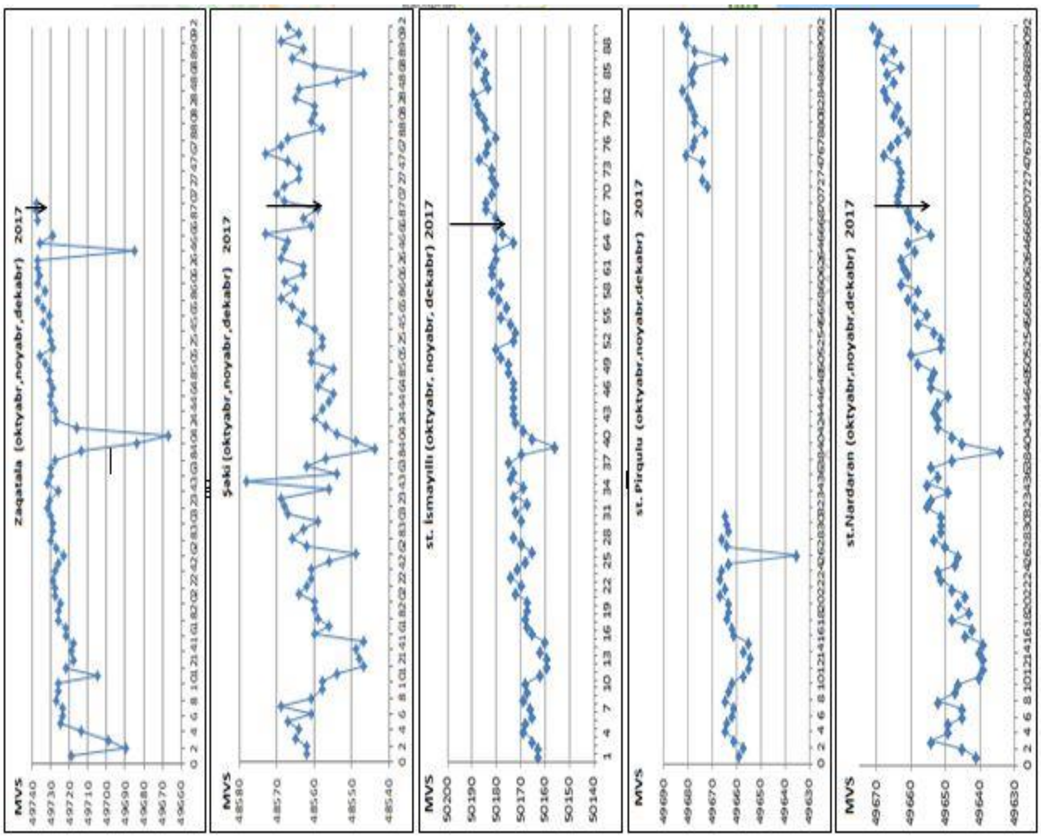
The depth of the source with the magnitude of 5.7 in **Barda-Agjabadi zone** on 15.11.2017, began to form 7 days ago with the seismomagnetic effect of 10-40 nT in Zagatala point of the earthquake occurring in the granite layer at depth of 25 km. There is seismomagnetic effect in Sheki, but in Ismayilli it is observed weakly.

In the Lankaran zone, on December 17, 2018, the depth of the epicenter with a magnitude of 4.7 in the basalt layer and at depth of 44 km in Sheki and Ismayilli points with seismomagnetic effect of 10-15 nT extinguished 9 days after the earthquake.


01.08.2016 04:46:35
39.91 47.85
ml=5.6h=28 (Qranitqat)
Azerbaijan


MVS
st.Zaqatala (iyul, avqust, sentyabr) 2016
49670
49660
49650
49640
49630
49620
49610
49600
MVS
st. Şəki(iyul, avqust, sentyabr) 2016
48420
48410
48400
48390
48380
48370
MVS
st.İsmayıllı (iyul , avqust , sentyabr) 2016
50130
50120
50110
50100
50090
50080


15.11.17 19:48:02
40.17 47.11
ml=5.7 h=25 (Qranitqat)
200,00 км
100,00 км
Azerbaijan


Zaqatala (oktyabr,noyabr,dekabr) 2017
Şeki (oktyabr,noyabr,dekabr) 2017
st. İsmayilli (oktyabr, noyabr, dekabr) 2017
st. Pirqulu (oktyabr,noyabr,dekabr) 2017
st.Nardaran (oktyabr,noyabr,dekabr) 2017
MVS


05.06.18 18:40:27
41.50 46.67
ml=5.5 h=10 (Sediment layer)
200,00 км
100,00 км
Azerbaijan

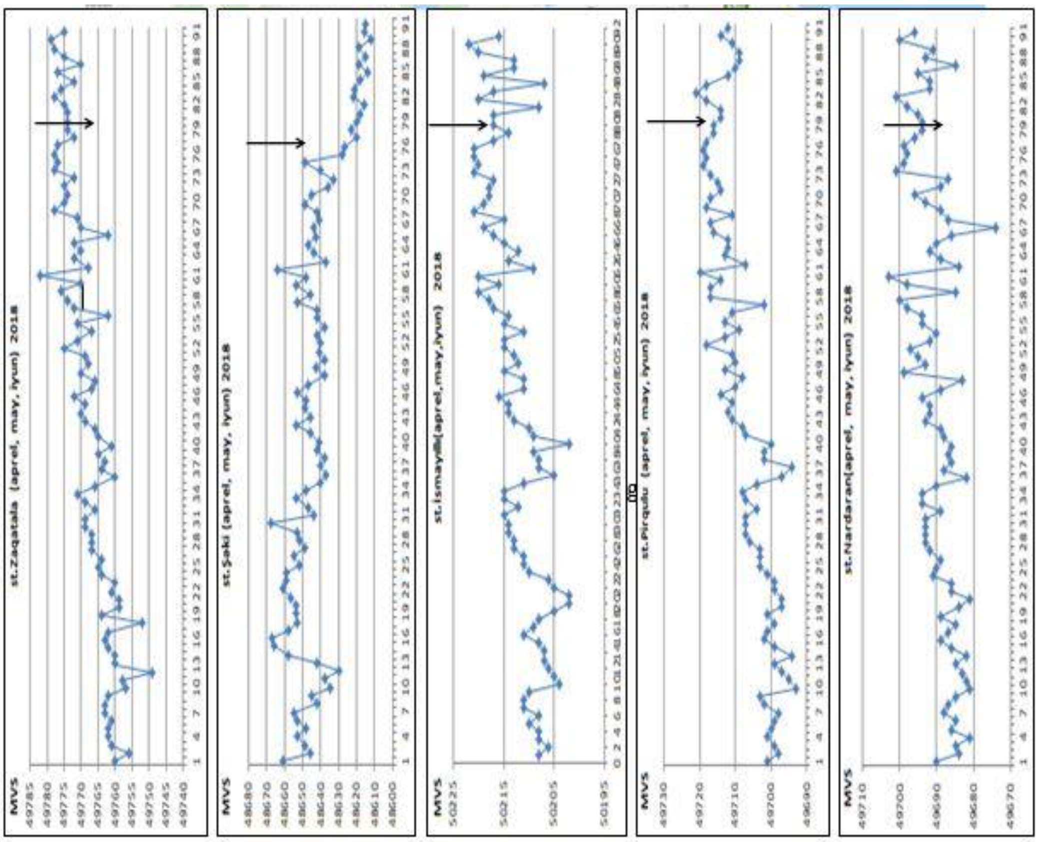

st.Zaqatala (aprel, may, iyun) 2018
st.Şaki (aprel, may, iyun) 2018
st.Ismayilli(aprel,may,iyun) 2018
st.Pirqulu (aprel, may, iyun) 2018
st.Nardaran(aprel, may, iyun) 2018
MVS

Figure 4. Graphs of seismomagnetic effect associated with earthquakes of magnitude M≥ 4.0 in the territory of Azebaijan.

In the Zagatala zone on 05.06.2019, the seismomagnetic effect began to form 5-6 days ago in all observation points of the earthquake with a magnitude of ml=5.5, the depth of the epicenter in the sedimentary layer h=10 km and it was observed being bay- shaped of 10-35 nT.

Measurement data of magnetometric regime observations in 6 permanent points of the Republican Seismic Survey Center of ANAS were analyzed in connection with earthquakes of M≥4.0 in the territory of Azerbaijan and features of epicenter-dependent change of seismomagnetic effect were investigated. It has been found that anomalous magnetic changes sometimes last from 2-3 days to 25-30 days, and the amplitude of the changes is 30-40 nTl and sometimes more. Features of the seismomagnetic effect associated with M≥4.0 earthquakes in the territory of Azerbaijan. For the first time, based on the analysis carried out taking into account the depth of the hypocenter of the earthquake and the stratum complex, it was determined that the seismomagnetic effect was observed in different forms.

Conclusion

1. The epicenter-dependent variability of the seismomagnetic effect associated the earthquakes with magnitude of M≥4.0 in Azerbaijan has been studied and it was determined that the anomalous magnetic changes sometimes lasted from 2-3 days to 25-30 days, the amplitude of the changes was 30-40 nTl and sometimes more.
2. It has been observed that in the absence of an earthquake, the magnetic field sometimes changes abnormally to a similar shape, and that such changes are thought to be due to other, unobservable geodynamic processes occurring in the Earth's crust.
3. It has been observed that magnetic fields sometimes have anomalous changes of a similar shape in the absence of earthquakes, and that such changes are thought to be related to other, unobservable geodynamic processes occurring in the Earth's crust.
4. The characteristics of the seismomagnetic effect depending on the epicenter distance were studied, taking into account the presence of the earthquake sources in the sedimentary layer, granite and basalt layers. Depending on the location of the observation point and the distance between the magnetometric observation point and the epicenter with physical-mechanical properties and magnetometric observation point and the composition of the medium in which the seismic magnetic effect spreads according to the layer in which the hypocenter is located, the observation and form of the observed anomalous seismomagnetic effect were different.
5. The seismomagnetic effect observed from the source in granite and basalt deposits is an bay-shaped form and is observed for about 20-25 days. This seismomagentic effect observed in sedimentary deposits is monitored with rhythmic changes and often in an uncharacteristic way for 40-50 days.
6. It has not been possible to determine the relationship between the depth of the layer where the epicenters are located and the physical and mechanical properties of the rocks formed by the environment in which the seismomagnetic effect is spread.

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STUDY OF ENGINEERING-GEOLOGICAL CONDITION OF THE TERRITORY OF BAKU CITY IN ORDER TO DETERMINE THE LEVEL OF SEISMIC HAZARD

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Introduction. Earthquakes are the most dangerous natural phenomena and are often accompanied by great disasters. Seismic hazard is mainly caused by seismic waves propagating in the epicenter of earthquakes. The severity of a seismic hazard varies depending on the magnitude of the earthquake, its depth and the distance to the study area. When the magnitude (M) of the earthquake is large, the depth (H) is small and the distance to the research area is close (Δ), the intensity of the hazard increases.

Studies show that, in addition to the above mentioned parameters, the level of seismic hazard is significantly influenced by the physical and mechanical parameters of the ground, hydrogeological and geomorphological conditions. Sometimes these factors can increase the level of seismic hazard to 1 (one) point, which has a significant impact on the seismic stability of civil and industrial facilities built there. For this reason, the study of physical and mechanical parameters, hydrogeological and geomorphological conditions of the ground in seismically active areas is important.

Seismic zoning and micro-zoning research is one of the important directions in modern seismology and these studies are conducted to ensure the seismic and environmental safety of industrial and civil facilities. If the micro-zoning works are carried out competently and accurately, then it may be possible to minimize seismic risk in the areas as well. These research works should be a reliable basis for seismic construction.

Seismic hazard assessment is related to the strong earthquakes, that is, earthquakes with the maximum magnitude should be selected from the strongest earthquakes in each region, and the highest level of seismicity should be determined for that region and the tectonic conditions, geological structure, lithological composition, seismological and hydrogeological conditions of each construction site should be carefully studied. Accurate information about the location of buildings and facilities should be obtained.

Analysis of historical and modern, macroseismic and instrumental data on earthquakes in Azerbaijan shows that no earthquake with a magnitude of higher than 7 points according to the MSK-64 scale has been recorded in the Absheron Peninsula, including Baku city.

In order to determine the spatial position of potential source zones in Azerbaijan, the regularities of the distribution of strong earthquakes on space (both lateral and vertical) and their connection with large depth faults have been studied [Mammadli, 2011]. It was revealed that, the greatest seismic hazard for the Absheron Peninsula, including the Baku city is expected to arise from potential source zones in the highly active Adjichay-Alyat, Palmir-Absheron, Goychay, Vandam, Siyazan and Makhachkala-Turkmenbashi depth faults.

In general, the background level of seismic hazard in different regions of Azerbaijan is currently assessed on the basis of the "Temporary seismic zoning map of the territory of the Azerbaijan Republic" [Ahmedbeyli et al. 1991]. (Fig.1).

According to this map, the background level of seismic hazard in the Absheron Peninsula, including Baku city, is 8 points on the 12-point MSK-64 scale. As mentioned above, in addition to the background level, the level of seismic hazard is also greatly influenced by the engineering-geological and hydrogeological conditions of the field.

These conditions are not identical in Baku. That is why the fact that the strong Caspian (Baku) earthquake on 25.11.2000 (M=6,2) was felt differently in different parts of Baku [Hasanov, Mammadli, 2008]. The earthquake occurred mostly in the areas where coastal areas are soft, wetlands are widespread and the groundwater levels are close to the surface.

In order to study the impact of engineering-geological and hydrogeological conditions on the level of seismic hazard in the territory of Baku city, during the last 15 years, the data of engineering-geological wells drilled in the areas where high-rise buildings were built have been analyzed

The results of the analysis show that the specified seismicity is estimated with 9 (nine) points, taking into account the engineering-geological and hydrogeological data of local soils in 30 construction sites of Sabayil district. These areas are mainly close to the seaside area of Sabayil district or 1.0-1.50 km away from the seashore. In these a[2]reas, the waters are mainly formed in the cast soil layer.

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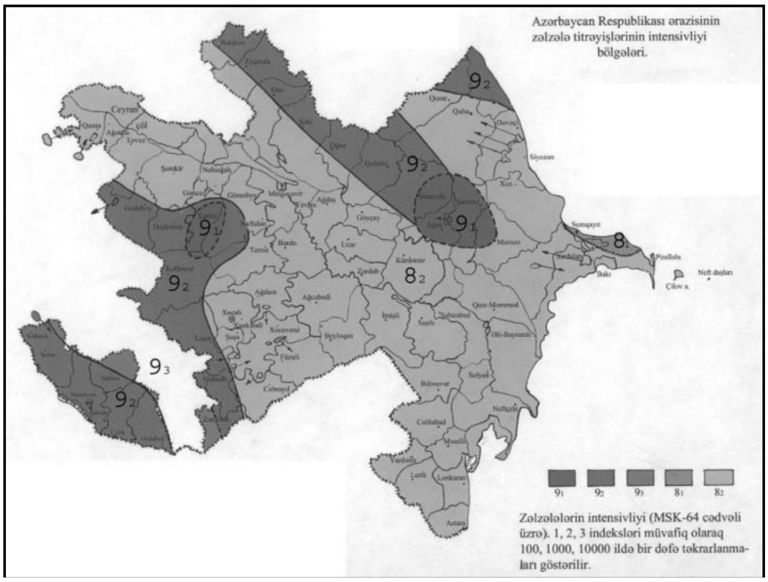

Figure.1. Seismic zoning map of the territory of Azerbaijan (1991)

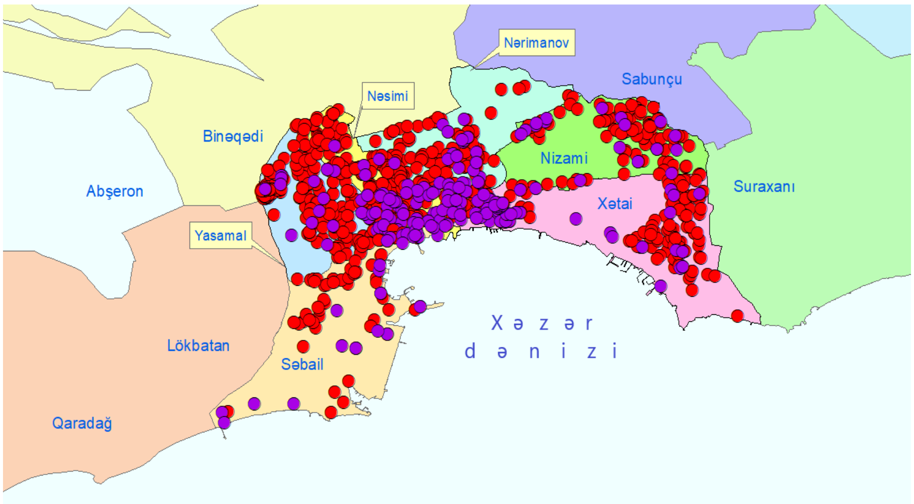

Figure 2. The distribution map of the areas with specified seismicity in the territory of Baku

Symbols

● - zones with low-intensity -8 (eight) point

● -zones with high-intensity -9 (nine) points

The majority part of Sabayil district belongs to the 8 points zone. In general, Sabayil district is assessed by 8 points.

The information obtained in Narimanov district belongs to the southern part of the area. Areas of high and relatively low-intensity are located chaotically in this area. Relatively low-intensity areas are in the majority and in general, Narimanov district belongs to the 8 (eight) points zone.

Groundwater is found at different depths in the area and has no effect on seismicity. There are very few fields with 8 (eight) points in the upper part of the district. It is impossible to make a conclusion about the intensity in that part.

A total of 27 research areas in Yasamal district have been assessed by 9 (nine) points, and the remaining areas with 8 (eight) points. Groundwater is mostly in one horizon, rarely found in two horizons, and have had little effect on ground composition. The seismicity of Yasamal district is estimated with magnitude of 8 (eight) points.

Both engineering-geological and hydrogeological conditions have a great influence on the level of intensity in Khatai district. In particular, the impact of existing waters on the so-called "White City" and coastal areas is great. Groundwater is mostly formed in sands and plastic clays and are found at at different depths of the ground. However, in some areas there is no groundwater at all. As a result, the area called "White City" and coastal areas are assessed by high-magnitude earthquake. In general, 37 research areas in the district are assessed with 9 (nine) points. In the rest part of area, the level of seismic hazard is estimated with 8 (eight) points.

27 research areas in Nasimi district are assessed with high magnitude. 25 of these areas are located in the south-eastern part of the region. Groundwater is mainly formed in cast and moist, wet sandy soils and has an effect on seismicity (in the area with 9 (nine) points zones).

The rest of the district was assessed by a relatively low magnitude. Almost weak grounds in Nasimi district are mainly developed compeletely in the south-eastern part of the district. Thus, Nasimi district is divided into two parts: the south-eastern part - high-magnitude zones and the rest zones - low- magnitude zones.

Both weak and strong grounds are found in lithological sections in Nizami district.The most common grounds are limestone and clay. The role of groundwater affecting seismic intensity in this region is great. There are two types of groundwater in Nizami district: pressurized groundwater - found at depths of 30, 50 and 80 m; unpressurized groundwater is found in two horizons and at different depths (5,0-10.0 m).

Artesian (pressurized) groundwater is located in the northwest of the region - near the lake "Boyuk Shor" (source of artesian water). This is a dangerous situation for the area, that is, it is an unsuitable for construction.

In the north-eastern part of Nizami district, unpressurized groundwater is found. These groundwater is formed in a thick sandy ground. The seismicity of the area is estimated with high-magnitude. In the rest part of area, the groundwater is found at different depths and is less in thickness. This part is estimated by low magnitude.

Grounds typical of the fourth period are found in the territory of Baku city and the grounds in the sections are shown below:

1. Solid consistency, semi-solid consistency, hard, hard plastic clays
2. Fine-grained, dusty, wet and moist sand soils
3. Solid consistency and plastic sandy loam
4. Solid consistency, solid plastic, hard plastic, soft plastic sandy loam grounds
5. Medium-durable and less durable limestone grounds
6. Weakly durable sandstone
7. Gravel is rarely found

There are semi-solid clay rocks that are widespread in the area and have a large thickness (4,50 – 50m).This ground is considered to be the standard soil and is widespread in 5 (five) districts of Baku. Limestone ground predominates only in Yasamal district. (Fund of RSSC of ANAS. Reports, 2003-2018).

According to AzSCS (AzDTN) - 2,3-1, semi-solid clay ground – standart ground of the fourth period, belonging to the II class with natural moisture, has the following seismic hardness indicators:

In case of natural moisture-Medium

Volume weight (density) - ρ0 = 1.60 g / cm3

The average velocity of transverse seismic wave propagation in the ground -

$$V0 = 550 \text{ m / sec}$$

It is a widespread limestone soil in Yasamal district: its thickness varies from 4.50 to 25.0 m and its main parameters are as follows:

$$\rho o = 2.0 \text{ q / cm3}$$
$$Vo = 800 \text{ m / sec.}$$

The composition of grounds, especially clay grounds, may vary depending on the season. It is seasonal: when atmospheric precipitation occurs, the rocks are moistened, irrigated, and the cement of the ground is broken down or the ground is swollen. In dry hot weather, grounds dry out and fractures may form in them. And this increases the negative impact on the seismicity of the area.

Conclusion

1. Totally it has been determined that, the reference standart ground for the 5 (five) district of Baku city (Sabayil, Nasimi, Narimanov, Nizami and Khatai) is semi-solid clay according to AzSCS2.3-1, and only for Yasamal district the standard ground is limestone.

2. Seismic hazard is estimated with the high-magnitude in coastal areas (mainly Sabayil and Khatai districts).

3. The level of potential seismic hazard has been specified for six districts of Baku based on fund materials.

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STUDY OF STRESS-STRAIN STATE OF GEOLOGICAL ENVIRONMENT BY GRAVIMETRIC STUDIES OF THE FILIZCHAY PYRITE-POLYMETALLIC DEPOSIT

E.M.Baghirov[1], A.T.Ismayılova[1]

The deposit we will inform about in the article is one of the largest deposits in Europe in terms of ore reserves, very rich polymetallic (Zn, Pb, Cu, Ag, Au, Co, etc.) reserves and is one of the largest projects in the Filizchay field prepared by “AzerGold” CJSC for operation. It is necessary to conduct complex preventive seismological and geophysical studies in the area in order to prevent adequate measures from the impact of any expected natural disaster factors on these facilities, sustainability of mining complexes and related infrastructures during operation in general, to minimize risk factors. For this purpose, a local gravimetric observation network has been established in this area to determine the activation dynamics and the gravimetric studies have been conducted.

A network of observation points has been established, taking into account the geomorphological features, relief, forest and impassable places with bushes of the field area and studies have been carried out to determine the relative gravity and the probable stress dynamics.

Isoanomal maps and 3D models reflecting the stress and depth dynamics of the gravitational field of both areas and characterizing these geodynamic stress changes have been created by the method of gravimetric exploration. The obtained data allowed to monitor tectonic disturbances in different depth intervals in the area and to assess the geodynamic regime of the area during the operation of the field.

Thus, the growth gradient of gravitational field stress detected as a result of discrete gravimetric observations in the deposit area in terms of space-time, stress situation in the exploitation field allows to get information about the relative gravity.

Gravimetric observations have been carried out at selected points established on a special network on foot by operators, with a high-precision gravimeter device CG-5 AutoGrav made in Canada in the area where “AzerGold” CJSC is preparing for operation in the Filizchay field located in Balakan region.

The studies have been carried out by the method of repeated measurement at the observation and support points in the 1st and 2nd areas of the Filizchay field, where “AzerGold” CJSC is preparing for operation (Fig. 1).

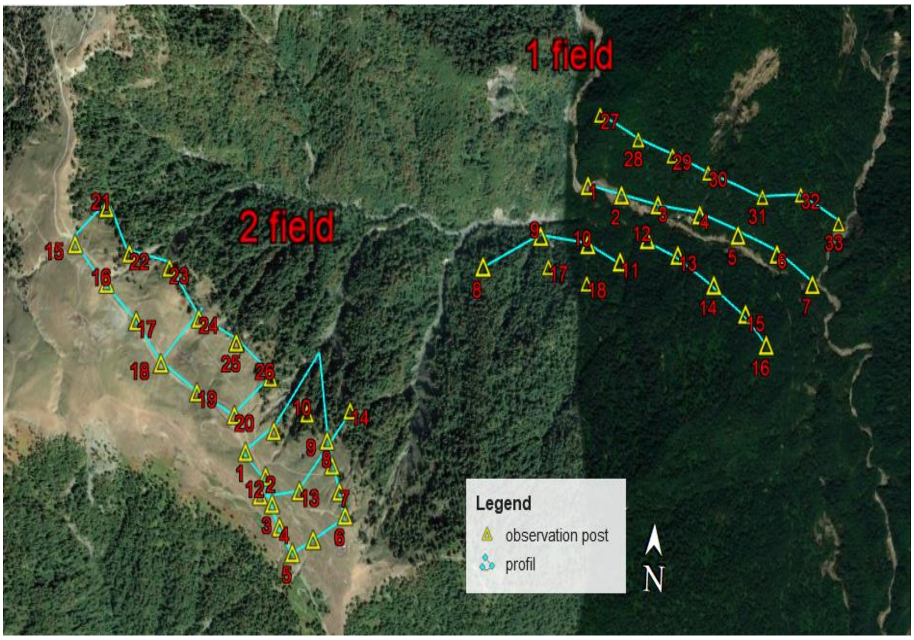

Figure 1. The layout scheme of the gravimetric observation points in the Filizchay area.

Based on the information obtained during the selection of gravimetric plofiles, the geological structure of the area, the location of tectonic faults, the dimensions, depth and contours of potential danger zones of the mass which may be the activity dynamics will be determined. Gravimetric measurements have been carried

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out in Filizchay area numbered 1 with profile IV of 25 physical point and Filizchay with 26 ph.p. The total volume of observation works have been 51 ph.p.

Visually the structure of the relief in the intersection scheme on profile, distance between observation points, at what height above sea level and etc. have been presented as an example (Fig. 2)

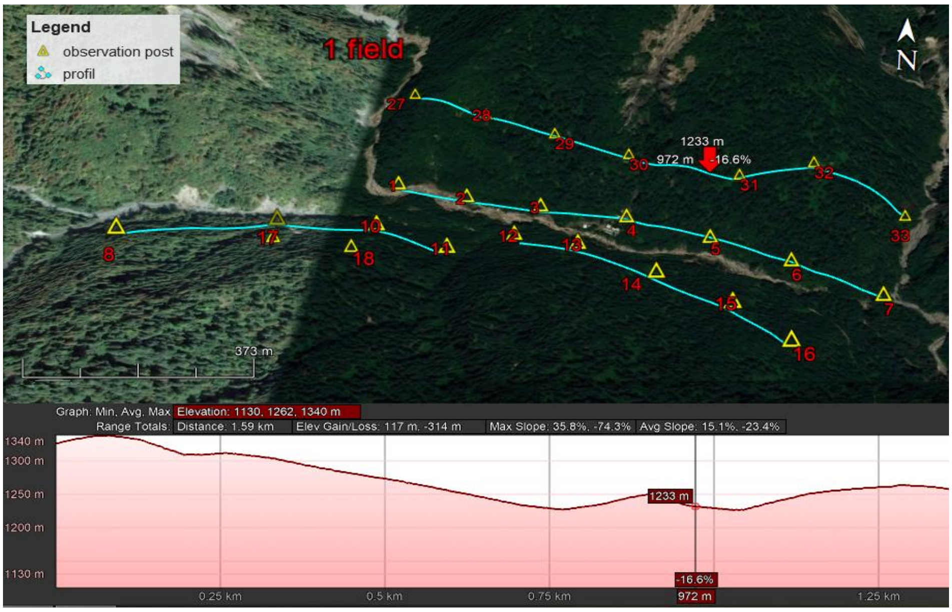

Figure 2. The scheme of intersection on profile I, where gravimetric observation points are located in Filizchay 1 area.

Based on the results of the initial calculations and change of gravity field on each profile in Balakan Filizchay 1 field, a 2-dimensional isoanomals map of the gravitational field (Fig. 3) and 3-dimensional models have been compiled (Fig. 4)

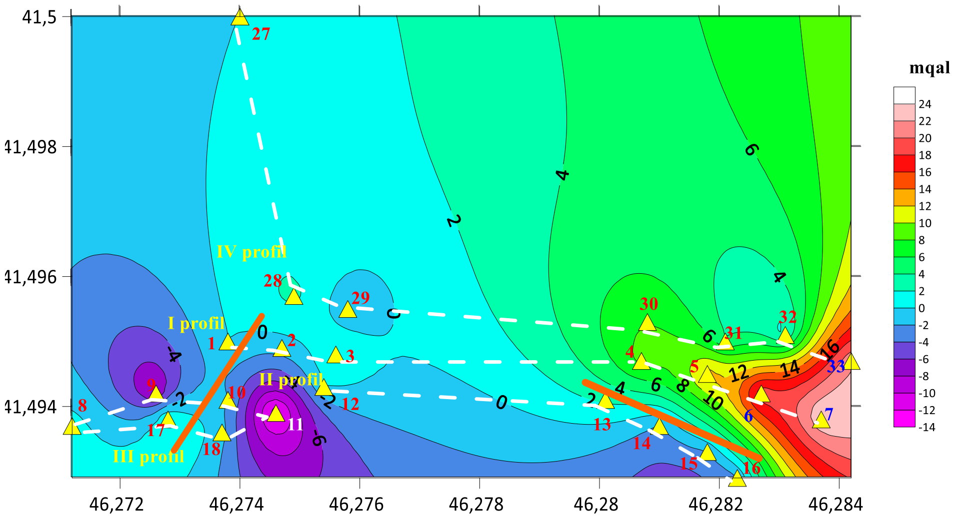

Figure 3. Isoanomals map of the gravitational field reflecting the stress-strain state of the Filizchay 1 area.

Symbols:

△ observation points — — — profiles ▬ violation zone

As can be seen from the isoanomal map of the gravitational field, the anomalous zones accompanied by a variable value of relative gravity have been accurately covered in this map. Thus, the relative gravity varies from the north of the study area to the south-west and relatively south-east with a minimum value - from 1,179 mg to 13,364 mg. This anomaly is spread from north to south and southwest and remains closed in the north and open in the south.

In the south-eastern wing of the map, there is another complication in the gravitational field, which is the exact opposite of the anomaly in the south-west direction, with an increase in the gravitational field from 2,466 mg to 21,488 mg at the maximum value. These anomalies are from the first observation point of profile IV from north to south, from 1, 2, 3 m/m of profile I, and in the form of completely stretched of profiles II and III.

If we pay attention to the 3D model of the stress-strain state of the geological environment based on gravitational field data, according to field numbered 1 of Filizchay deposit, the results of the interpretation which mentioned above is noticeable with precision (Fig. 4).

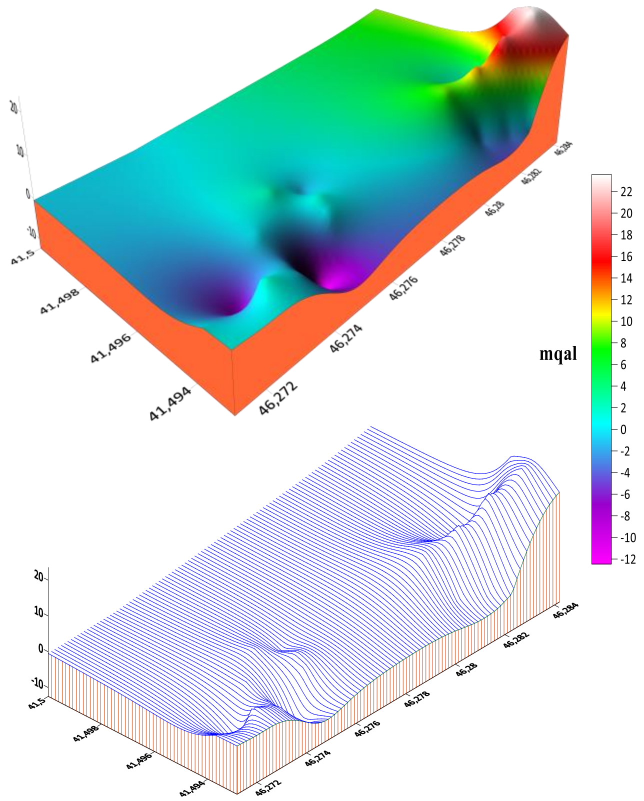

Figure 4. 3D model reflecting the stress-strain condition of Filizchay 1 area.

Gravimetric measurements in Balakan Filizchay 2 have been carried out in the same way as in field 1, taking into account the repeated and auxiliary measurements in the amount of 26 ph.p.

Based on the gravimetric observation data developed in the Filizchay field numbered, change maps of the gravitional field have been compiled. Here we pay attention to the schematic map of the stress-strain state of the geological environment in 2D format (Fig.5.).

Glancing at the map, it is clear that there is anomaly varies from 0.138 mgal to -9.813 mgal of the relative gravitation of isoanomals, characterized by minimums in a diagonal shape from southwest to northeast.

On the contrary, there is an increase in the gravitational field from 2,526 mgal to 7,321 mgal in the south-east and from 2,203 mgal to 4,149 mgal in the northwest of the diagonal that divides the map into two minimum values.

The above-mentioned anomalous zones are more clearly visible on the map created in 3D format (Fig. 6). The intensity of the gravitational field is almost at the background level, except for small increases in the right and left wings of the map. Along the diagonal, in the north-east of the direction, on the contrary, there are complex anomalous zones characterized by a minimal value of the intensity of the gravitational field.

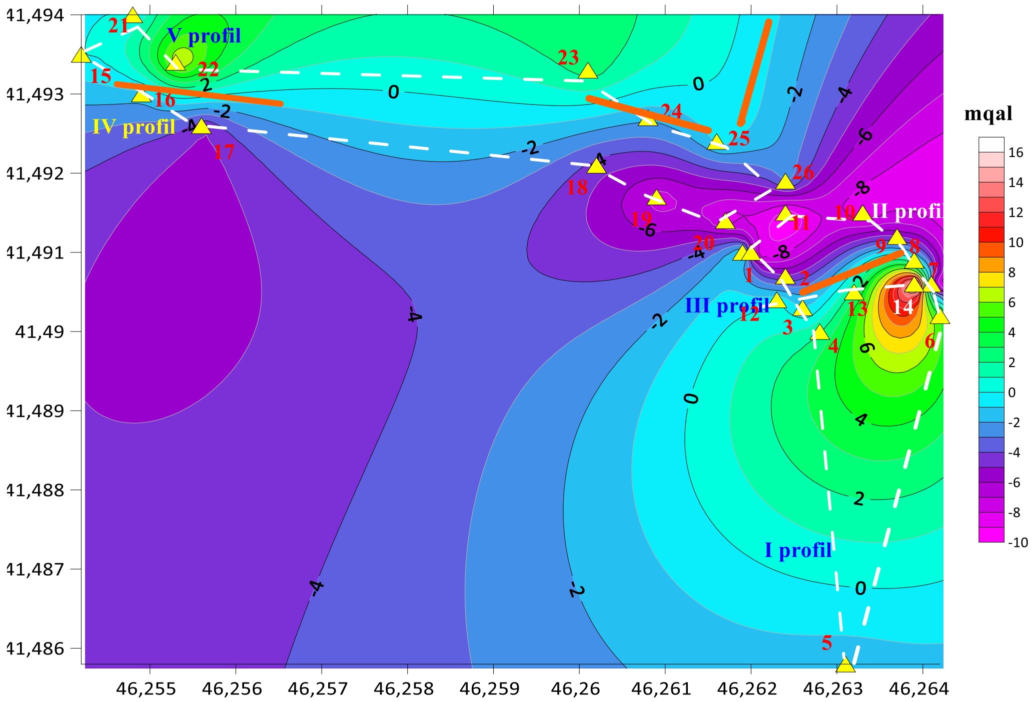

Figure 5. Isoanomals map of the gravitational field reflecting the stress-strain state of the Filizchay 2 area (around Gubek mountain).

Symbols:

△ observation points — — — profiles ▬ violation zone

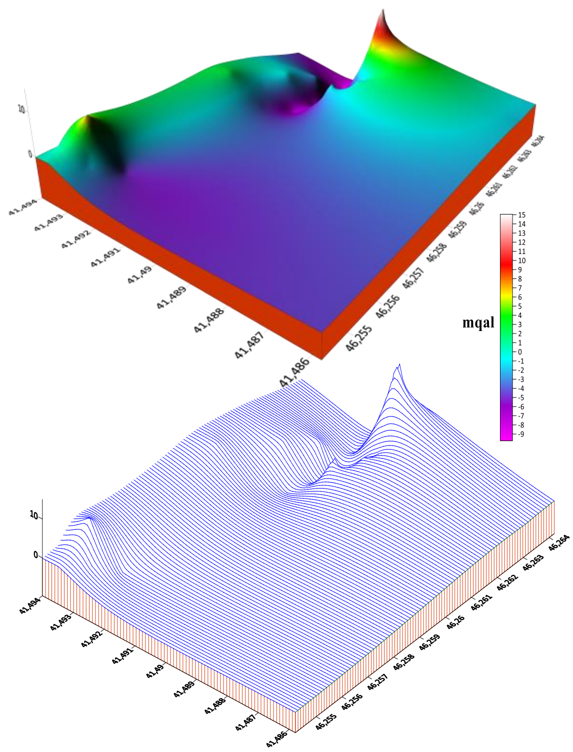

Figure 6. 3D model reflecting the stress-strain state of the gravitational field in the Filizchay 2 area (Mount Gubek).

In addition, based on observations conducted in both areas of the Filizchay field, spectral analysis was provided along with the construction of 2D format isoanomal maps and 3D models reflecting the stress-strain state of the geological environment.

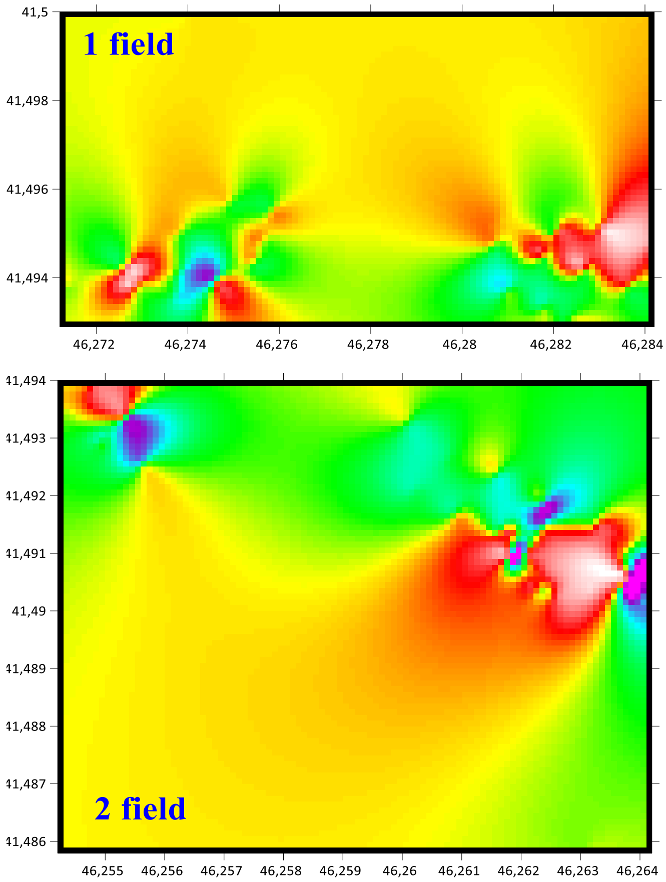

Figure 7. Spectral analysis reflecting the stress-strain state of the gravitational field in Filizchay fields numbered 1 and 2
Symbols:
- stable areas - intensive areas (min-max)
- an intensive area accompanied by minimums

The result

1. The geodynamic regime of the area to be exploited in the Filizchay field has been assessed and the stress dynamics of the gravitational field has been studied and a potential tectonic fault zone has been identified in each of the fields 1 and 2.

2. On the map of isoanomalities of the gravitational field, the anomalous zones accompanied by a variable value of Δg and dynamics of the mass characterizing the anomalous areas are shown to be active and these areas are tend to landslides.

3. Isoanomal maps, 3D models and shadow maps of spectral analysis reflecting the stress-strain state of the geological environment have been created by gravimetric method, based on observations in the field, anomalous areas have been separated accompanied by gradient increase and decrease of tension in local areas.

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ANNOTATIONS

1. SEISMICITY OF THE TERRITORY OF AZERBAIJAN IN 2019

G.J. Yetirmishli, S.S. Ismayilova, S.E.Kazimova

The article provides an analysis of the seismicity of Azerbaijan territory for 2019 year. Maps of the earthquake epicenters are shown in this article and 5442 seismic shocks were recorded. The distribution of earthquakes by regions is related to their tectonic structure. Histograms of the number of earthquakes in the area and the distribution of released seismic energy for months, as well as years have been created.

It was determined that seismic activity in the south-eastern slope of the Greater Caucasus-Zagatala-Balakan zone is A_{10} = 1.6-2.0, in Shamakhi-Ismayilli zone A_{10} = 1.6-2.0, in Talish A_{10} = 1.6-2.0, in the north of the Caspian Sea A_{10} = 0.6-1.0, in the center A_{10} = 0.9-1.6, and in the southern part the active areas are equal to A_{10} = 1.0-1.7.

Compared to 2018, the number of earthquakes in 2019 increased, and the amount of released seismic energy has decreased. Thus, in 2018, the number of earthquakes in the territory of Azerbaijan was 4081, the amount of released seismic energy ∑E = 42.7 · 1011C, the maximum magnitude ml = 5.5, the number of earthquakes in 2019 was 5442, the amount of released seismic energy ∑E = 31.9 · 1011C, the highest magnitude ml = 5.2.

Based on the data of the obtained earthquake source mechanisms, the scheme of compression and tension axes was constructed. As can be seen from the map, the compression axes in the Zakatala-Balakan zone are mainly directed in the direction of the NEW-SE, in the Shamakhi-Ismayilli, Middle and Lower Kura basins and in the Talish zone in the direction of the NE-SW.

Keywords: *epicenter, background seismicity, source mechanisms.*

2. QUANTITATIVE ASSESSMENT OF SEISMIC HAZARD IN THE AZERBAIJANI PART OF THE SOUTHERN SLOPE OF THE GREATER CAUCASUS

T.Y.Mammadli, T.I. Jafarov

Analysis of the seismicity of the territory of Azerbaijan shows that the southern slope of the eastern part of the Greater Caucasus is characterized by higher activity. In the seismic zoning map of the territory of Azerbaijan compiled by the method called "seismotectonic" or "genetic", the seismic hazard of this zone is estimated at 9 points on the MSK-64 scale. In the article, the level of seismic hazard of the Azerbaijani part of the southern slope of the Greater Caucasus was calculated by the probabilistic method. In this case, the seismic hazard is expressed in terms of peak ground acceleration (PGA), which can be caused by strong earthquakes on the earth's surface and the probable seismic hazard in the area has been quantified.

Keywords: *seismicity, ground acceleration, seismic hazard, seismic zoning, depth faults, earthquake source zones.*

3. FEATURES OF GEOMAGNETIC EFFECTS OF SEISMOGEODYNAMIC CHANGES IN THE TERRITORY OF AZERBAIJAN

A.G.Rzayev, H.O.Veliyev, A.N.Sultanova,
A.N.Memmedova, A.F.Aliyeva

In seismically active regions of the world, before strong earthquakes, it was recorded that the geomagnetic field has changed abnormally, and so far, the regularity of the seismomagnetic effect and other warning factors as a short-term, instantaneous forecast has not been fully confirmed.

As one of the warning factors, since the signs of anomalous electromagnetic change are more convincing than other forecasting factors, data on changes in magnetic field over time at different points in Azerbaijan have been analyzed since the 1980's. Measurement data of magnetometric regime observations in 6 regular points of the Republican Seismic Survey Center of ANAS have been analyzed in connection with earthquakes magnitude of M≥4.0 in the territory of Azerbaijan and features of epicenter-dependent change of seismomagnetic effect have been investigated. It has been found that anomalous magnetic changes sometimes last from 2-3 days to 25-30 days, and the amplitude of the changes is 30-40 nTl and sometimes more. Features of the seismomagnetic effect associated with M≥4.0 earthquakes in the territory of Azerbaijan. For the first time, based on the analysis carried out taking into account the depth of the hypocenter of the earthquake and the stratum complex, it was determined that the seismomagnetic effect was observed in different forms.

It has been shown that the seismomagnetic effect observed in the foci in the granite and basalt layers is bay-shaped and observed for about 20-25 days, while the seismomagnetic effect observed in the foci in the sedimentary layer is observed with rhythmic changes and sometimes uncharacteristic for 40-50 days.

Keywords: *geomagnetic field, stress-strain conditions, tectonomagnetic effect, seismomagnetic effect, anomalous geomagnetic fields, earthquake sources and etc.*

4. STUDY OF ENGINEERING-GEOLOGICAL CONDITION OF THE TERRITORY OF BAKU CITY IN ORDER TO DETERMINE THE LEVEL OF SEISMIC HAZARD

Z.S.Aliyeva, L.T.Fattahova, L.A.Ibrahimova, I.N.Djalilova, S.S.Hajıyeva, A.G.Rahimli

Engineering-geological studies have been conducted in a part of the territory of the Republic of Azerbaijan, Baku city (Sabayil, Yasamal, Nasimi, Narimanov, Nizami and Khatai districts). Mainly engineering-geological and hydrogeological data, obtained from more than ten thousand wells drilled in the study area, as well as geomorphological conditions have been studied.

In the end, the potential seismicity in the studied area of Baku has been specified.

Keywords: *ground, seismic hazard, hydrogeological, engineering-geological, intensity.*

5. STUDY OF STRESS-STRAIN STATE OF GEOLOGICAL ENVIRONMENT BY GRAVIMETRIC STUDIES OF THE FILIZCHAY PYRITE-POLYMETALLIC DEPOSIT

E.M.Baghirov, A.T.Ismayılova

Reflecting the gravitational field stress and depth dynamics of the area by gravimetric exploration, these geodynamic stress changes allowed the observation of tectonic disturbances in different depth intervals in the area and the assessment of the geodynamic regime of the area during field operation. The dynamics of the mass characterizing Δg the anomalous areas have been shown to be active.

Keywords: *Filizchay deposit, landslide, tectonic disturbances, anomalous zones, gravity force, conducted observations, gravimetric field.*

ANNOTASİYALAR

1. 2019-CU İL ƏRZİNDƏ AZƏRBAYCAN ƏRAZİSİNİN SEYSMİKLİYİ

Q.C. Yetirmişli., S.S. Ismailova., S.E. Kazimova

Məqalədə Azərbaycan ərazisinin 2019-cu il üçün seysmikliyinin təhlili verilmişdir. Zəlzələnin episentrlər xəritələri göstərilir. 5442 seysmik hadisə qeyd olunub. Zəlzələlərin bölgələr üzrə paylanması, tektonik quruluşu ilə əlaqısi göstərilib. Ərazilərdə baş vermiş zəlzələlərin sayının və ayrılan seysmik enerjinin aylar, eləcədə illər üzrə paylanması histoqramları qurulub.

Müəyyən olunub ki, Böyük Qafqazın cənub-şərq yamacında - Zaqatala-Balakən zonasında seysnik aktivlik A_{10}=1.6-2.0, Şamaxı-İsmayıllı zonasında A_{10}=1.6-2.0, Talışda A_{10}=1.6-2.0, Xəzər dənizində şimalında A_{10}=0.6-1.0, mərkəzində A_{10}=0.9-1.6, cənub hissəsində aktiv sahələr A_{10}=1.0-1.7 bərabərdir.

2018-ci ilə nisbətən 2019-cu il ərzində zəlzələlərin sayı çox, ayrılan seysmik enerjinin miqdarı isə azalmışdır. Belə ki, 2018-ci ildə Azərbaycan ərazisində zəlzələlərin sayı 4081, ayrılan seysmik enerjinin miqdarı $\sum E=42.7\cdot 10^{11}$C, ən yüksək maqnituda ml=5.5 olduğu halda, 2019-cu ildə zəlzələlərin sayı 5442, ayrılan seysmik enerjinin miqdarı $\sum E=31.9\cdot 10^{11}$C, ən yüksək maqnituda ml=5.2 olmuşdur.

Alınmış zəlzələ ocaq mexanizmlərin məlumatların əsasında sıxılma və gərilmə oxların sxemi qurulmuşdur. Xəritədən göründüyü kimi Zakatala-Balakən zonasında sıxılma oxları əsasın ŞŞQ-CŞ istiqamərində, Şamaxı-İsmayıllı, Orta və Aşağı Kür çökəkliyində və Talış zonasında ŞŞ-CQ istiqamətində yönəlmişdir.

Açar sözlər: *episentr, fon seysmikliyi, ocaq mexanizmləri.*

2. BÖYÜK QAFQAZIN CƏNUB YAMACININ AZƏRBAYCAN HİSSƏSİNDƏ SEYSMİK TƏHLÜKƏNİN KƏMİYYƏTCƏ QİYMƏTLƏNDİRİLMƏSİ

T.Y.Məmmədli, T.İ. Cəfərov

Azərbaycan ərazisinin seysmikliyinin analizi Böyük Qafqazın şərq hissəsinin cənub yamacının daha yüksək aktivliklə səciyyələndiyini göstərir. “Seysmotektonik” və ya “genetik” adlanan metodla tərtib edilmiş Azərbaycan ərazisinin seysmik rayonlaşdırma xəritəsində bu zonanın seysmik təhlükəsi MSK-64 şkalası ilə 9 bal qiymətləndirilir.

Məqalədə Böyük Qafqazın cənub yamacının azərbaycan hissəsinin seysmik təhlükəlilik səviyyəsi ehtimal metodu ilə hesablanmışdır. Bu zaman seysmik təhlükə güclü zəlzələlərin yer səthində əmələ gətirə biləcəyi qrunt təcilinin maksimum kəmiyyətləri (PGA) ilə ifadə olunmuş və ərazidə ehtimal olunan seysmik təhlükə kəmiyyətcə qiymətləndirilmişdirir.

Açar sözlər: *seysmiklik, qrunt təcili, seysmik təhlükə, seysmik rayonlaşdırma,dərinlik qırılmaları, zəlzələlərin ocaq zonaları.*

3. AZƏRBAYCAN ƏRAZİSİNDƏ SEYSMOGEODİNAMİK DƏYİŞMƏLƏRİNİN GEOMAQNİT EFFEKTLƏRİNİN XÜSUSİYYƏTLƏRİ

A.Q.Rzayev, H.Ö.Vəliyev, A.N.Sultanova,
A.N.Məmmədova, A.F.Aliyeva

Dünyanın seysmoaktiv regionlarında, baş verən güclü zəlzələlərdən əvvəl geomaqnit sahəsinin anomal dəyişdiyi qeyd edilmiş və indiyə kimi qısa müddətli, ani proqnoz kimi seysmomaqnit effektin və digər xəbərverici amilin qanunauyğunluğunun tam təsdiqlənmədiyi göstərilmişdir.

Xəbərverici amillərdən biri kimi, anomal elektromaqnit dəyişmə əlamətləri digər proqnoz amillərindən, daha inandırıcı olduğundan Azərbaycan ərazisində 1980-ci illərdən başlayaraq müxtəlif məntəqələrdə maqnit sahəsinin zaman etibarilə dəyişmələrinə dair məlumatların təhlili aparılmışdırş. AMEA Respublika Seysmoloji Xidmət Mərkəzinin daimi fəaliyyət göstərə 6 məntəqədə maqnitometrk rejim müşahidələrinin ölçmə məlumatları Azərbaycan ərazisində M≥4,0 zəlzələlərlə əlaqəli təhlil edilmiş və seysmomaqnit effektin episentral məsafədən asılı dəyişmə xüsusiyyətləri araşdırılmışdır.Anomal maqnit dəyişmələrinin bəzən 2-3 gündən 25-30 günə qədər davam etdiyi, dəyişmələrinin amplitudasının 30-40 nTl və bəzən daha çox olduğu müəyyən edilmişdir. Azərbaycan ərazisində M≥4,0 zəlzələlərlə əlaqəli seysmomaqnit effektin xüsusiyyətləri ilk dəfə olaraq zəlzələnin hiposentrinin dərinliyi və hansı lay kompleksində olması nəzərə alınmaqla aparılan təhlil əsasında seysmomaqnit effektin müxtəlif formada izləndiyi müəyyən edilmişdir.

Qranit və Bazalt qatlarda olan ocaqlardan müşahidə olunan seysmomaqnit effektin buxtaşəkilli formada olması və təqtibən 20-25 gün ərzində izlənildiyi, Çökmə qatda olan ocaqlardan isə müşahidə olunan seysmomaqnit effekt ritmik dəyişmələrlə və çoxda xarakterik olmayan şəkildə olmaqla bəzən 40-50 dün müddətində izlənildiyi göstərilmişdir

Açar sözlər: *geomaqnit sahəsi, gərginlik-deformasiya şəraiti, tektonomaqnit effekt, seysmomaqnit effekt, anomal geomaqnit sahələri, zəlzələ ocaqları və s.*

4. BAKI ŞƏHƏRİ ƏRAZİSİNİN SEYSMİK TƏHLÜKƏ SƏVİYYƏSİNİN DƏQİQLƏŞDİRİLMƏSİ MƏQSƏDİLƏ MÜHƏNDİSİ-GEOLOJİ ŞƏRAİTİNİN TƏDQİQİ

Z.S.Əliyeva, L.T.Fəttahova, L.A.İbrahimova, İ.N.Cəlilova, S.S.Hacıyeva, A.G.Rəhimli

Aərbaycan Respublikası, Bakı şəhəri ərazisinin bir hissəsində (Səbail, Yasamal, Nəsimi, Nərimanov, Nizami və Xətai rayonları ərazisində) mühəndisi-geoloji tədqiqat işləri aparılmışdır. Əsasən tədqiqat ərazisində qazılmış on mindən artıq quyudan alınmış mühəndisi-geoloji və hidrogeoloji məlumatlar, həmçinin geomorfoloji şərait araşdırılmışdır.

Yekunda Bakı şəhərinin tədqiq olunan ərazisində potensial seysmiklik dəqiqləşdirilmişdir.

Açar sözlər: *qrunt, seysmik təhlükə, hidrogeoloji, mühəndisi-geoloji, intensivlik.*

5. FİLİZÇAY KOLÇEDAN-POLİMETAL YATAĞININ QRAVİMETRİK TƏDQİQATLARLA GEOLOJİ MÜHİTİNİN GƏRGİNLİK DEFORMASİYA VƏZİYYƏTİNİN ÖYRƏNİLMƏSİ

E.M. Bagirov , A.T.İsmayılova

Qravimetrik kəşfiyyat üsulu ilə ərazinin qravitasiya sahəsinin gərginliyini və dərinlik dinamikasını əks etdirən, bu geodinamik gərginliyin dəyişməsi ərazidə müxtəlif dərinlik intervallarında tektonik pozulmaların izlənilməsinə və yatağın istismarı zamanı ərazinin geodinamik rejiminin qiymətləndirilməsinə imkan vermiş, Δg-nin dəyişkən xarakterli qiyməti ilə müşayət olunan anomal zonalar ayrılmış və anomal sahələri səciyələndirən kütlənin dinamikası aktiv olduğu göstərilmişdir.

Açar sözlər: *Filizçay yatağı, ağırlıq qüvvəsi, qabarmayan variasiyalar, anomal zonalar,tektonik pozulmalar, qravimetrik sahə.*

АННОТАЦИИ

1. СЕЙСМИЧНОСТЬ ТЕРРИТОРИИ АЗЕРБАЙДЖАНА В 2019 ГОДУ

Г.Дж.Етирмишли, С.С.Исмайлова, С.Э.Казымова

В статье дан анализ сейсмичности территории Азербайджана за 2019 год. Показаны карты эпицентров землетрясений. Локализовано 5442 сейсмособытия. Представлено распределение землетрясений по районам, приведены графики выделенной сейсмической энергии и числа землетрясений по месяцам.

Самым значительным сейсмическим событием на территории республики в 2019 году было землетрясение 5 февраля с ml=5.2 и интенсивностью в эпицентре I_0=6 баллов, произошедшее в Исмаиллинском районе. Анализ сейсмической активности в Закатало-Балаканской зоне показал A_{10}=1.6-2.0, в Шамахы-Исмаиллинской зоне A_{10}=1.6-2.0, в Талышском регионе A_{10}=1.6-2.0, в акватории Каспия на севере A_{10}=0.6-1.0, в центре акватория A_{10}=0.9-1.6, на юге A_{10}=1.0-1.7.

Подводя итоги анализа сейсмичности Азербайджана в 2019 году, можно отметить, что ее уровень, по сравнению с 2018 годом, увеличился по числу землетрясений, (2018 N_Σ=4081), но уменьшился по величине выделенной сейсмической энергии, с $\Sigma E=42{,}7\cdot10^{11}$ *Дж* в 2018 г. до $\Sigma E=31{,}9\cdot10^{11}$ *Дж* в 2019 г.

Были проанализированы механизмы 60 землетрясений. По данным механизмов очагов землетрясений была построена карта осей сжатия и растяжения. Было установлено, что в Закатало-Балаканском районе оси сжатия ориентированы в ССЗ-ЮВ направлении, а в Шамаха-Исмаиллинском районе, на территории Куринской впадины и в Талышском районе - СВ-ЮЗ направлении.

Ключевые слова: *Эпицентр, фоновая сейсмичность, механизм очага.*

2. КОЛИЧЕСТВЕННАЯ ОЦЕНКА СЕЙСМИЧЕСКОЙ ОПАСНОСТИ АЗЕРБАЙДЖАНСКОЙ ЧАСТИ ЮЖНОГО СКЛОНА БОЛЬШОГО КАВКАЗА

Т.Я.Маммадли, Т.И.Джафаров

Анализ сейсмичности территории Азербайджана показывает, что южный склон восточной части Большого Кавказа характеризуется более высокой активностью. На карте сейсмического районирования территории Азербайджана, составленной по так называемым «сейсмотектоническим» или «генетическим» методам, сейсмическая опасность данной зоны оценивается в 9 баллов по шкале MSK-64.

В статье уровень сейсмической опасности азербайджанской части южного склона Большого Кавказа был рассчитан вероятностным методом. Это позволяет оценивать сейсмическую опасность количественно, выраженной в значениях максимального ускорения грунта (PGA), которое может быть вызвано сильными землетрясениями на поверхности Земли.

Ключевые слова: *сейсмичность, ускорение грунта, сейсмическая опасность, сейсмическое районирование, глубинные разломы, очаговые зоны землетрясений.*

3. ОТРАЖЕНИЕ ГЕОДИНАМИКИ ТЕРРИТОРИИ АЗЕРБАЙДЖАНА В ОСОБЕННОСТЯХ ИЗМЕНЕНИЙ ГЕОМАГНИТНОГО ЭФФЕКТА

А.Г.Рзаев, Х.У.Велиев, А.Н.Султанова, А.Н.Маммадова, А.Ф.Алиева

Проанализированы данные мониторинга напряженности геомагнитного поля на 6-ти опорных магнитовариационных станциях Республиканского центра сейсмологической службы НАНА, выявлены особенности проявления сейсмомагнитного эффекта при землетрясениях M≥4. Установлено, что аномальные изменения напряженности геомагнитного поля длятся от 2-3 дней до 25-30 дней до основного толчка, при этом амплитуда изменений сейсмомагнитного эффекта составляет до 30-40 нТл. Впервые на основе анализа, проведенного с учетом глубины гипоцентра землетрясения и толщи комплекса пород, установлены особенности различных форм проявления сейсмомагнитного эффекта. Показано, что сейсмомагнитный эффект в гранитном и базальтовом слоях наблюдался в эллиптической форме в течение примерно 20-25 дней, а сейсмомагнитный эффект в осадочном слое проявлялся с ритмическими изменениями, иногда не характерным образом в течение 40-50 дней.

Ключевые слова: *геомагнитное поле, напряженно-деформированные условия, тектономагнитный эффект, сейсмомагнитный эффект, аномальные геомагнитные поля, очаги землетрясений и др.*

4. ИЗУЧЕНИЕ ИНЖЕНЕРНО-ГЕОЛОГИЧЕСКИХ УСЛОВИЙ С ЦЕЛЬЮ УТОЧНЕНИЯ УРОВНЯ СЕЙСМИЧЕСКОЙ ОПАСНОСТИ ТЕРРИТОРИИ ГОРОДА БАКУ

З.С.Алиева, Л.Т.Фаттахова, Л.А.Ибрагимова, И.Н.Джалилова, С.С.Гаджиева, А.Г.Рагимли

Инженерно-геологические исследования проводились на части территории Азербайджанской Республики, в городе Баку (Сабаильский, Ясамальский, Насиминский, Наримановский, Низаминский и Хатаинский районы). Изучены инженерно-геологические и гидрогеологические данные, полученные по более чем десяти тысячам скважин, пробуренным на исследуемой территории, а также геоморфологические условия.

В результате, была уточнена потенциальная сейсмичность в исследуемом районе города Баку.

Ключевые слова: *грунт, сейсмическая опасность, гидрогеологический, инженерно-геологический, интенсивность.*

5. ИЗУЧЕНИЕ НАПРЯЖЕННОСТИ И СОСТОЯНИЯ ДЕФОРМАЦИИ ГЕОЛОГИЧЕСКОЙ СРЕДЫ ПО ГРАВИМЕТРИЧЕСКИМ ИССЛЕДОВАНИЯМ ФИЛИЗЧАЙСКОГО КОЛЧЕДАН-ПОЛИМЕТАЛЛИЧЕСКОГО МЕСТОРОЖДЕНИЯ

Э.М. Багиров, А.Т.Исмайлова

Эти изменения геодинамических напряжений, отражающие напряжение гравитационного поля и динамику глубины области посредством гравиметрических исследований, позволили наблюдать тектонические нарушения в различных интервалах глубин в области и оценивать геодинамический режим области во время полевых работ, что динамика массы, характеризующая аномальные области Δg, активна.

Ключевые слова: *месторождения Филизчай, гравитационное поле, аномальные зоны, тектонические нарушения, неприливные вариации.*

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