SEISMICITY OF THE TERRITORY OF AZERBAIJAN IN 2019

G.J. Yetirmishli[1], S.S. Ismayilova[1], S.E.Kazimova[1]

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].

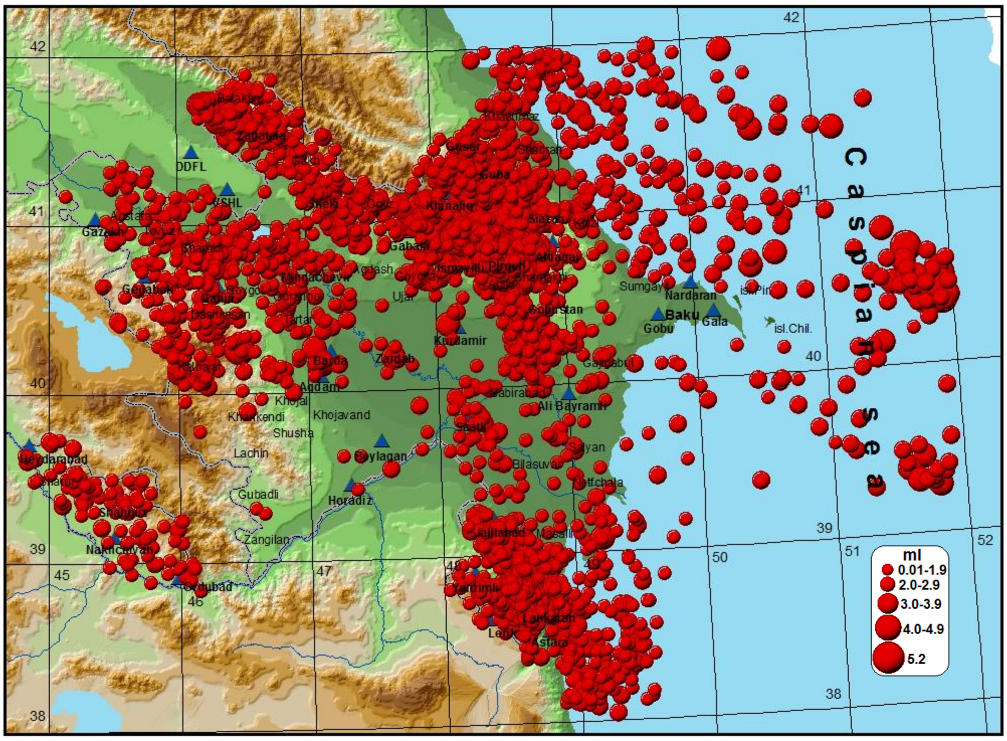

Figure 1. The map of earthquakes epicenters of Azerbaijan in 2019

[1] *Republican Seismic Survey Center of Azerbaijan National Academy of Sciences*

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.

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).

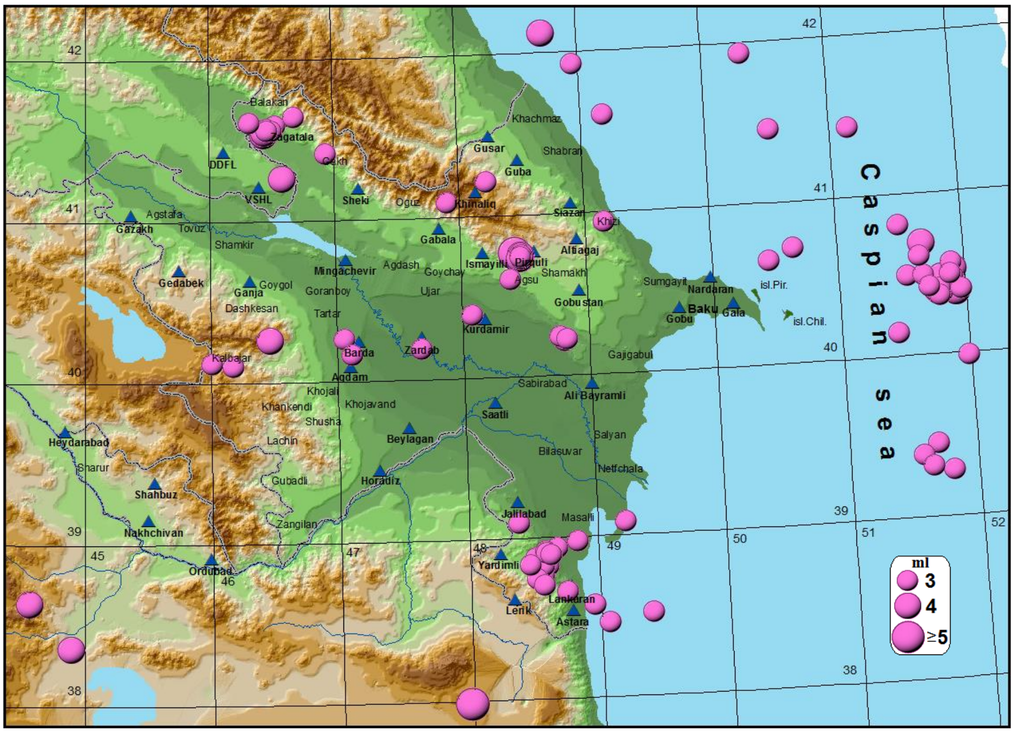

Figure 2.The epicenters map of earthquakes with magnitude of ml≥3.0 in the territory of Azerbaijan during 2019

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 ∑E = 42.7 · 1011C, the maximum magnitude 5.5, the number of earthquakes was 5442 in 2019, the amount of released seismic energy ∑E = 31.9 · 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.

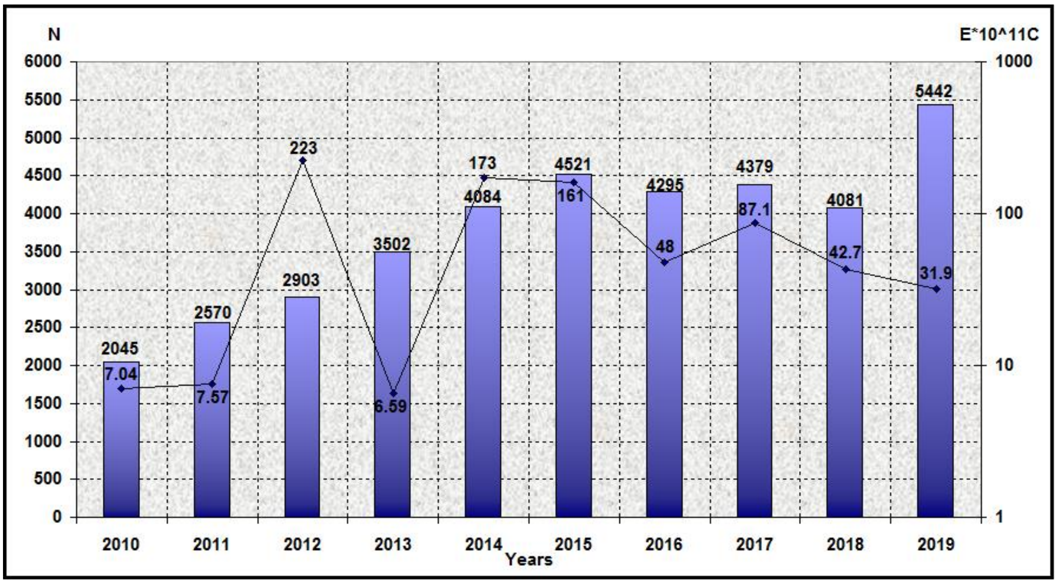

Figure 3. The histogram of the number of earthquakes and the distribution of released seismic energy in the territory of Azerbaijan in 2010-2019

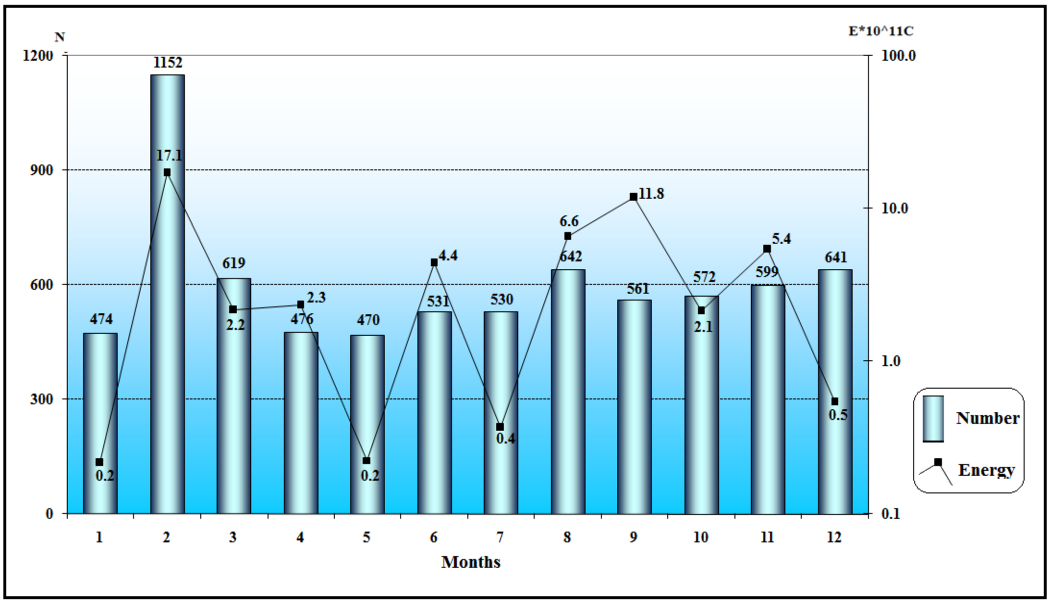

Figure 4. The histogram of the number of earthquakes in Azerbaijan and adjacent areas in 2019 and the distribution of seismic energy by months

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. Thisearthquake occurred on 10August at 11:35 local time in Zagatala district, 18 km south-west of Zagatala station. The intensityof 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.

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.

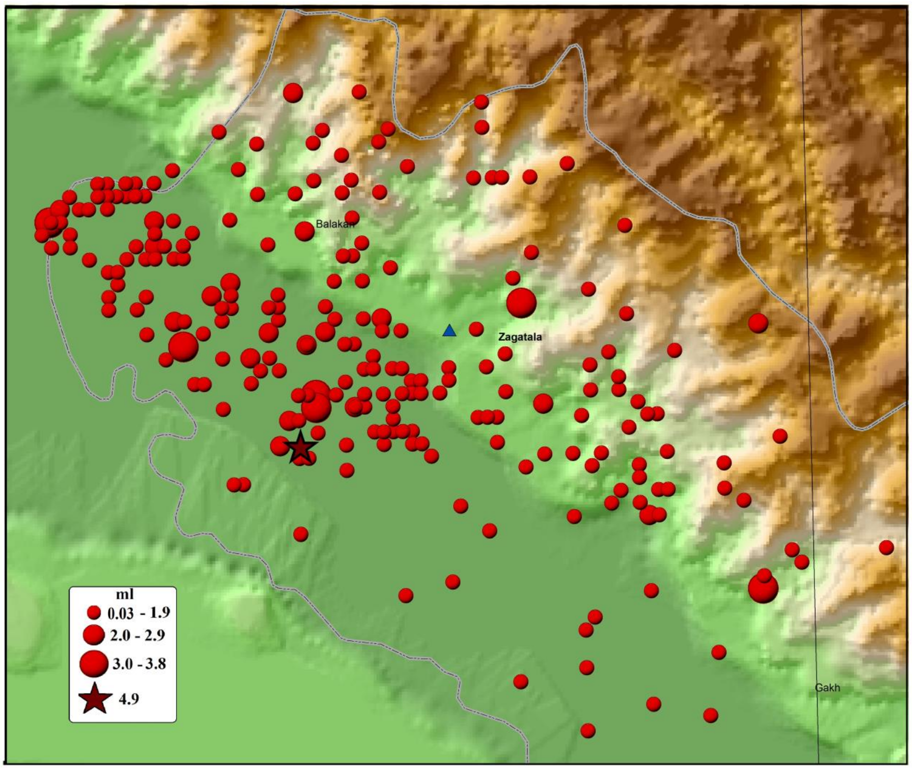

Figure 5. Map of the earthquake epicenters occurred in Balakan-Zagatala, Sheki, Gabala districts

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].

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.

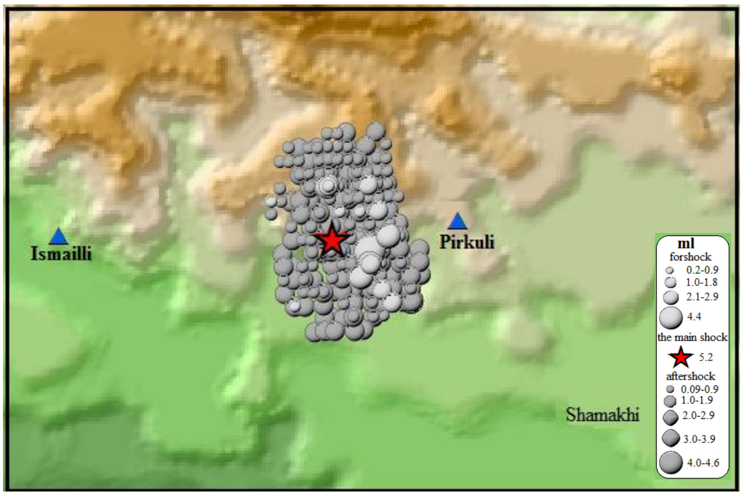

Figure 6.5 Map of epicenters of foreshock and aftershocks of Ismayilli earthquake with magnitude of ml = 5.2

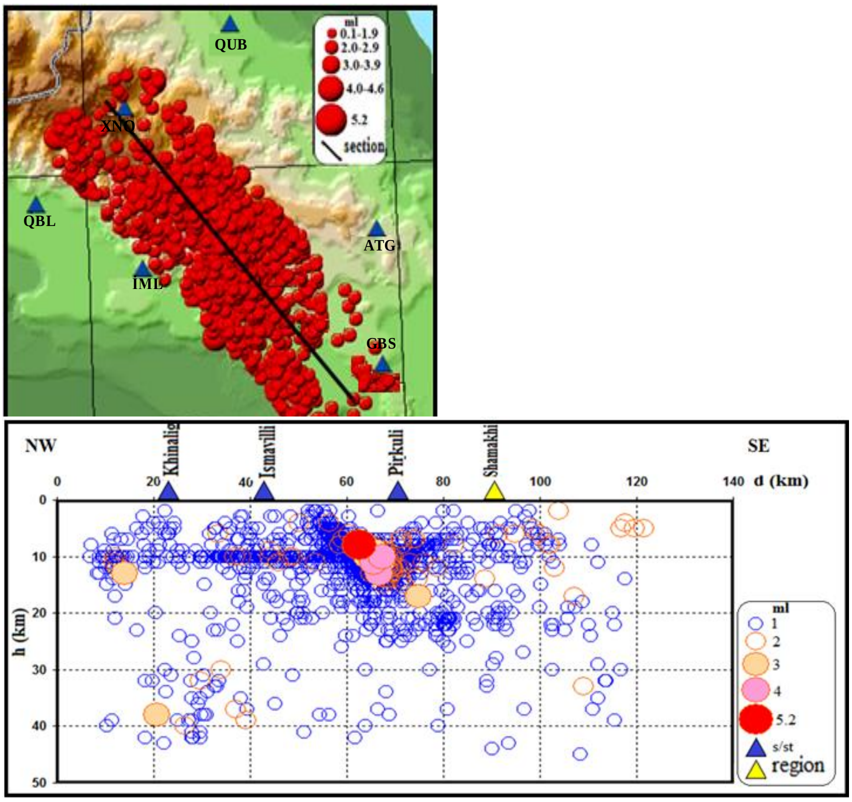

Figure 7. Seismological section of Shamakhi-Ismayilli seismogenic zone on the II-II profile

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.

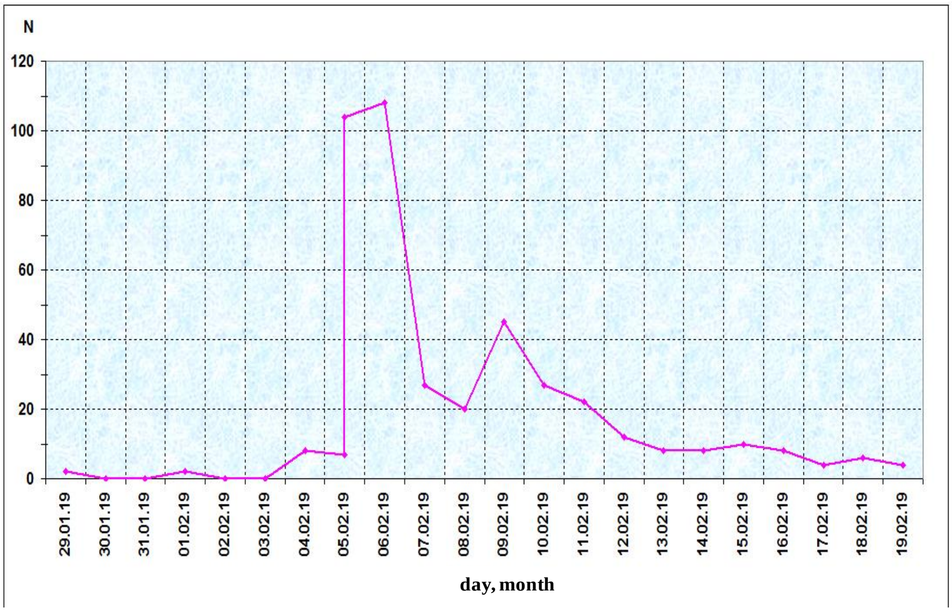

Figure 8. Histogram of the distribution of foreshocks and aftershocks by the earthquake of February 5, 2019

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.

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.

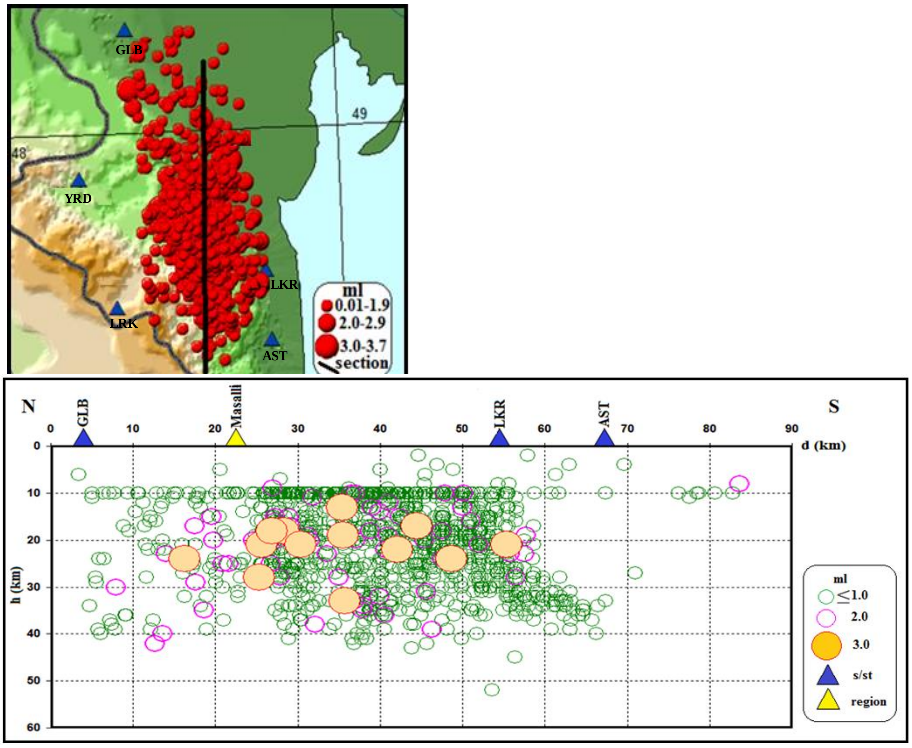

Figure 9. Seismological section of Talish mountain zone on IV-IV profile

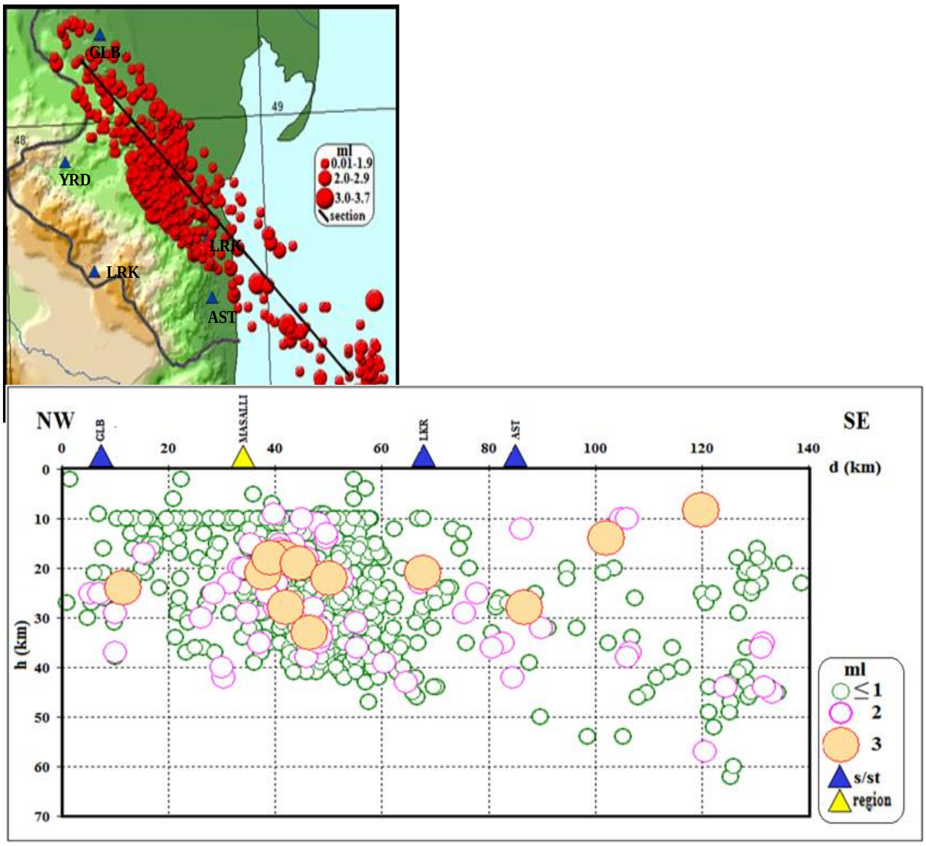

Figure 10. Seismological section of Talish mountain zone on V-V profile

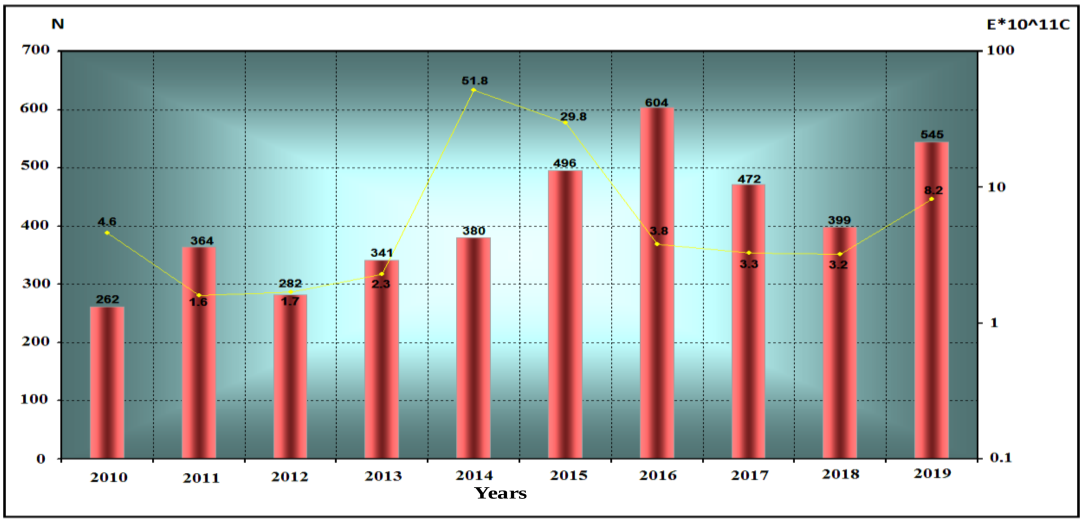

Figure 11. Histogram of the number of earthquakes in the Caspian Sea and the released seismic energy by years during 2010-2019

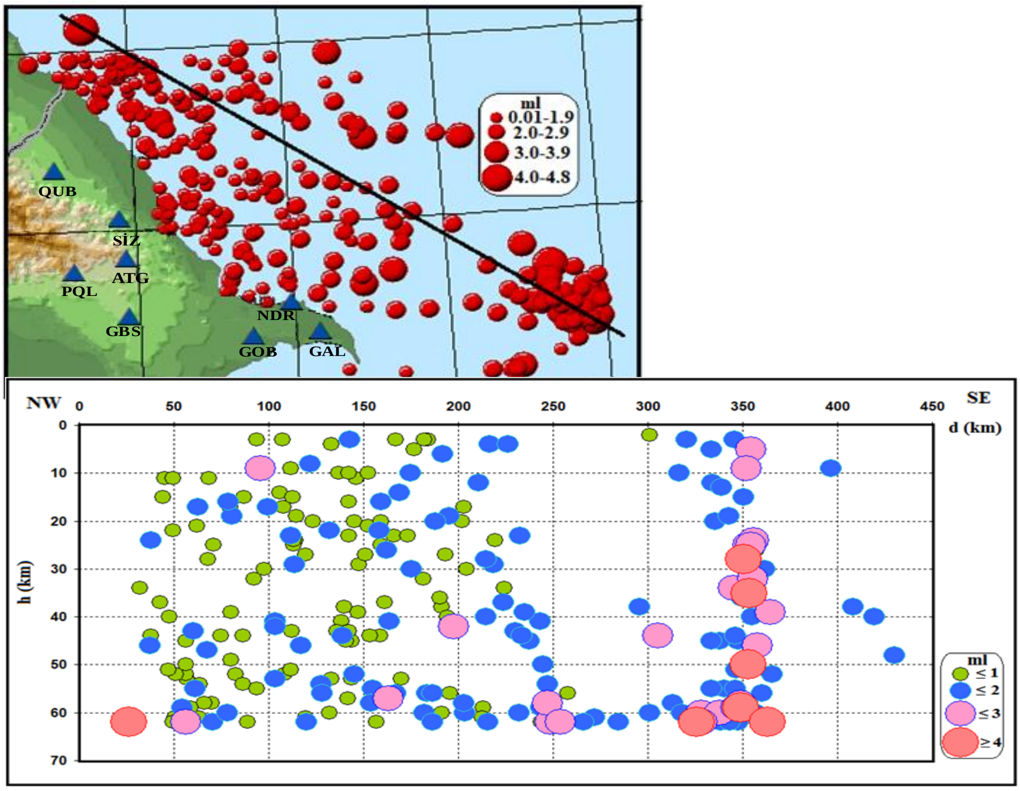

Figure 12. Seismological section of the northern part of the Caspian Sea on VI-VI profile

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.

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.

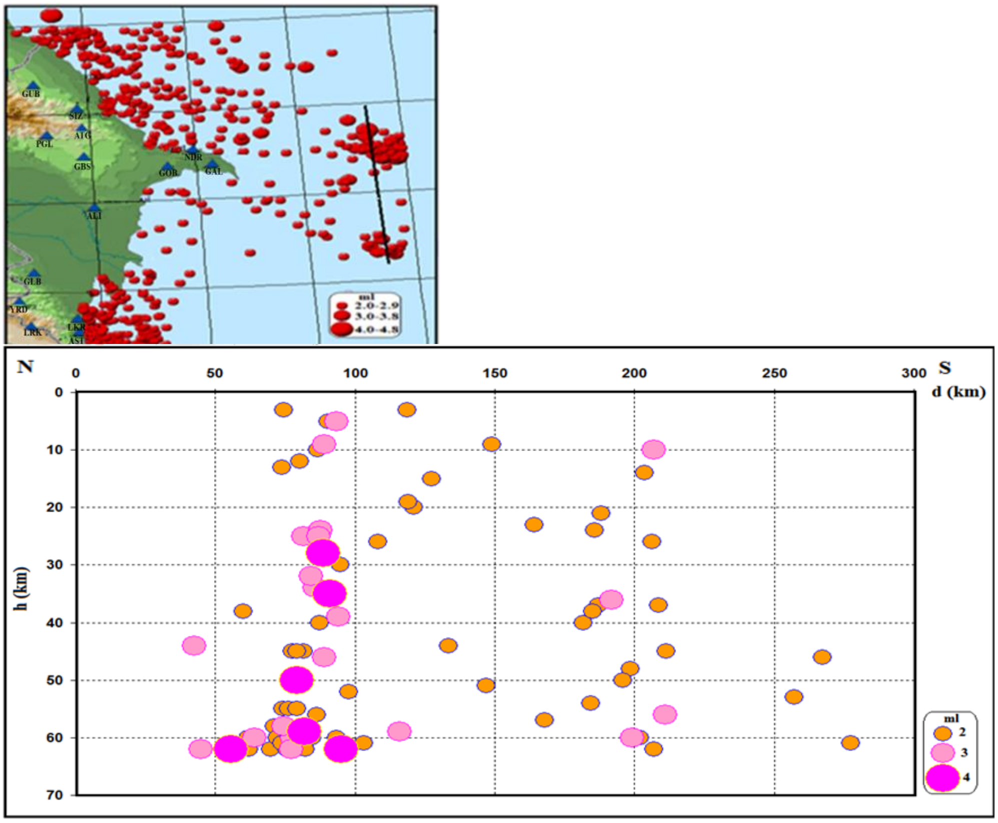

Figure 13. Seismological section of the central part of the Caspian Sea on VII-VII profile

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).

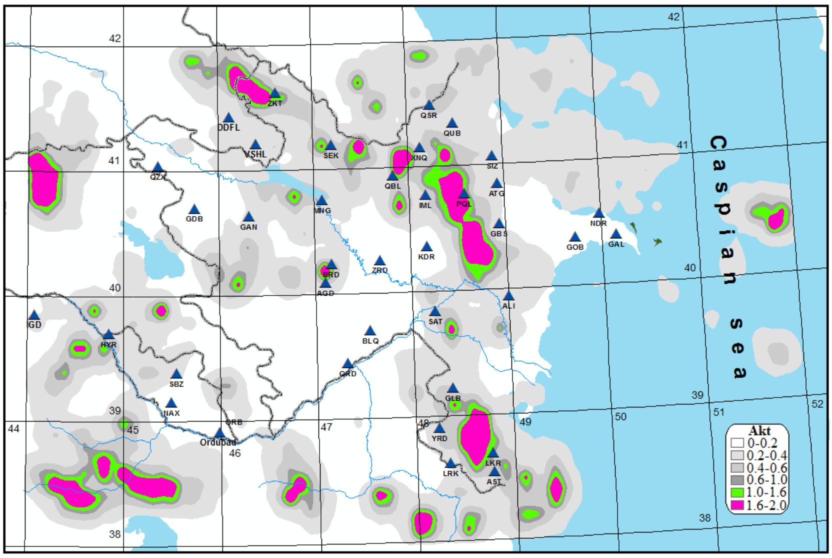

Figure 14.The seismic activity map of Azerbaijan and adjacent territories during 2019

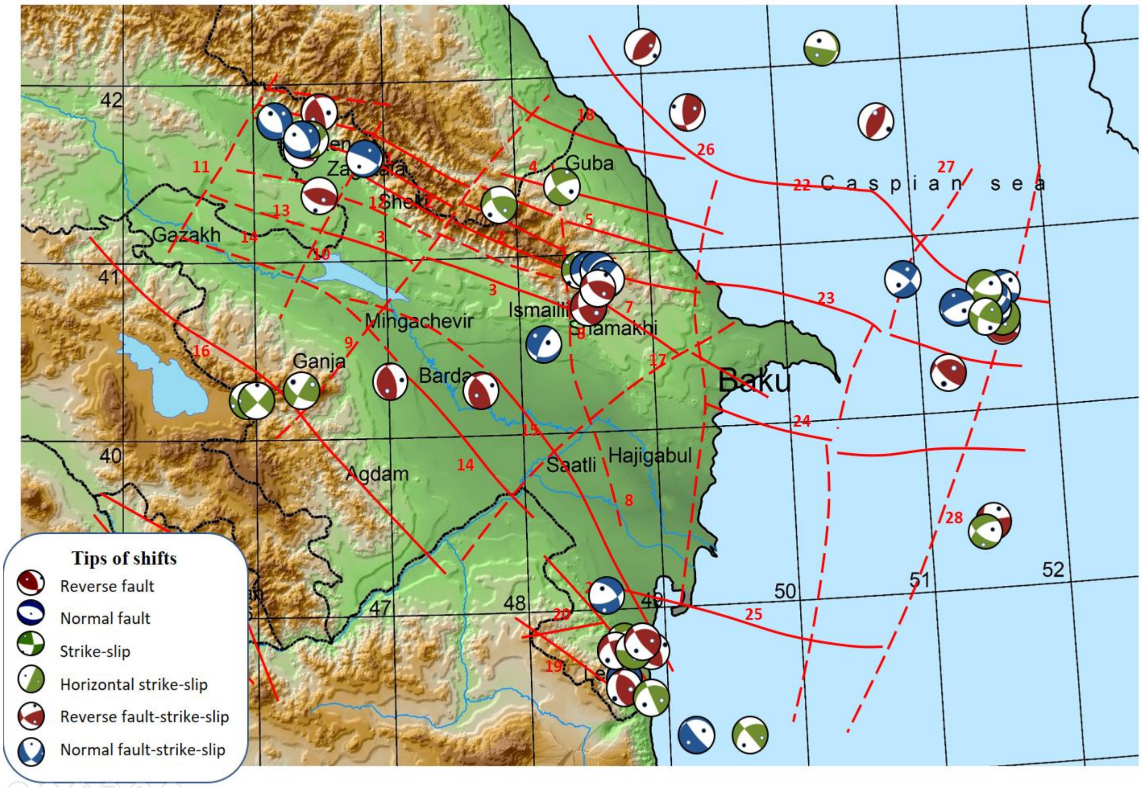

Figure 15. The mechanisms of earthquakes source with a magnitude of ml≥3.0 in 2019 (Compiled a faults map: [17, 18])

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.

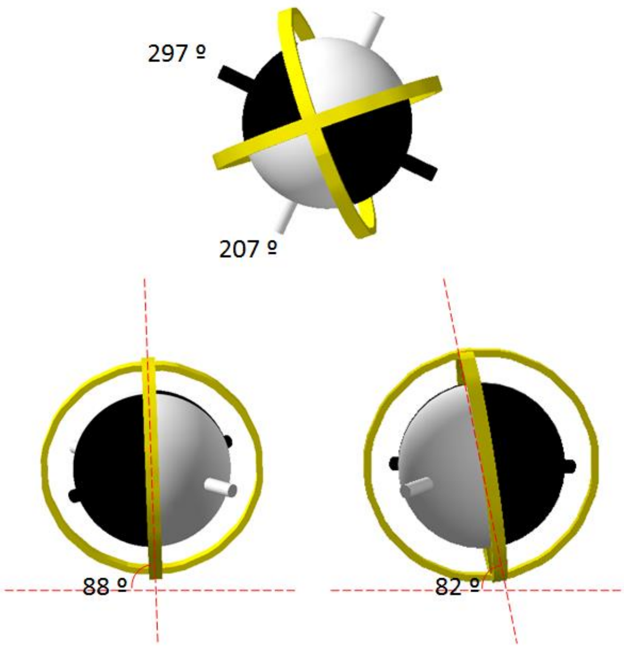

Figure 16. The source mechanism of the earthquake that occurred on 05.02.2019 at 23:31:37 in the territory of Ismayilli with a magnitude of ml = 5.2

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.

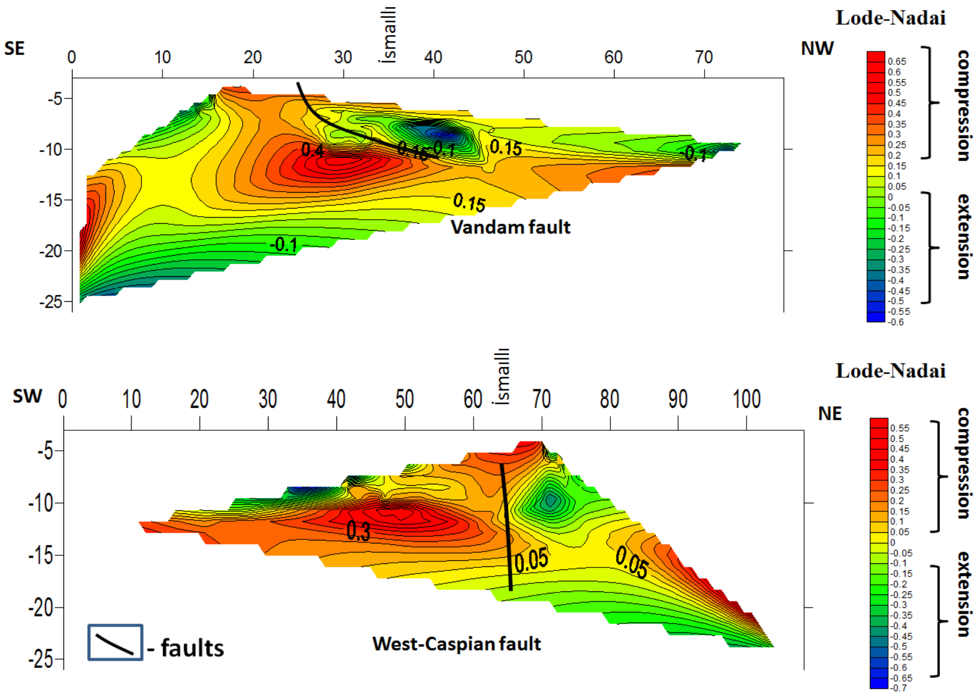

Fig. 17. Depth distribution scheme of Lode-Nadai coefficient along Shamakhi-Ismayilli seismogenic zone for 2018-06.02.2019

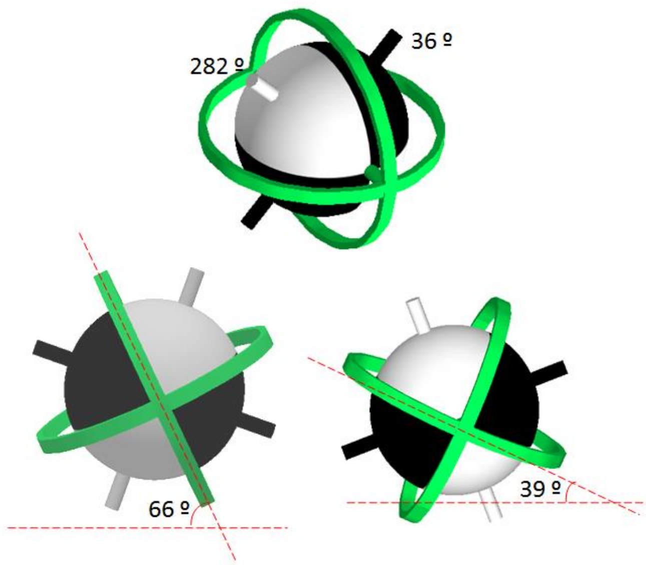

Fig.18. The mechanism of the earthquake source that occurred on August 10, 2019 at 11: 35-07 in the territory of Zagatala district

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.

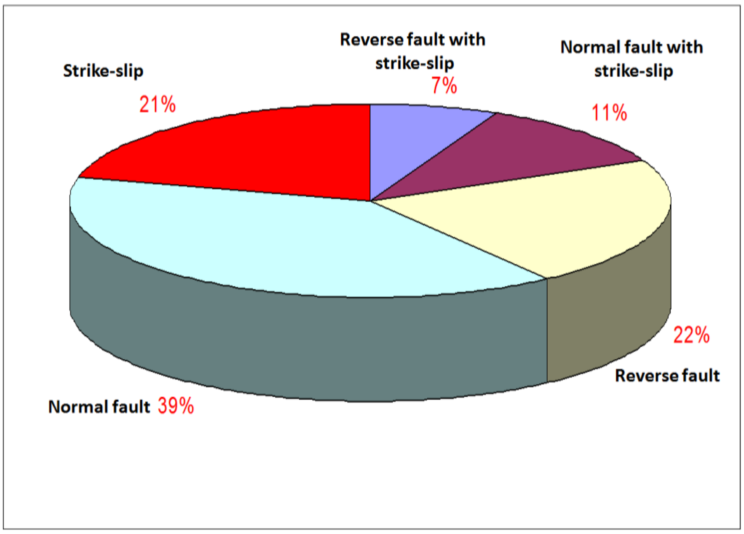

Fig. 19. The histogram of distribution of the earthquakes mechanisms occurred in the Caspian Sea by percentage

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). A 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-Kasnavodsk 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.

References

1. Seysmoloji bölmənin 2010-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2011
2. Seysmoloji bölmənin 2011-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2012
3. Seysmoloji bölmənin 2012-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2013
4. Seysmoloji bölmənin 2013-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2014
5. Seysmoloji bölmənin 2014-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2015
6. Seysmoloji bölmənin 2015-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2016
7. Seysmoloji bölmənin 2016-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2017
8. Seysmoloji bölmənin 2017-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2018

9. Seysmoloji bölmənin 2018-ci ildə Azərbaycanın seysmoaktiv bölgələrində apardığı tədqiqatların hesabatı. AMEA, RSXM. Bakı 2019
10. Агамирзоев Р.А., 1976. К сейсмическому районированию Азербайджана. В кн.: «Сейсмотектоника некоторых районов юга СССР». Москва, «Наука», С. 31-41.
11. Етирмишли Г.Д., Рзаев А.Г., Казымов И.Э., Казымова С.Э., Ибрагимова Л.А. Моделирование геодинамической ситуации Куринской впадины на основе новейших сейсмологических, геодезических и магнитометрических данных, Бюллетень Оренбургского научного центра УрО РАН , On-line, 2018, № 2, s. 1 – 11
12. Етирмишли Г.Д., Абдуллаева, Р.Р., Казымова, С.Э., 2010. Взаимосвязь очаговых зон землетрясений с глубинными разломами в Шамахы-Исмаиллинском районе за период 1993-2009 гг., 2010-cu ildə Azərbaycan ərazisində seysmoproqnoz müşahidələrin kataloqu, "Təknur", 2011, s. 70 – 75
13. Етирмишли Г.Д., Исмаилова С.С., Казымова С.Э., Бекдамирова Г.И. Исмаиллинское землетрясение 7 октября 2012 г. с ML Азр=5.3, Mw=5.1, IoP=5-6 (Азербайджан), Землетрясения Северной Евразии 2012 год, "Альпринт", 2018, s. 392–400
14. Етирмишли Г.Д., С.Э. Казымова, И.Э. Казымов Расчет тензора сейсмического момента землетрясений Азербайджана за период 2012-2015 гг., Геология и геофизика, СО РАН, 2019, 60(№7), s. 1036 – 1051
15. Етирмишли Г.Д., Маммадли Т.Я., Казымова С.Э., Исмаилова С.С., Современная сейсмическая обстановка Азербайджана, Опасные природные и техногенные процессы в горных регионах: модели, системи, технологии, ГФИ ВНЦ РАН, 2019, с. 29–36
16. Кенгерли Т.Н., Особенности геолого-тектонического строения юго-восточного Кавказа и вопросы нефтегазоносности, Elmi əsərlər, №9, Гос. Нефт. Компания Респ. Азербайджан, 2007 г., с. 3-12.
17. Рзаев А.Г., Етирмишли К.Дж, Казымова С.Э., Отражение геодинамического режима в вариациях напряженности геомагнитного поля (на примере южного склона Большого Кавказа) Известия, Науки о Земле. Баку 2013, № 4., с. 3-15
18. Хаин В.Е., Ализаде Ак.А., Геология Азербайджана, Том IV Тектоника, ред. Баку, Из-во Nafta-Press, 2005, с. 214-234.
19. Brune J.N. Tectonic stress and the spectrum of seismic shear waves from earthquake // J.Geophys. Res. – 1970. – 75. № 26.- P.4997-5009.
20. Dreger D.S. 2002. Time-Domain Moment Tensor INVerseCode (TDMT_INVC) // University of California, Berkeley Seismological Laboratory.18 p.
21. Hanks T.S., Kanamore H.A. A moment magnitude scale // J.Geophys. Res. – 1979. – 84. № 135.- p.2348-2350.
22. Ismayilova S.S., Kazimova S.E., Muradova G.I., Khadidji Sh.N., Muradova E.Kh. Focal parameters of Ismayıllı earthquake of october 7, 2012, Seismoprognosis observations in the territory of Azerbaijan,"Elm", 2019,16(№1), s. 16 – 23
23. Tibaldi A , Tsereteli N., O.Varazanashvili , G.Babayev, T.Mumladze , F.L.Bonali, E.Russo , F.Kadirov, G.J.Yetirmishli , S.Kazimova, Active stress field and fault kinematics of the Greater Caucasus, Journal of Asian Earth Sciences, On-line, 2019, 188, s. 1 – 18
24. Yetirmishli G.C., Abdullaeva R.R., Kazimova S.E., Ismailova S.S., 2015. Strong earthquakes on the territory of Azerbaijan for the period of 2012-2014 // Seismoprognosis observations in the territory of Azerbaijan, volume 12, № 1, p. 19-26