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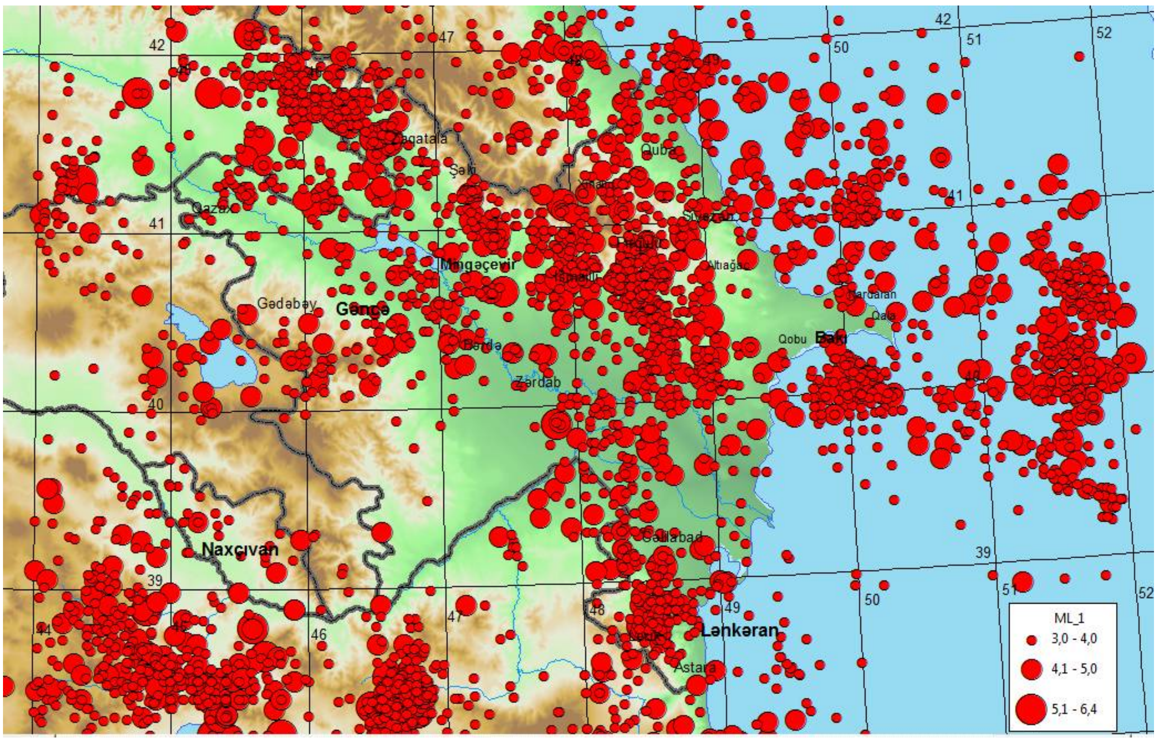
SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN



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Republican Seismic Survey Center of
Azerbaijan National Academy of Sciences

SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN

Seismoprogn. Observ. Territ. Azerb. V.14, №1, 2017, pp.3-11

SURFACE WAVE TOMOGRAPHY USING AMBIENT NOISE CROSS-CORRELATION FOR THE AZERBAIJAN TERRITORY

G.J.Yetirmishli[1], R.Gok[2], A.Chiang[2], S.Kazimova[1]

ABSTRACT. This paper presents the current status of ambient noise data processing as it has developed over the past several years and is intended to explain and justify this development through salient examples. The Ambient Noise Tomography (ANT) method provides a powerful tool for sampling the Earth's shear-wave-velocity structure (e.g., Campillo and Paul 2003; Shapiro et al. 2005). Noise correlations between pairs of stations at hundredths of kilometer distances, stacked over time, provide Green's functions of largely surface wave propagation between the stations. These signals are most robust at 5-20 s periods where fundamental-mode Rayleigh waves sample the crust and uppermost mantle, allowing 3D imaging at these depths (e.g., Harmon et al. 2008; Bensen et al. 2009).

We studied the Rayleigh wave group and phase velocities beneath the Azerbaijan territory using ambient seismic noise tomography. Noise data were gathered from 35 broadband seismological stations in and around the republic.

One approach of ambient noise tomography is to estimate surface wave dispersion maps at multiple spatial scales over a broad period band. The group/phase velocity approach is one way of doing ambient noise tomography; some people invert the GF directly. The technique provides a means to make observations of short period surface waves along inter station paths in seismically inactive regions. Because earthquakes are primarily limited to plate margins and tectonically active regions the tomography of tectonically quiescent regions requires the observation of teleseisms or the use of active sources. Shorter period surface waves which are most sensitive to the crust are preferentially attenuated and scattered often leading to poor constraints on the crust from teleseismic earthquake observations. In addition the distribution of azimuths from earthquakes is restricted by the timing and location of natural events. In contrast with traditional earthquake surface wave tomography ambient noise tomography is limited by the number and path density of inter station paths. For the technique to provide high resolution results across large areas requires both dense instrumentation and widely distributed stations.

Introduction

The Caucasus-Caspian region exhibits large seismic velocity variations due to its complex geologic and tectonic setting. The Arabian-Eurasian collision led to complex lithospheric structures of diffused deformation and deep sedimentary basins. As a result of northwestward movement of Anatolian plate, Lesser and Greater Caucasus mountains are formed. A comprehensive lithospheric model is crucial in understanding the complex tectonic and geologic setting of the Caucasus-Caspian region and essential in mapping the regional wave propagation, therefore improving regional earthquake hypocenter locations and source parameterization. To develop a 3D velocity model we use three years of continuous broadband seismic recordings from the Azerbaijan Seismic Network, consisting of 35 stations, and perform ambient noise cross correlation to obtain fundamental Rayleigh wave group and phase velocity dispersion. Initial results show slower group and phase velocities in the basin and faster velocities in the Greater and Lesser Caucasus, consistent with the geologic structure. The resulting dispersion curves are used to invert for Rayleigh wave group velocity maps. Additional constraints on Moho thickness from receiver functions will be included when available.

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Regional tectonics

Azerbaijan lies in a complex yet relatively poorly understood tectonic region of the Eastern Caucasus. It is bounded to the north by the Greater Caucasus, to the south by the Lesser Caucasus and Iranian Plateau, and to the east by the South Caspian basin. The Greater Caucasus is a zone of active shortening and the Lesser Caucasus comprises of a variety of faulting structures and significant volcanism. Separating the two Caucasus is the Kura basin with sediments up to 15 km thick and inferred to be the foreland basin to both Caucasus. The Kura basin is structurally separated from the South Caspian Basin by a ridge of uplifted basement and the inferred West Caspian fault. Although poorly constrained, high Pn and Sn velocities appear to extend into the Kura basin from the South Caspian.

Triangles are broadband stations from the Azerbaijan seismic network, and major tectonic features are labeled as well.

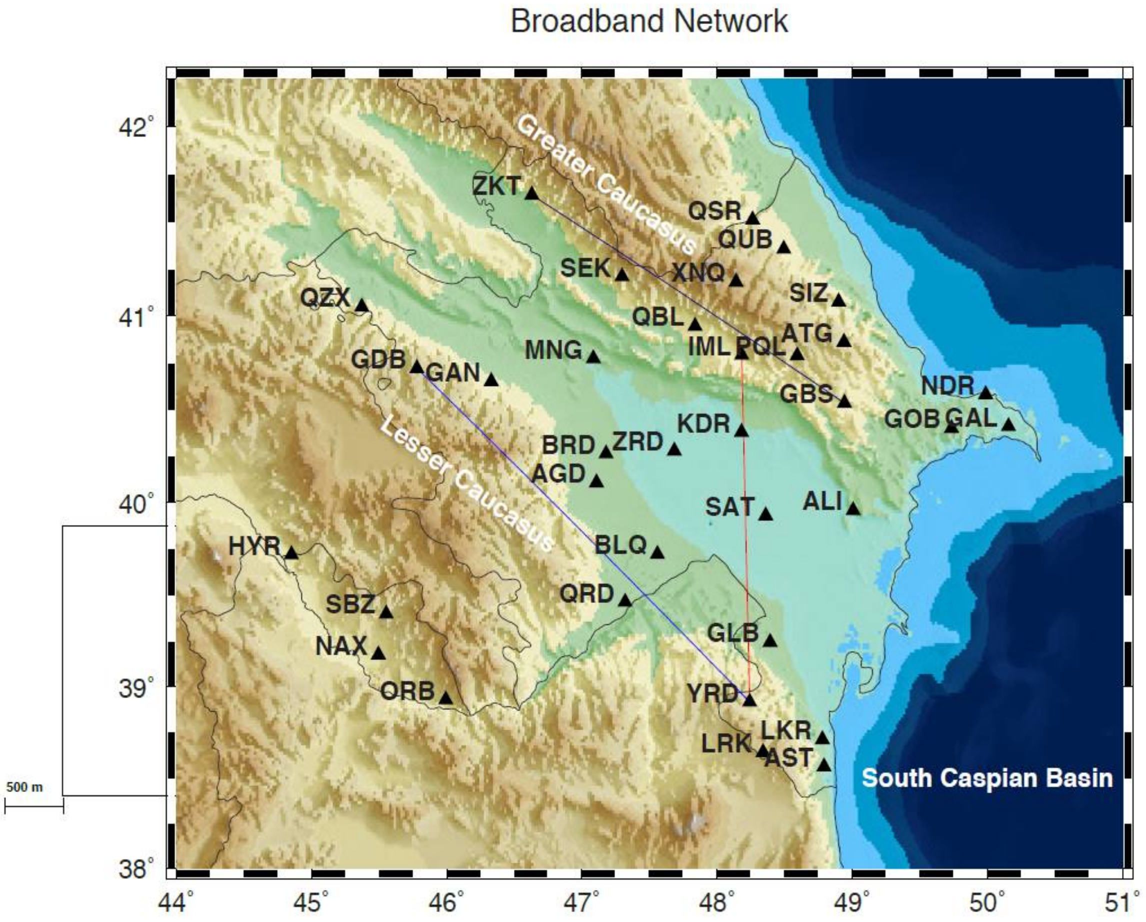

Figure 1. Azerbaijan Broadband Seismic Network.

Previous work

Gok et al. (2011) developed 3D lithospheric velocity model of the much broader Anatolian plateau-Caucasus-Caspian region from joint inversion of teleseismic receiver functions and surface wave dispersion measurements from data recorded at networks in Turkey, Georgia and Azerbaijan. In this study we focus our efforts on modeling velocity variations across Azerbaijan where a network of 35 broadband stations within the country provided us the opportunity to model the velocity structure using ambient noise surface wave tomography.

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Theoretical studies have shown that the cross-correlation of diffuse wavefields (e.g. ambient noise, scattered coda waves) can provide an estimate of the Green function between the stations (e.g. Weaver, Lobkis 2001a,b, 2004; Derode *et al.* 2003; Snieder 2004;Wapenaar 2004; Larose *et al.* 2005). Seismic observations based on crosscorrelations between pairs of stations have confirmed the theory for surface waves using both coda waves (Campillo, Paul 2003; Paul *et al.* 2005) and long ambient noise sequences (Shapiro, Campillo 2004; Sabra *et al.* 2005a) and for crustal body waves using ambient noise (Roux *et al.* 2005).

Data Processing

We apply the following signal processing procedure described in Bensen et al. (2007) to vertical component seismograms:

1. Instrument correction, remove mean, detrending, bandpass filtering and down-sampling.
2. Apply temporal normalization using the running average method.
3. Apply spectral whitening.
3. Compute daily cross-correlations and stack three years of daily correlations.

The resulting correlations are often asymmetrical due to the inhomogeneous distribution of the noise source, and although temporal normalization is defined on data bandpass filtered between 15 and 50 seconds spurious precursory signals are still observed.

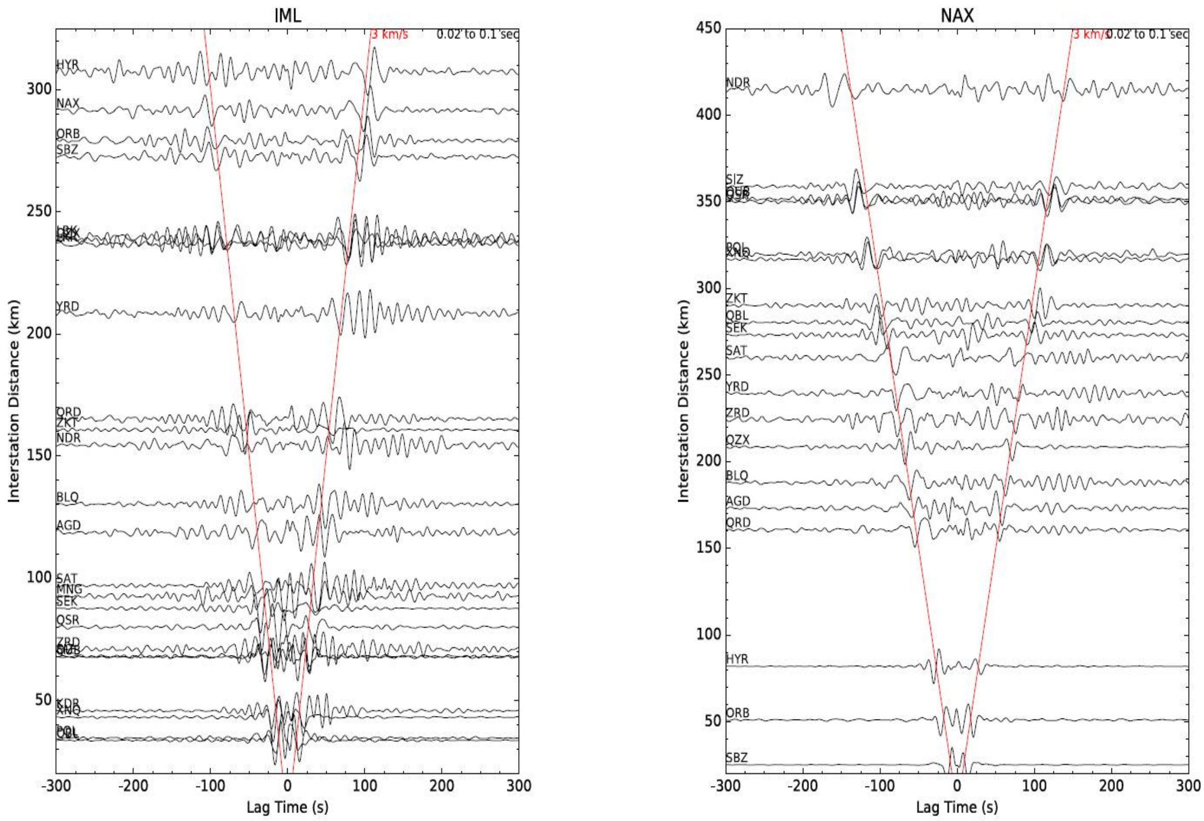

Figure 2. Ambient Noise Correlations from station IML and NAX.

Noise correlations are bandpass filtered from 10 to 50 seconds and sorted by distance. The correlations are mostly asymmetric due to inhomogeneous distribution of the noise source. Three years of data were used to compute the correlations. IML and NAX are located in the Greater and Lesser Caucasus, respectively.

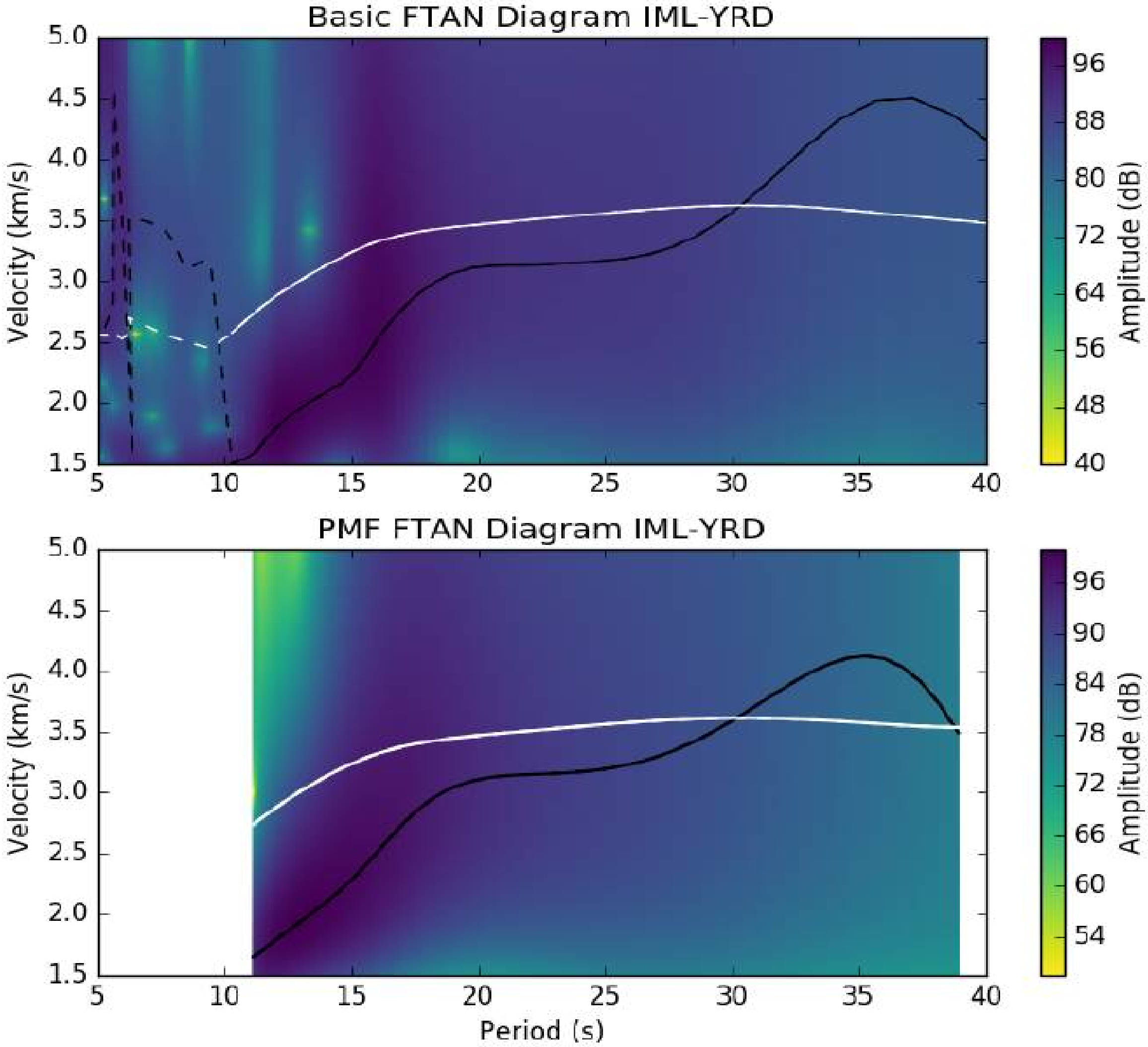

Figure 3. Frequency-Time Analysis (FTAN) for IML-YRD.

Rayleigh wave group (black) and phase (white) velocity curves with and without phase-matched filtering. SNR is typically weak at long periods for ambient noise correlation. We stack and fold the correlations to obtain the symmetric correlations, and perform frequency-time analysis (FTAN) to measure Rayleigh wave dispersion. We use the method from Levshin and Ritzwoller (2001) for the FTAN analysis. We see variation in wave speed across different tectonic regions (Fig. 4).

Velocities for three different tectonic regions: Greater Caucasus (black), Kura basin (red) and Lesser Caucasus (blue).

Single station data preparation

The first phase of data processing consists of preparing waveform data from each station individually. The purpose of this phase is to accentuate broad-band ambient noise by attempting to remove earthquake signals and instrumental irregularities that tend to obscure ambient noise. Obscuration by earthquakes is most severe above about 15 s period, so this step of the data processing is most important at periods longer than the microseism band (5 to 17 s period). In addition, because

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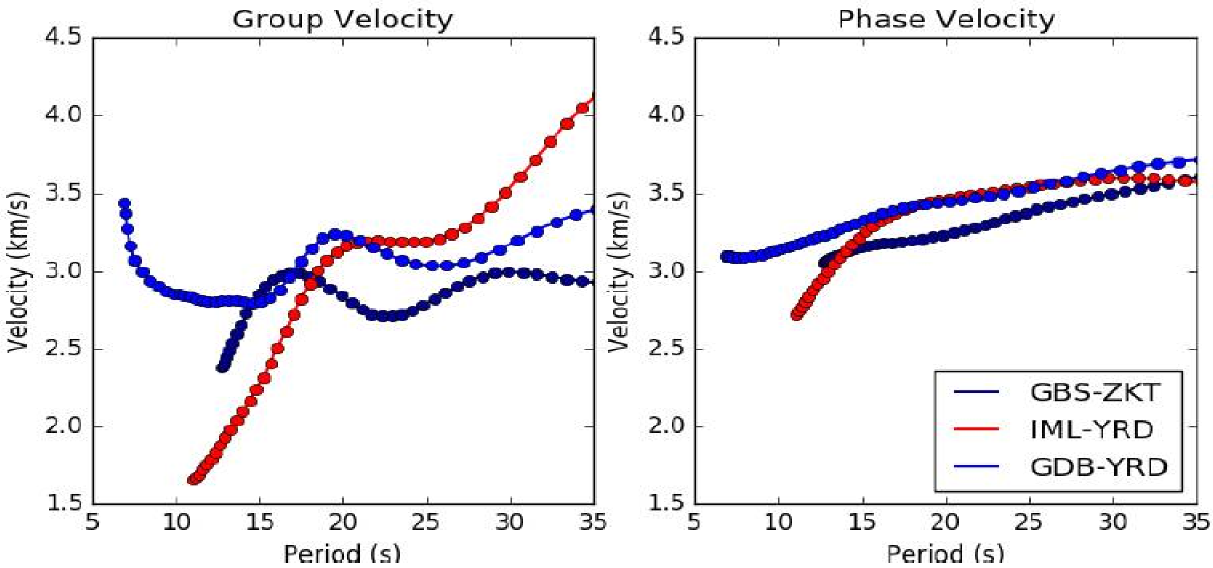

Figure 4. Group and Phase Velocity Curves.

the spectral amplitude of ambient noise peaks in the microseism band, methods have to be devised to extract the longer period ambient noise from seismic records.

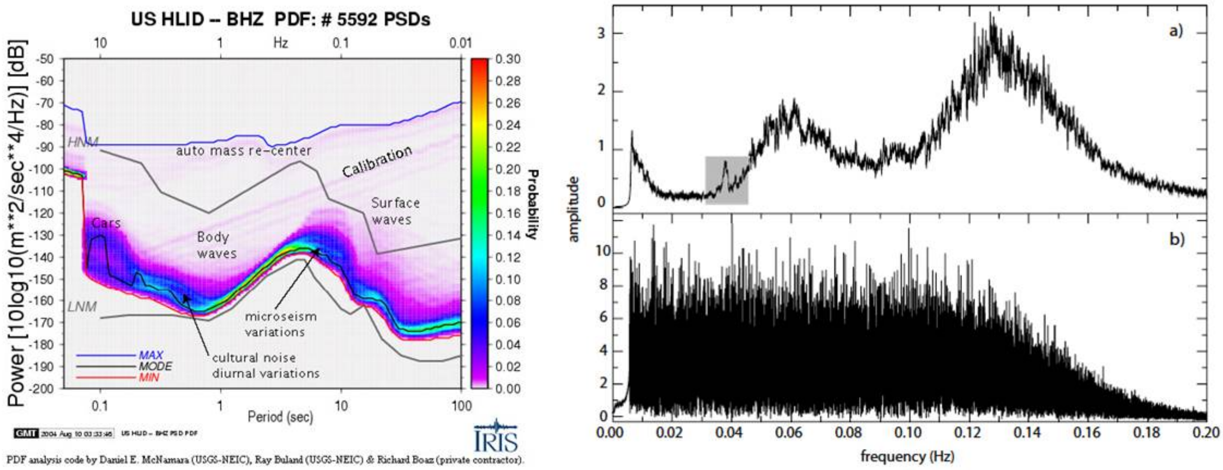

Figure 5. Processing seismic ambient noise data to obtain reliable broad-band surface waves.

One application of the surface wave models is to invert the dispersion results to derive models of the crust and upper mantle structure. This is particularly useful in aseismic regions that are poorly sampled by other data sets.

Surface wave tomography

At 14 and 20 seconds we see low surface wave velocities in the Kura Basin, indicative of the shallow sediments, and high velocities at the Caucasus. At 28 seconds we see high velocity features below the Kura Basin. The low velocity upper crust overlying a high velocity lower crust is similar to what has been observed in Gok et al. (2007, 2011). The Moho depth range between 35-40 km around this region. Due to the station distribution velocities are better resolved at the Kura Basin and Lesser

Caucasus. Most surface wave signals at periods less than ~12 seconds have relatively poor SNR resulting in poor coverage at those periods.

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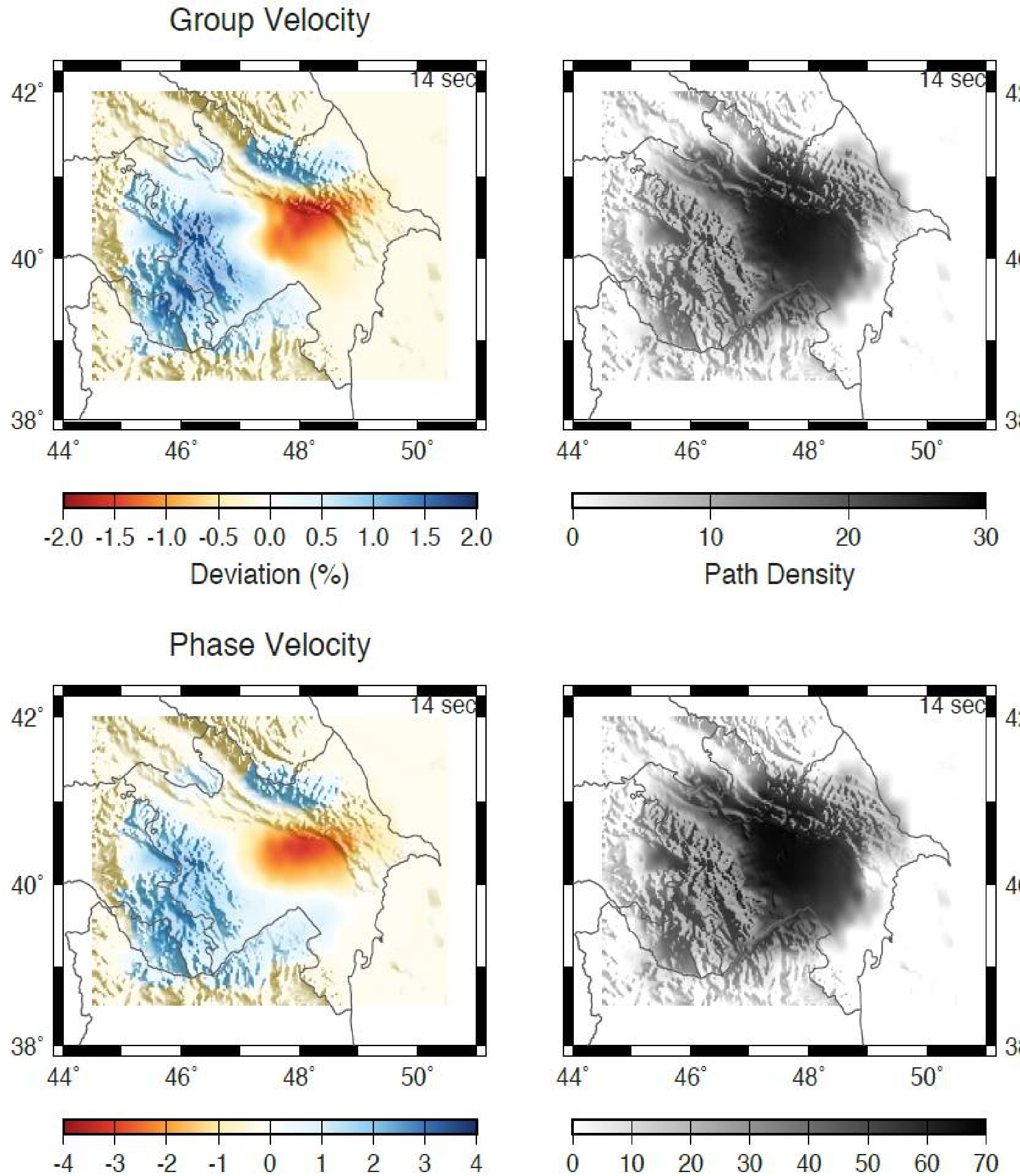

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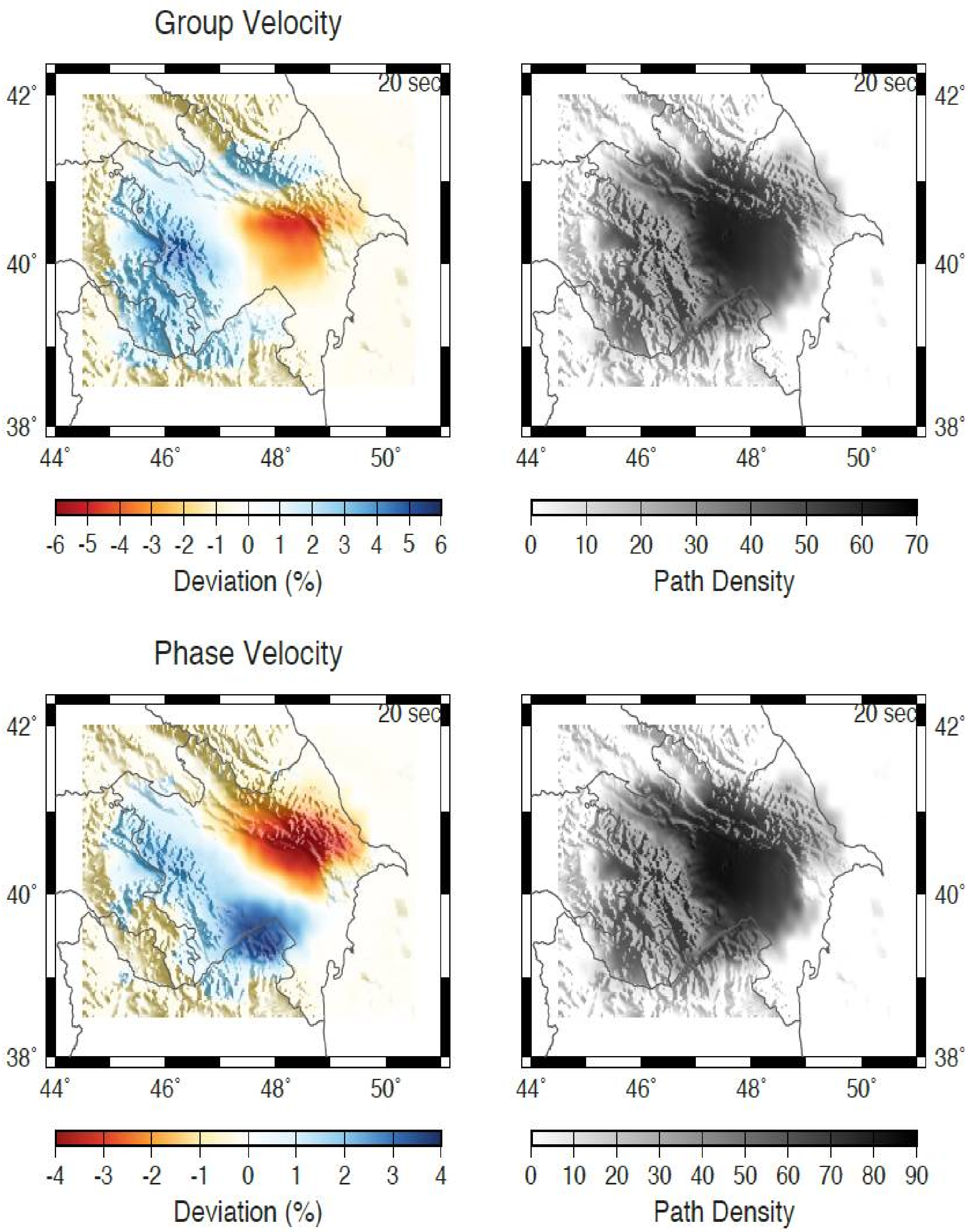

Figure 6. Group and Phase Velocity Maps.

Rayleigh wave group and phase velocities at 14, 20 and 28 seconds and their corresponding path densities. Path density is defined as the number of rays intersecting a 0.25 degree cell (~770 km2). The inversion is performed using the technique developed by Barmin et al. (2001).

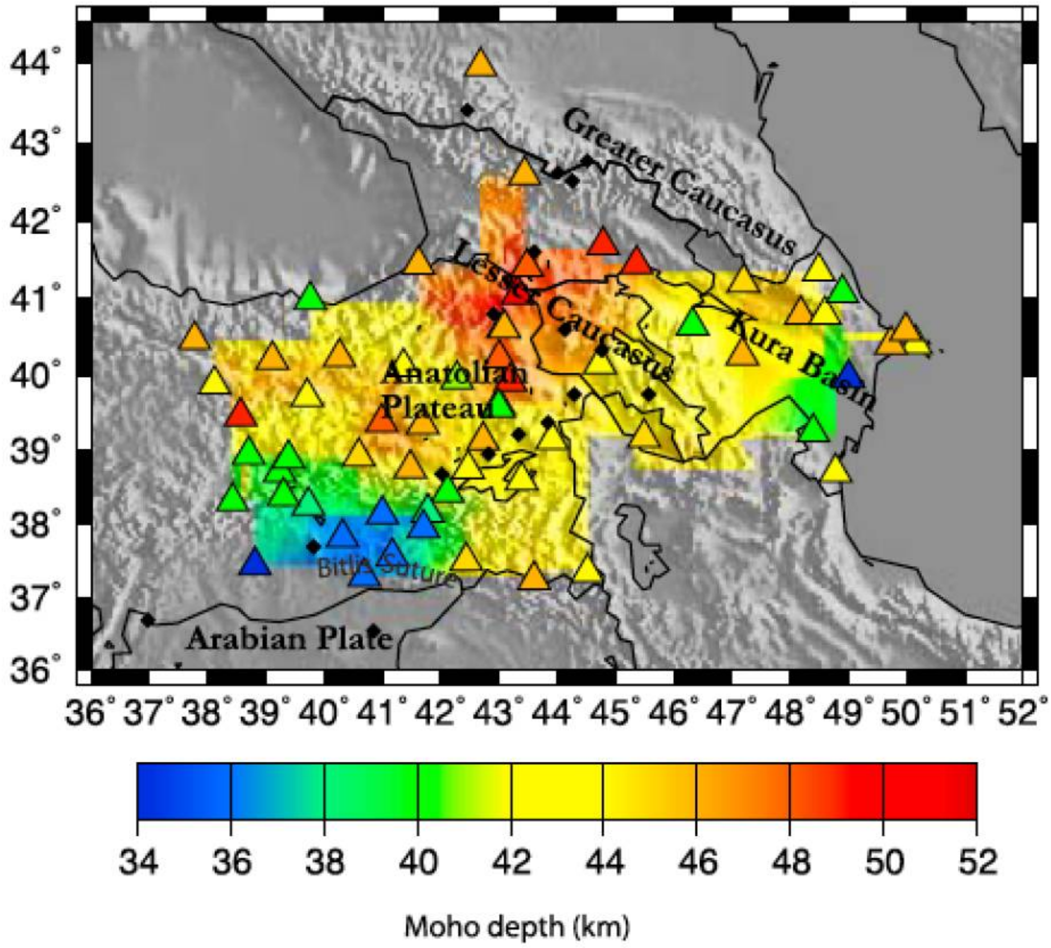

Figure 7. Moho Depths from Gok et al. (2011).

Conclusion

Eastern Caucasus is a region of complex geology where we expect to see large variations in wave propagation speeds. From three years of continuous ambient noise correlations we measured the Rayleigh wave surface dispersion. Group and phase velocity curves show different wave speeds correspond to the three major tectonic regions: the Greater Caucasus, the Lesser Caucasus and the Kura Basin. The inverted group and phase maps at shorter periods show high velocities at the Caucasus and low velocities at the Kura basin. At 28 seconds high velocities are observed underneath the Kura basin, which agrees with previous results. Event-based dispersion measurement should be included to model long period structure (>40 seconds) and include more continuous data to increase the noise correlation SNR, particularly at shorter periods. The next step is to invert for the velocity structure using the group and phase velocity maps, and include receiver functions to constrain the Moho depth.

Besides it, the obtained results as well as the additional studies will allow revealing the geodynamic anomalies, to perform the computed distribution of tensions of the region of study by data of the main axes of solutions of the earthquake focuses' mechanisms, to compare the various geodynamic processes and to reveal the interrelation between these processes. It allows compiling the digital maps to forecast the active zones of dislocations and risk in the region of study. The obtained results within Azerbaijan will allow defining reliably the active zone of fault and to reveal the risk

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potential in zone of seismic hazard along which the pipelines run and oil producing rigs allocate. The obtained results will also express the scientific value when studying the earthquakes forerunners. Besides it, the results will have the commercial significance and will be proposed to various petroleum and insurance companies and the authorities. The proposed investigations play a significant role in preservation of oil and gas deposits of Absheron peninsula and the Caspian Sea owing to increase of seismic activity in the peninsula.

REFERENCES

[1] Shapiro, N.M. and Campillo, M. (2004), "Emergence of broadband Rayleigh waves from correlations of the ambient seismic noise", *Geophys. Res. Lett.*, **31**, L07614.

[2] Harmon, N., Gerstoft, P., Rychert, C.A. and Abers, G.A. (2008), "Phase velocities from seismic noise using beamforming and cross correlation in Costa Rica and Nicaragua", *Geophys. Res. Lett.*, **35**, L19303.

[3] Bensen, G.D., Ritzwoller, M.H., Barmin, M.P., Levshin, A.L., Lin, F., Moschetti, M.P., Shapiro, N.M. & Yang, Y., 2007. Processing seismic ambient noise data to obtain reliable broad-band surface wave dispersion measurements, Geophys. J. Int., 169, doi:10.1111/j.1365-1246X.2007.03374.x.

[4] Harmon, N., Gerstoft, P., Rychert, C.A., Abers, G.A., Salas de la Cruz, M. & Fischer, K.M., 2008. Phase velocities from seismic noise using beamforming and cross correlation in Costa Rica and Nicaragua, Geophys. Res. Lett., 35, doi:10.1029/2008GL03587.

[5] Campillo, M. & Paul, A., 2003. Long-range correlations in the diffuse seismic coda, *Science,* 299, 547–549.

[6] Derode, A., Larose, E., Tanter, M., de Rosny, J., Tourim, A., Campillo, M. & Fink, M., 2003. Recovering the Green's function from field-field correlations in an open scattering medium, *J. acoust. Soc. Am.,* 113, 2973–2976.

[7] Geology of Azerbaijan, Volume IV Tectonics, ed. Khain V.E., Alizadeh Ak.A. 2005. Baku, due to Nafta-Press, pp. 214-234.

[8] Paul, A., Campillo, M., Margerin, L., Larose, E.&Derode, A., 2005. Empirical synthesis of time-asymmetrical Green function from the correlation of coda waves, *J. geophys. Res.,* 110, doi:10.1039/2004JB003521.

[9] Roux, P., Sabra, K.G., Gerstoft, P., Kuperman, W.A. & Fehler, M.C., 2005. *P*-waves from cross-correlation of seismic noise, *Geophys. Res. Lett.,* 32, L19393, doi: 10.1029/2005GL023803.

[10] Sabra, K.G., Gerstoft, P., Roux, P., Kuperman, W.A. & Fehler, M.C., 2005b. Surfacewave tomography from microseism in southern California, *Geophys. Res. Lett.,* 32, L14311, doi: 10.1029/2005GL023155.

[11] Shapiro, N.M. & Campillo, M., 2004. Emergence of broadband Rayleigh waves from correlations of the ambient seismic noise, *Geophys. Res. Lett.,* 31, L07614, doi: 10.1029/ 2004GL019491

[12] Gök R., Pasyanos M.E., Zor E.. Lithospheric structure of the continent–continent collision zone:eastern Turkey, *Geophys. J. Int.* , 2007, vol. 169 (pg. 1079-1088)

[13] Gök R., Mellors R.J., Sandvol E., Pasyanos M., Hauk T., Takedatsu R., Yetirmishli G., Teoman U., Türkelli N., Godoladze T. et al. (2011). Lithospheric velocity structure of the Anatolian Plateau Caucasus-Caspian region. J Geophys Res 116: B05303.

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ABOUT THE SEISMIC RISK OF SABAYIL DISTRICT OF BAKU

G.J.Yetirmishli[1], T.Y.Mammadli[1], R.B.Muradov[1], T.I.Jafarov[1]

ABSTRACT. The seismic risk of Sabayil district of Baku is considered. The seismicity of East Azerbaijan has been investigated, potential zones and their seismic potential that can create a seismic hazard in Baku have been identified, the main factors causing seismic risk in the research area (engineering-geological conditions of separate areas, types of building-objects, sustainability situations etc.) have been widely analyzed. It was found that the territory of Sabayil district is characterized by the high seismic hazard. In addition, areas where many people live and many administrative buildings are concentrated are characterized by unfavorable ground conditions and this factor raises the level of seismic hazard to 9 points on the 12-point MSK-64 scale. The presence of frequently recurring Bayil landslides zone in the area is an additional source of hazard.

The assessment of possible seismic hazard in Baku where numerous administrative and high residential buildings, large industrial enterprises and other state-owned facilities are located, about 40% of the republic population is concentrated, is one of the actual problems of the period.

The territory of Azerbaijan is a part of Alpine-Himalayan folded system, characterized by the high seismic activity. The maps of epicenters (Fig.1and Fig.2) of strong and medium (M≥3,0) earthquakes [In the territory of Azerbaijan.... 1980-2016 years] recorded during the last 36 years (1980-2016 years) and strong (M≥5,0) earthquakes [Novıy..1977] occurred since 427 years until now create full impression about the high seismic activity of the Azerbaijan territory.

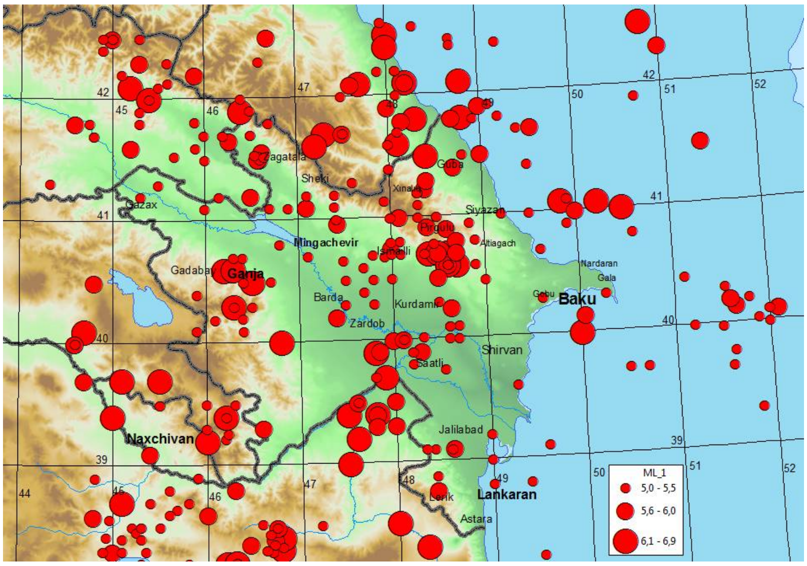

Figure 1.Epicenters maps of strong (M≥5.0) earthquakes that had been occurred in Azerbaijan and adjacent territories during 427-2016 years.

As can be seen from the maps, the eastern part of the republic is seismically active. In this region, the earthquakes occur mainly in the Caspian Sea.

In general, the Caspian Sea takes a particular place in the seismic life of Azerbaijan. Strong (M_{LH}≥6,0) earthquakes [Novıy catalog, 1977] that had occurred in 1910, 1935, 1963, 1986, 1989 have

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repeatedly trembled Baku and other coastal areas with high intensity (5-7 points on the 12 point MSK-64 scale).

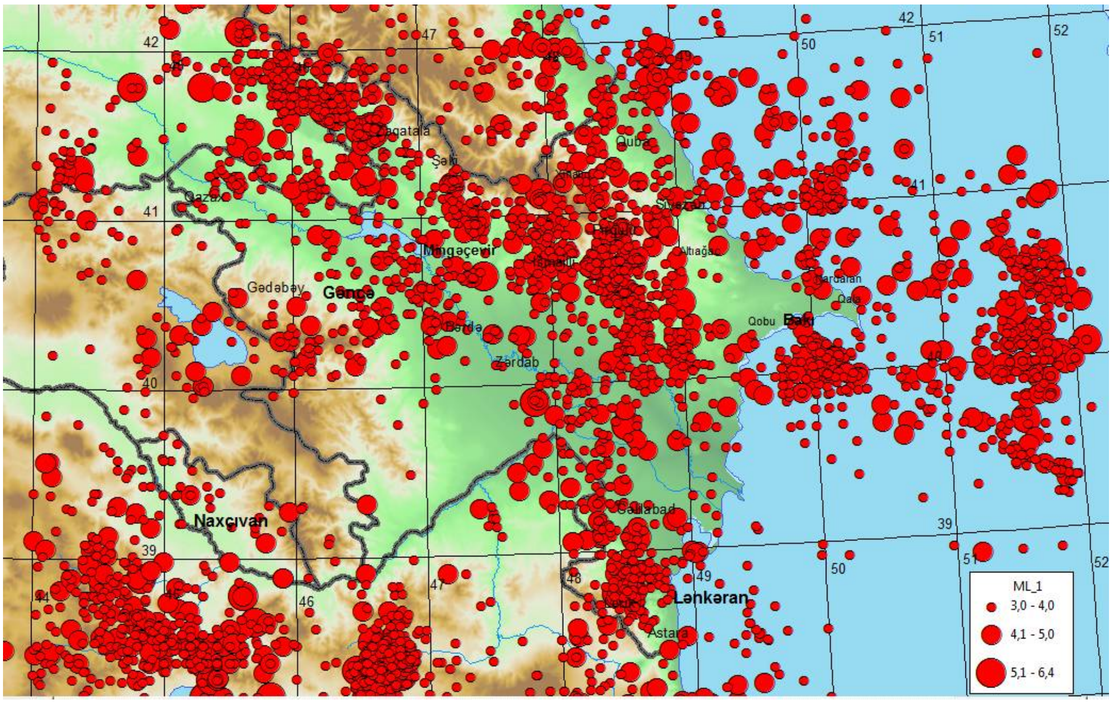
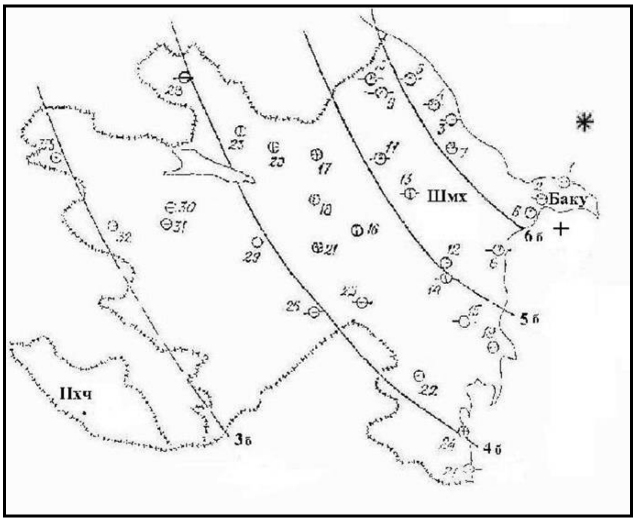


Figure 2. Epicenters maps of M≥3,0 earthquakes that had been occurred in Azerbaijan and adjacent territories during 1980-2016 years.

An earthquake with magnitude M_{LH}=6,1 that had occurred in the Caspian Sea (φ=40,3^0 N; λ=51,6^{0}E) on March 6, 1986, was felt in Neft dashları up to 7-8 points and in Baku up to 5 points.

A strong earthquake recorded on September 16, 1989 (φ=40,2^0 N; λ=51,8^{0}E; M_{LH}=6,3) was felt up to 5 points intensity in Absheron peninsula and some coastal areas.

The last strong earthquake in the Azerbaijani part of the Caspian Sea (M=6.2) occurred on November 25, 2000, 50-60 km south of Absheron and was felt in Baku and some coastal areas up to 6-7 points [Hasanov et al., 2005] (Fig.3).



*-Macroseismic epicenter; + - Instrumental epicenter

Figure 3. November 25, 2000. Isoseyst map of the Caspian Sea

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The seismic intersection constructed on different profiles indicated that with the exception of a few H = 60-70 km depth hypocenters that the earthquake sources were spread at the depth of up to 50 km in the Caspian Sea [Hasanov et al., 2000].

The strong earthquakes that took place on November 25, 2000, in the south of Absheron and their aftershock distribution characteristics on the place again confirm the results mentioned above [Hasanov et al., 2004]. It should be noted that the seismicity was at the background level in the earthquake area. A strong foreshock with M_{LH}=5.8 was also recorded 1.5 minutes before the main shock of the M_{LH}=6.2. The occurrence of two consecutive strong earthquakes within a short time (1.5 minutes) had resulted in the recording of numerous aftershocks (Fig.4 and Fig.5).

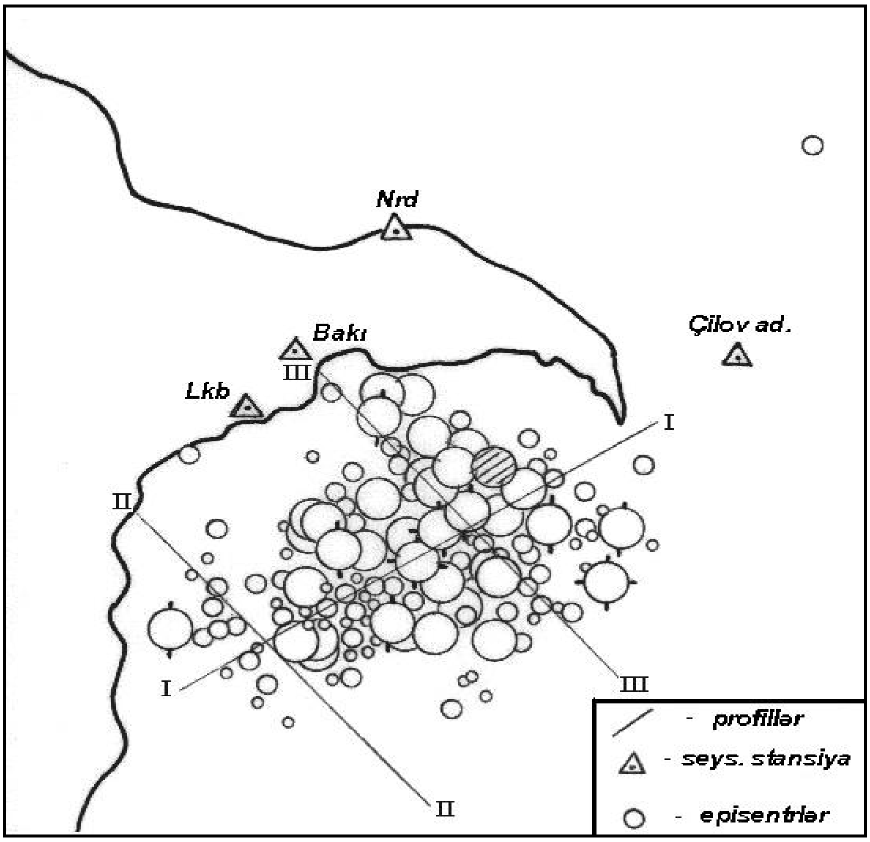

Figure 4. Epicenters map-scheme of general aftershocks of Caspian earthquake occurred on November 25, 2000

In general, the analysis of historical and present - day, macroseismic and instrumental data on earthquakes in the territory of Azerbaijan shows that there was no earthquake which was higher than 7 point on the 12 point MSK-64 scale in the Absheron peninsula including Baku city. However, this conclusion obtained from the observations does not give a reason to say that there will be no more intensive earthquakes in Baku in the future.

In order to determine the spatial position of the potential source zones of Azerbaijan territory, the connection of spatial (both lateral and vertical) distribution regularities of strong and weak earthquakes and intense concentration zones of seismic aftershocks with large depth faults have been investigated [Mammadli, 2011].

It is known that the largest seismic hazard is expected from potential source zones that are located in the Ajichay-Alat, Palmir-Absheron, Goychay, Vandam, Siyezen and Makhachkala-Turkmenbashı depth faults with high-intensity activity for the area where Absheron peninsula, including Baku city is located.

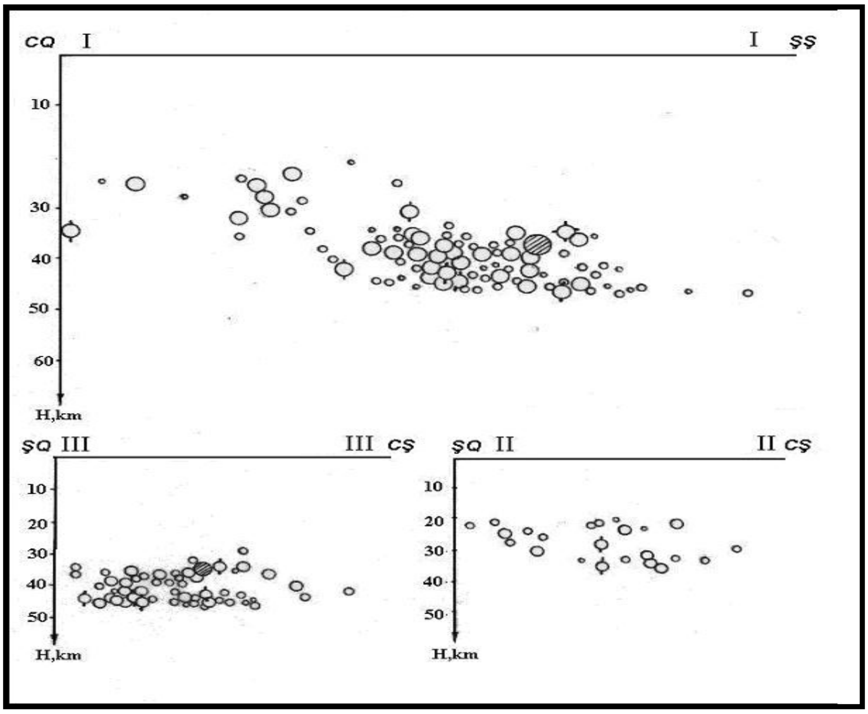

Figure 5. Distribution of aftershocks of November 25, 2000 earthquake according to the depth

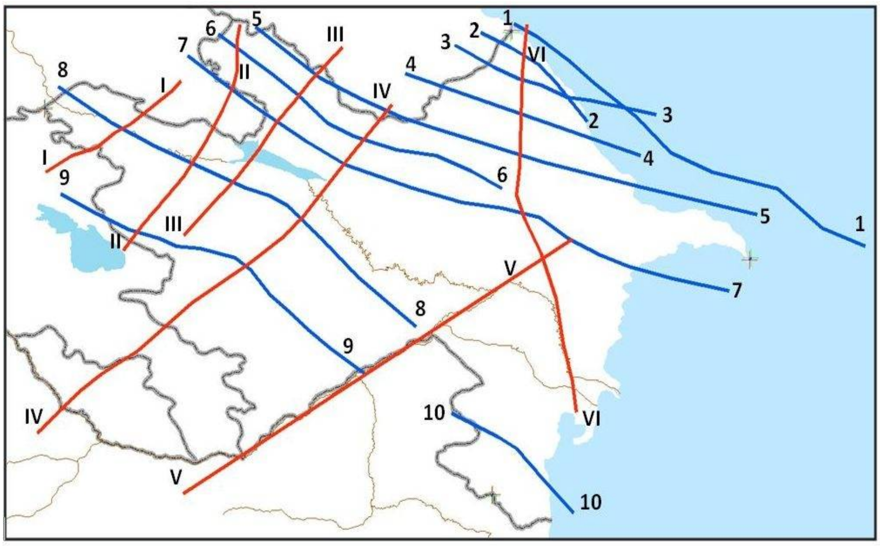

Figure 6. Map-scheme of generalized depth faults of Azerbaijan territory

1-1	Makhachkala – Turkmenbashi	I-I	Gazakh-Siqnakh
2-2	Khudat – Gilazi	II-II	Sharur-Zagatala
3-3	Akhtı-Nugadi-Gilazi	III-III	Ganjechay
4-4	Siyezen	IV-IV	Arpa-Samur
5-5	Qaynar-Zengi	V-V	Palmir-Absheron
6-6	Vandam	VI-VI	West-Caspian
7-7	Ajıchay-Elet		
8-8	Kura		
9-9	Lesser Caucasus		
10-10	Talysh		

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Currently, background level of seismic hazard of various regions of Azerbaijan is estimated on the basis of “Temporary seismic zoning map of Azerbaijan territory” [Ahmedbeyli et al., 1991] (Fig.7).

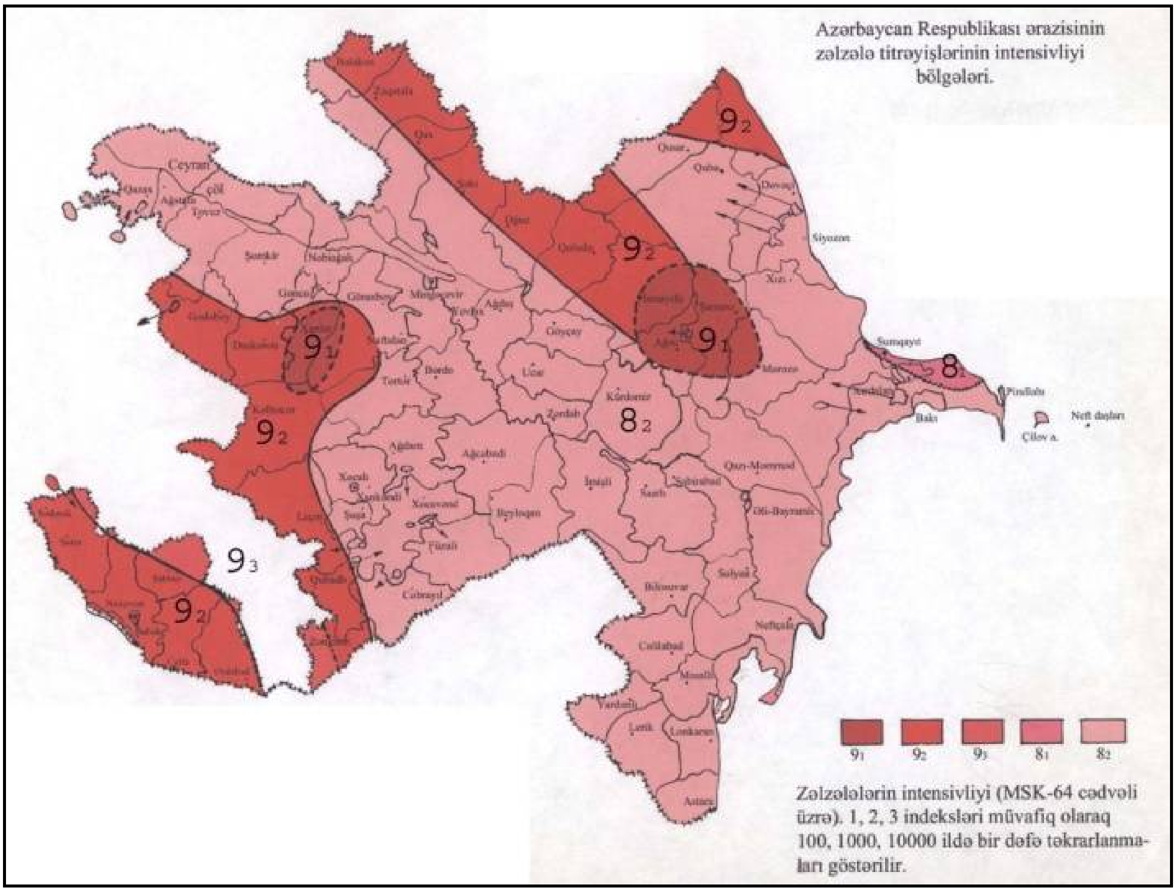

Figure 7. Seismic zoning map of Azerbaijan (1991)

According to this map, the background level of seismic hazard of the Absheron Peninsula, including Baku is 8 point according to 12 point MSK-64 scale. In addition to the background level, also the engineer-geological and hydrogeological condition of this area has great influence on the level of seismic hazard.

These conditions are not identical in Baku. Therefore, the strong Caspian Sea (Baku) earthquake on 25.11.2000 (M=6.2) was felt differently in the various areas of Baku [Hasanov, Mammadli, 2008]. The earthquake mostly was felt in the area where coastal zones of the city - soft, wet grounds are widespread and the groundwater levels are close to the ground surface.

The Sabayil district of Baku is an area with the complex relief where a number of important administrative departments and organizations and buildings of various types is concentrated. The variety of the types of buildings (a new high, old one or two-floor buildings and etc.), level of groundwater and ground necessitates research on seismic risk assessment.

In order to investigate the impact of engineer- geological and hydrogeological condition to the seismic level, the engineering-geological data on well drilling in the area where high-rise buildings were constructed within the last 10-15 years had been analyzed (Fig.8).

It was found that soft, wet grounds are widespread in the coastal zone of this district and the level of groundwaters is close to the ground.

As a result of the impact of these factors, the level of seismic hazard in this area had risen and this area should be evaluated as 9 points on 12 point MSK-64 scale.

Figure 8. Location scheme of engineering geological wells drilling in the Sabayil district

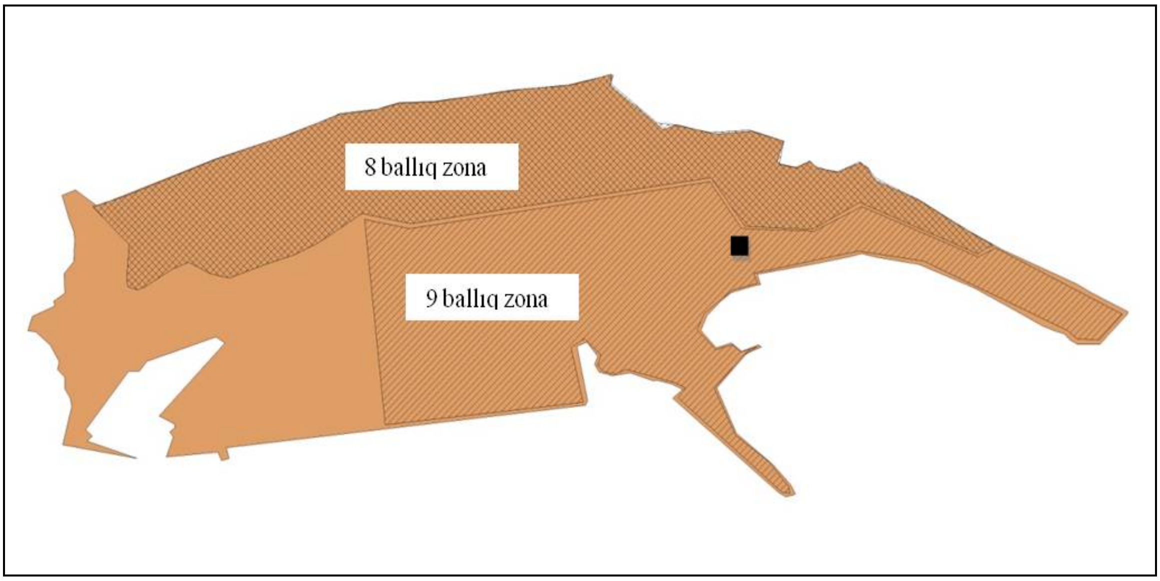

Figure 9. The estimated seismic hazard level scheme by taking into account engineer-geological data on well drilling in the area of Sabayil district.

The estimated risk assessment was conducted in the high seismic hazard zones mentioned at the next stage. The seismic risk means the socio-economic and other losses likely to occur as a result of seismic hazard. These losses are largely dependent on the seismic stability (technogenic risk) of buildings and facilities, and the level (social risk) of people's preparedness to a strong earthquake. Additionally, the losses caused by the indirect hazards (fires occurring after the earthquake, landslides, etc.) also belong to seismic risk.

The resistance level of living and administrative buildings located in Sabayil district has been investigated separately. For this purpose, the whole area has been researched and the district territory is divided into separate areas (Fig.10; 11) due to the structure and other characteristics of the buildings.


High-rise buildings built in recent years


The villa-style buildings built in recent years


High-rise 9 storey buildings built in the past (during Soviet times)

4- 5 - storey buildings built in the past (during Soviet times)

1-2 storey houses built in the past (during Soviet times)

Bayil landslide area

Figure 10. Types of buildings in Sabayil district

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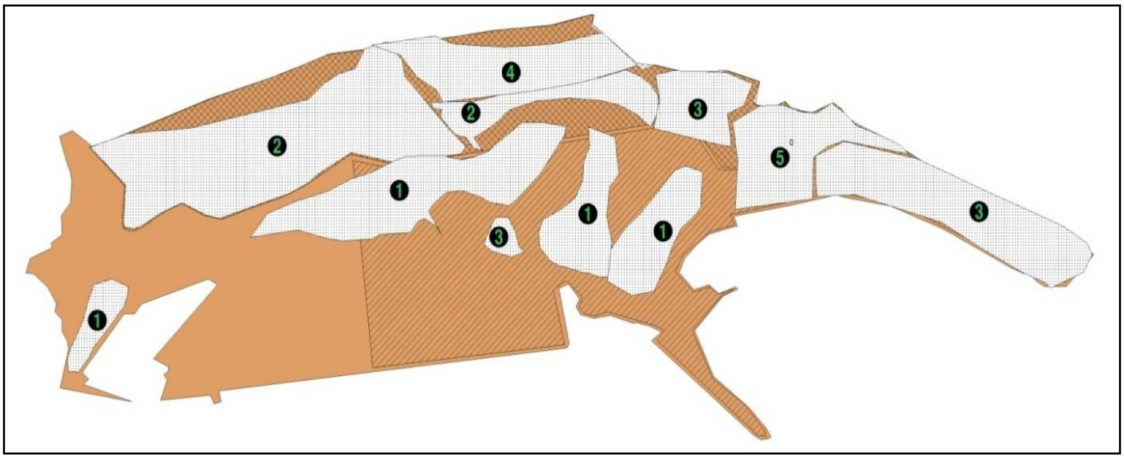

Figure 11. The layout scheme of areas where buildings are dominated.

Symbols:

1. Old private houses
2.Villa-style new houses
3.New high-rise buildings
4. 5-9-storey old buildings
5. 3-5 storey historical buildings

Symbols of 8-9 points zones

The seismic risk map-scheme of the region has been compiled by the comparison of seismic hazard levels with areas where buildings with different duration level are located (Fig. 12).

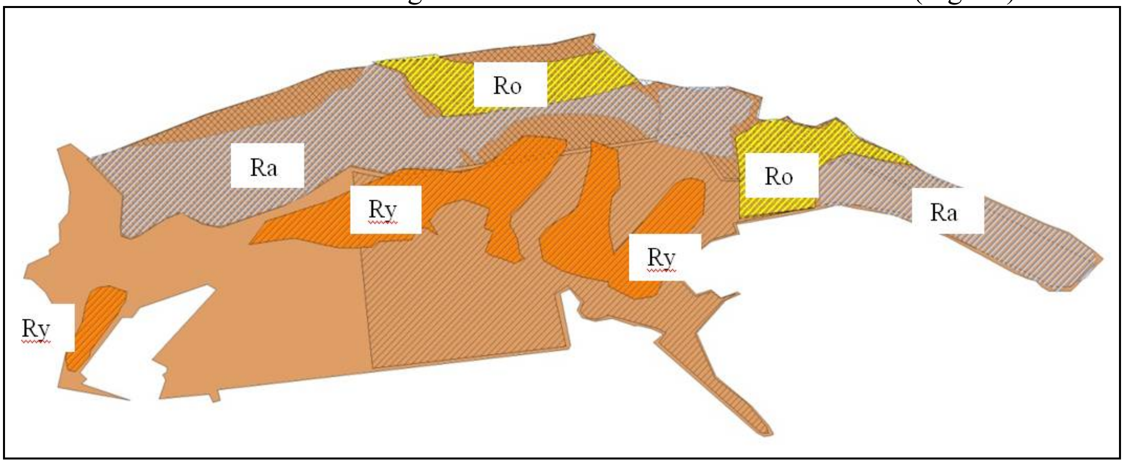

Figure 12. Seismic risk map-scheme of Sabayil district

Ra- low-risk area
Ro- medium risk area
Ry-high risk area

Thus, it was found that the level of seismic risk on separate areas of Sabayil district of Baku city is different: the low risk is observed in the areas where the buildings are constructed with strict observance of construction norms in the last 10-15 years regardless of the seismic hazard level (8 or 9 points). The medium risk is the characteristic for areas where middle and high-rise buildings are located which were constructed in the 1970's of the last century. Despite that the buildings were constructed with the construction norms in these areas, their seismic stability in the seismic zoning map compiled at that time was calculated to the level of seismic hazard defined for Absheron as well as Baku which evaluated one point below (7 points). The high-risk zones are the areas where the slums and houses are in an emergency condition built in the 1950-60's years without complying any construction norms.

Conclusion

The level of seismic hazard in separate areas of Sabayil district of Baku has a high degree of differentiation and this is conditioned by a number of factors.

- The seismic hazard level of the area is quite high (probably seismic hazard in the Absheron peninsula, as well as in Sabayil district of Baku is estimated at 8 points according to 12 point MSK-64 scale).
- Many areas of Sabayil district of Baku, where administrative buildings and the majority of population are concentrated, are characterized by unfavorable ground conditions and this factor raises the level of seismic hazard to 9 points on 12 point MSK-64 scale.
- There is a large, frequently repeated Bayil landslide zone in Sabayil district of Baku. During the strong earthquake, these sliding processes can be activated and increase the scale of the destructions.

REFERENCE

[1] Azərbaycan ərazisində seysmoproqnostik müşahidələr kataloqu. Bakı,"Elm", 1980-2016-cı illər. Гасанов А.Г., Етирмишли Г.Д., Панахи Б.М., Агаева С.Т., Абдуллаева Р.Р.. Каспийское землетрясение 25.11.2000 г. / Известия НАНА сер. Наука о Земли, 2005 №1,с. 43-51

[2] Ахмедбейли Ф.С., Гасанов А.Г., Кулиев Ф.Т., Панахи Б.М. Новые схемы областей возникновения очагов сильнейших землетрясений и сейсморайонирования территории Азербайджана / Каталог сейсмопрогностических наблюдений на территории Азербайджана 1987г. Баку: Элм, 1991, с.62-68.

[3] Гасанов А.Г., Маммадли Т.Я., Алиев А.Р. Сейсмичность Каспийского моря (Азербайджанская часть) по слабым землетрясениям. РЦСС АНА Каталог сейсмопрогностических наблюдений на территории Азербайджана в 1999 г. Издательство «ЭЛМ» Баку 2000. С.62-67

[4] Гасанов А.Г., Маммадли Т.Я., Паша Н.И. О сейсмических процессах в очаге Бакинского (Каспийского) землетрясения 25.11.2000 года. / Каталог сейсмопрогностических наблюдений на территории Азербайджана Баку, Элм, 2004 г. с. 74-82.

[5] Гасанов А.Г., Маммадли Т.Я., Сейсмическая опасность территории г.Баку по новым сейсмологическим и инженерно-геологическим данным. Опасные природные техногенные геологические процессы на горных и предгорных территориях северного Кавказа. Владикавказ 2008. С. 67-70

[6] Маммадли Т.Я, Новая методика выявления очаговых зон сильных землетрясений и определение их максимальных магнитуд (M_{max}) по слабой сейсмичности (на примере территории Азербайджана). ПРОБЛЕМЫ СЕЙСМОТЕКТОНИКИ. Материалы XVII Всероссийской конференции с международным участием 20-24 сентября 2011 года, Воронеж-Москва, 2011, с337-341.

[7] Новый каталог сильных землетрясений на территории СССР / Отв. редактор Н.В. Кондорская, Н.В.Шебалин. М.: Наука, 1977, 535 с.

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SEPARATION OF NATURAL AND TECHNOGENIC SEISMIC EVENTS ON THE TERRITORY OF AZERBAIJAN

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ABSTRACT. This article is devoted to the issue of recognizing the nature of seismic events in order to identify explosions. The results of analyzes of seismic events are presented. The criteria for the difference between explosions and earthquakes are established. A separate explosion catalogue has been created. Methodical bases of recognition of technogenic seismicity are developed.

Key words: seismicity, explosions, earthquakes, spectra.

Introduction

The expansion of the telemetric network of Azerbaijan and the commissioning of high-sensitivity digital seismic stations makes it possible to record weak earthquakes with M<1, which reduced the representativeness of the observed events. At the same time, the high resolution of modern equipment makes it possible to register also industrial explosions, which are conducted in the development of various deposits, in the laying of roads, pipelines, in the construction of tunnels, and explosions related to military exercises. The registration by highly sensitive equipment against the background of weak tectonic earthquakes makes the actual use of methods for recognizing the nature of seismic events to increase the information content of catalogues and to study weak seismicity. Studies have shown that industrial explosions are carried out in various zones of the Azerbaijani part of the Lesser Caucasus, the territory of which is rich in natural resources, as well as in the territories of Armenia and Iran adjacent to our republic. One of these zones is located in the occupied territory. It is possible that explosions related to military operations are also being conducted here.

The discussion of the results

The effect of chemical explosions is comparable to the effect of weak earthquakes. These explosions are recorded by sensitive stations of the republic and are treated as earthquakes. In this regard, the task was to control and monitor the explosive works carried out on the territory and near the borders of our republic. To solve this problem, was carried out the research to identify the criteria to differentiate in explosions from earthquakes. To work out the method of event identification, a number of methods were studied from international practice: the relationships of the spectral amplitudes of seismic phases, the method of spectrograms, the analysis of the wave pattern, the distribution of events in space and time, etc. [Gabsatarova, 2006].

For this purpose, the archive of seismic event records registered by seismic stations for the period 2011-2016 is being monitored. It was during this period that there was an increase in weak seismicity in these areas. The map (Fig.1) shows zones of increased density of weak seismic events' sources with M≤2.4 registered in 2015-2016.

A total of 4834 seismic events were considered and analyzed during this period. As can be seen from Table 1, over the years their number increased (with the exception of Chovdar zone) and in 2016 reached the greatest value.

In all these zones, mineral deposits are being developed. Only at Chovdar deposit, work since mid-2015 was suspended.

The overall picture of the sequential increase in the number of seismic events in the Lesser Caucasus and near the south-western border of the Republic, as well as separately for Kalbajar district is shown in the histogram (Fig. 2a, b).

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

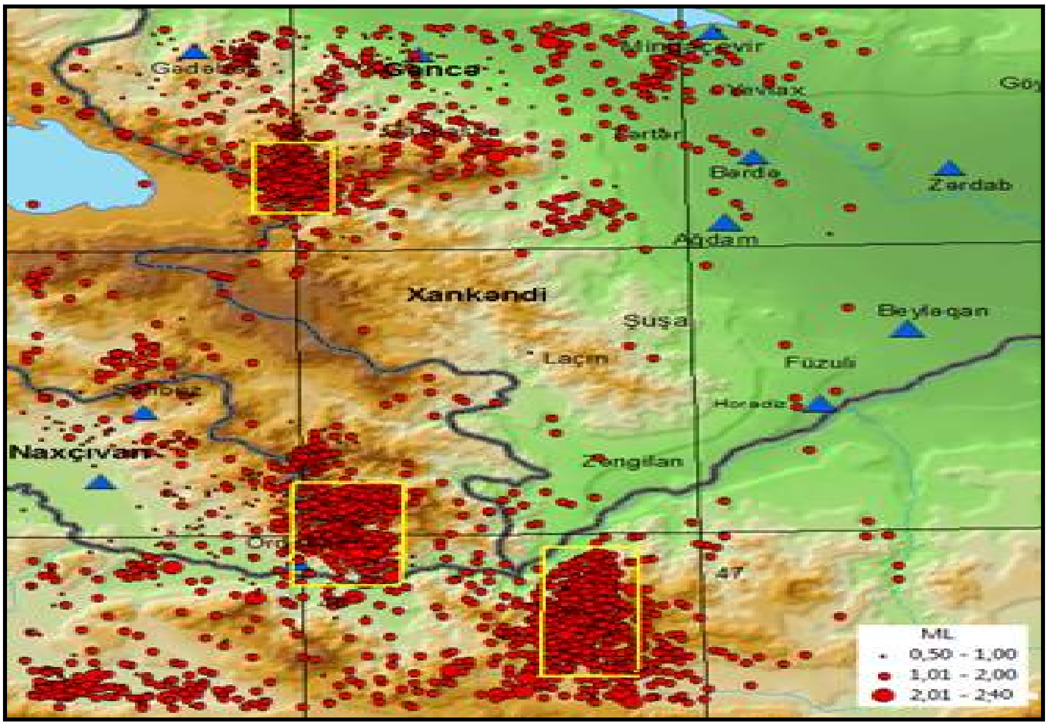

Figure1. Map of sources of weak seismic events for 2015-2016

Table 1. Seismic events recorded for the period 2011-2016 for the considered zones

Years / Districts	2011	2012	2013	2014	2015	2016	Total
Iran	79	330	339	475	544	731	2498
Zangezur	35	279	272	246	284	431	1547
Kalbajar	50	38	47	84	151	180	468
Chovdar	45	65	39	39	29	0	217
Dashkesan	12	7	18	14	17	36	104
Total	208	705	698	832	1013	1378	4834

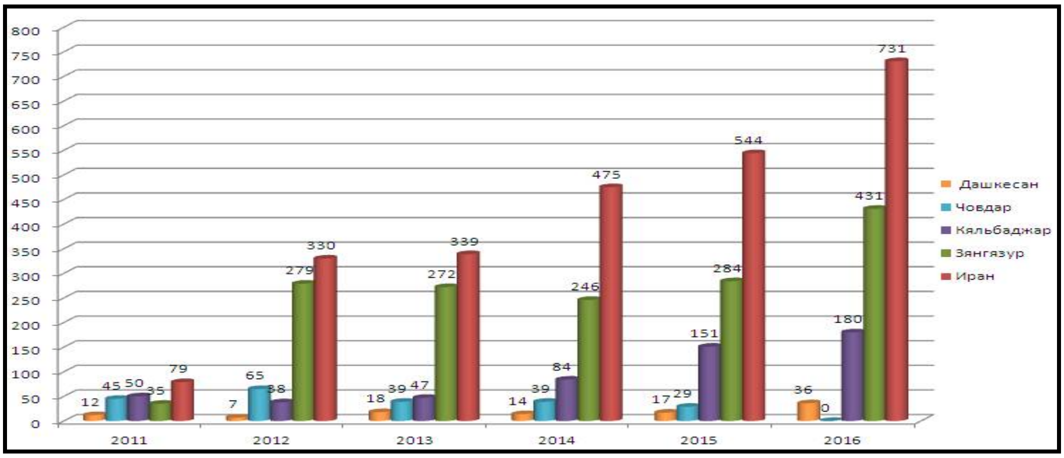

Figure 2a Seismic events in the Lesser Caucasus and near the south-western border of the republic for 2011-2016

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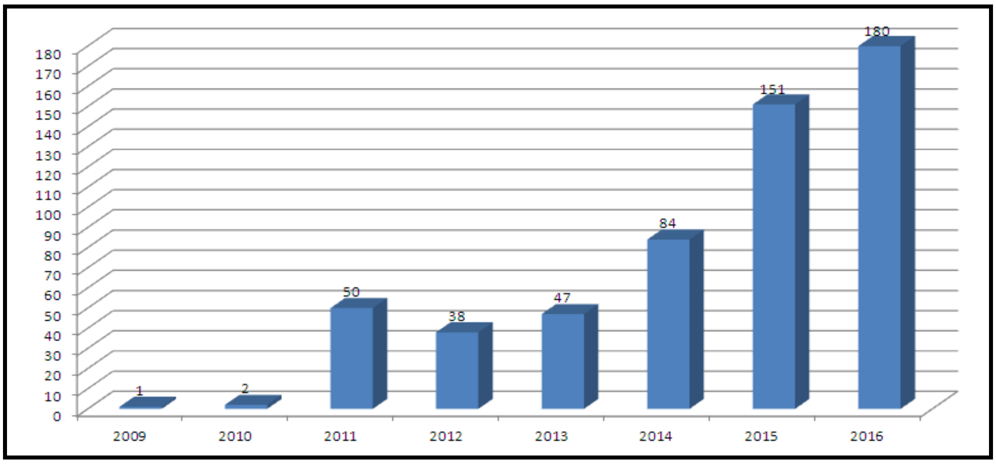

Figure 2b Histogram for Kalbajar district for 2009-2016

As an example, seismic events for 2016 are considered. On the map of the sources of seismic events (Fig. 3), the places of accumulation of epicenters were identified, on which industrial activity was observed. As noted above, on selected sites the number of seismic events increased every year and in 2016 reached its highest value.

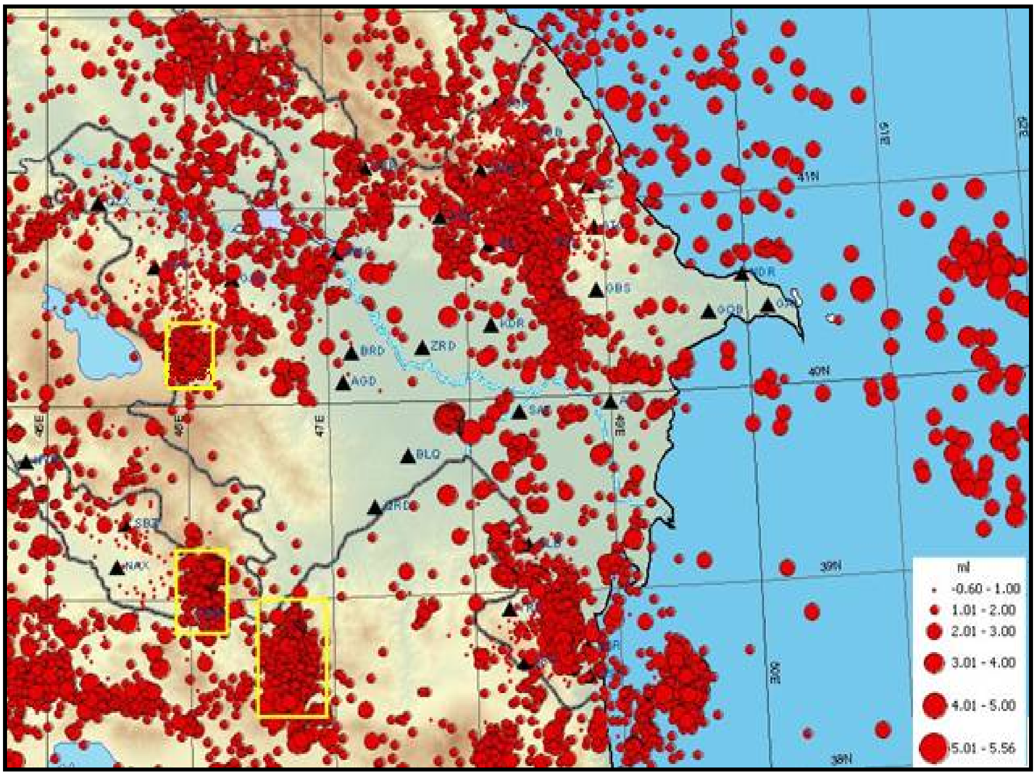

Figure 3. Map of sources of seismic events registered in 2016

An analysis of the distribution of the events occurrence time for a given year using the petal diagrams (Fig. 4) indicates the technogenic nature of seismic events at the selected sites [Godzikovskaya et al., 2000]. As an example, diagrams of the distribution of seismic events in Kalbajar district and the adjacent territory of Iran are given. The diagrams clearly show a sharp increase in events at 13-16 hours for Kalbajar zone and 9-10 hours for the zone of Iran, which is not typical for earthquakes.

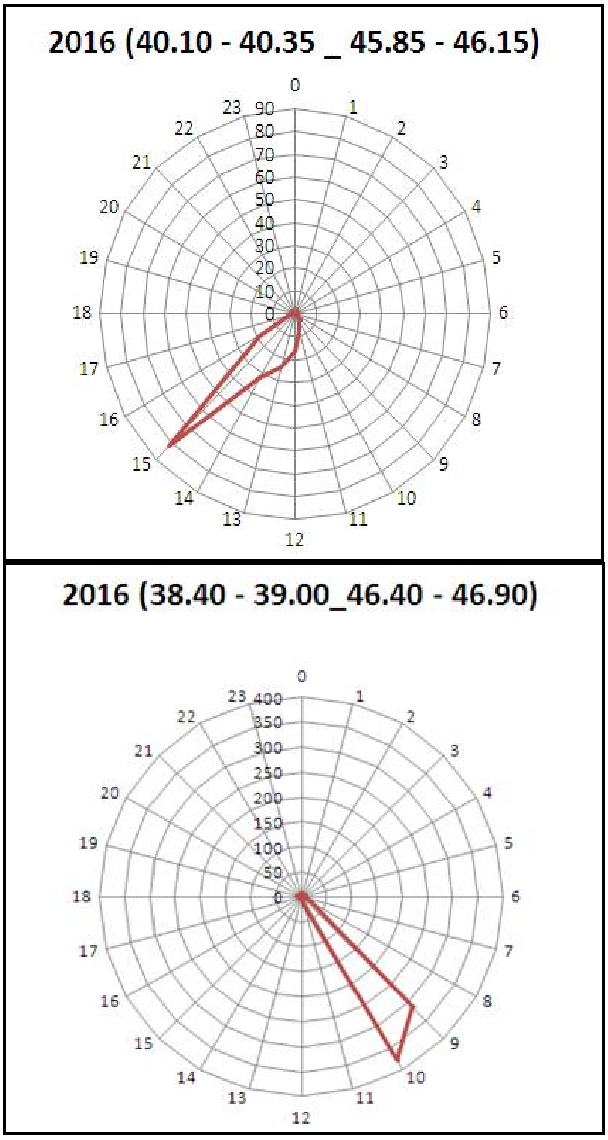

Figure 4. Diagrams of spatial and temporal distribution of seismic events for Kalbajar and Iran for 2016

The criteria for distinguishing explosions and earthquakes have been determined in the examined regions. For this purpose, the digital records of all seismic events were examined and analyzed, the spectral properties of their records were studied, spectrograms for each event were constructed, and the ratios of the spectral amplitudes of the volumetric P and S waves were calculated. The features of the wave pattern and spectra of seismic events of different nature are studied. To view and analyze industrial activity in the territory of Lesser Caucasus, the data of the stations close to the studied areas were considered: Ganja and Gadabey, for the territories of Iran and Armenia data from Ordubad station were considered.

As an example, records of earthquakes and explosions recorded by digital seismic stations of the republic are shown (Fig. 5-7). Analysis of spectrograms of seismic events records showed that during explosions the amplitude of the displacement spectra is less than 100 at a frequency of 1-10 Hz, while for earthquakes the amplitude of displacement is significantly more than noise spectrum, its

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value reaches 1000 at frequencies of 1-20 Hz (for example, on September 27, 2016 - earthquake, January 21, 2016 - for an explosion).

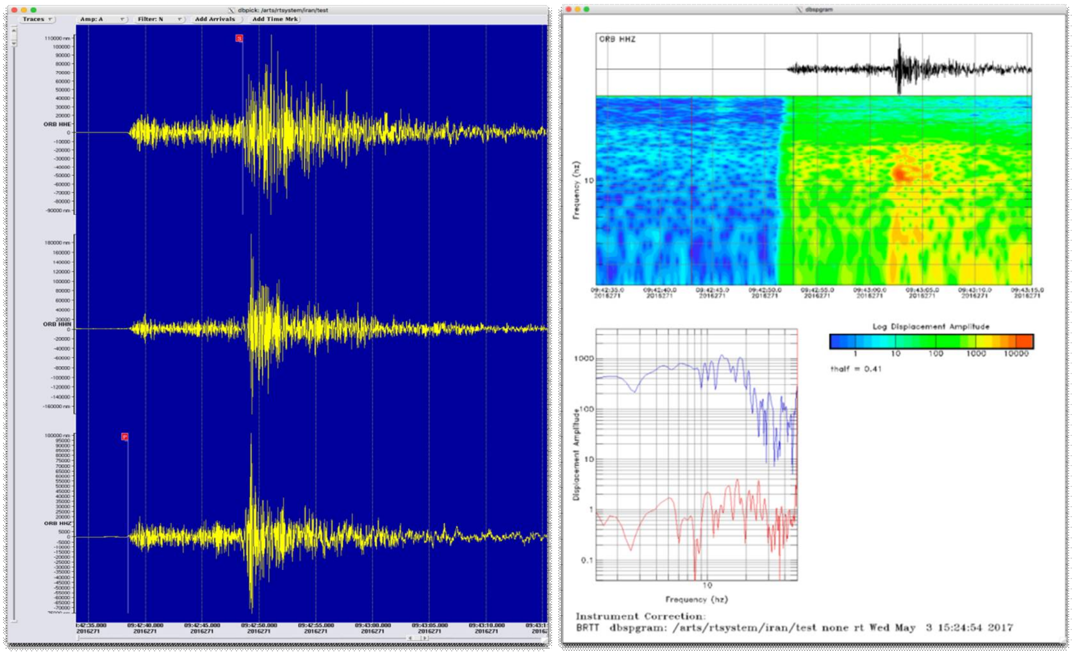

Figure 5. Wave pattern and spectrogram at the station of "ORD" of the earthquake occurred on September 27, 2016 in Iran

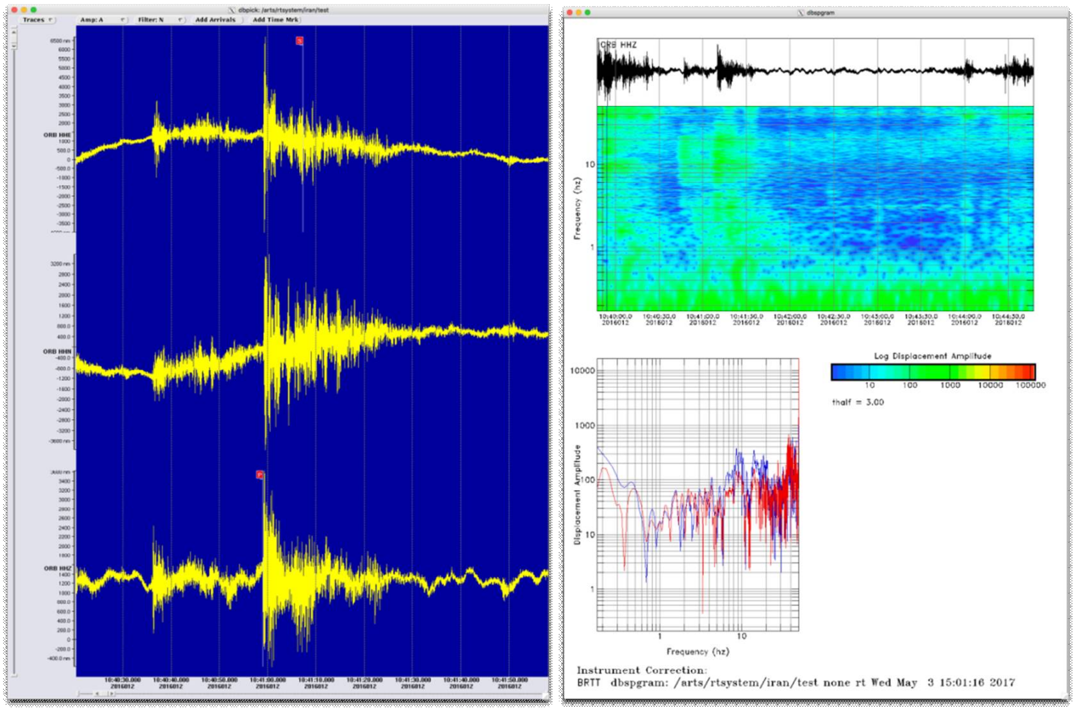

Figure 6. The wave pattern and the spectrogram at the station of "ORD" of the explosion produced on January 21, 2016 in the territory of Iran

Records of earthquakes recorded by these stations near the considered areas look different than explosions. In earthquakes, S-wave amplitudes predominate over P-wave amplitudes, in explosions the P-wave entry is distinct, the S-wave on all components is less clear, sometimes at noise level, i.e. the spectral ratios of P/S for explosions will be much higher than 1. In earthquakes, on the contrary - the spectral amplitude of S-waves is higher than P-waves, i.e. the spectral ratios of P/S for them are much lower than 1. The analysis of the wave pattern showed that such a pattern can be traced on the vertical and one of the horizontal components: EW at Ordubad station for Iranian and Zangezur explosions, NS at Ganja and Gadabey stations for small Caucasian explosions. In addition, in the case of an explosion in the records of horizontal components, a short-period surface wave *Rg* with a change in the oscillation periods of 1-2s, which occurs immediately after the transverse wave and is well distinguished in the indicated components.

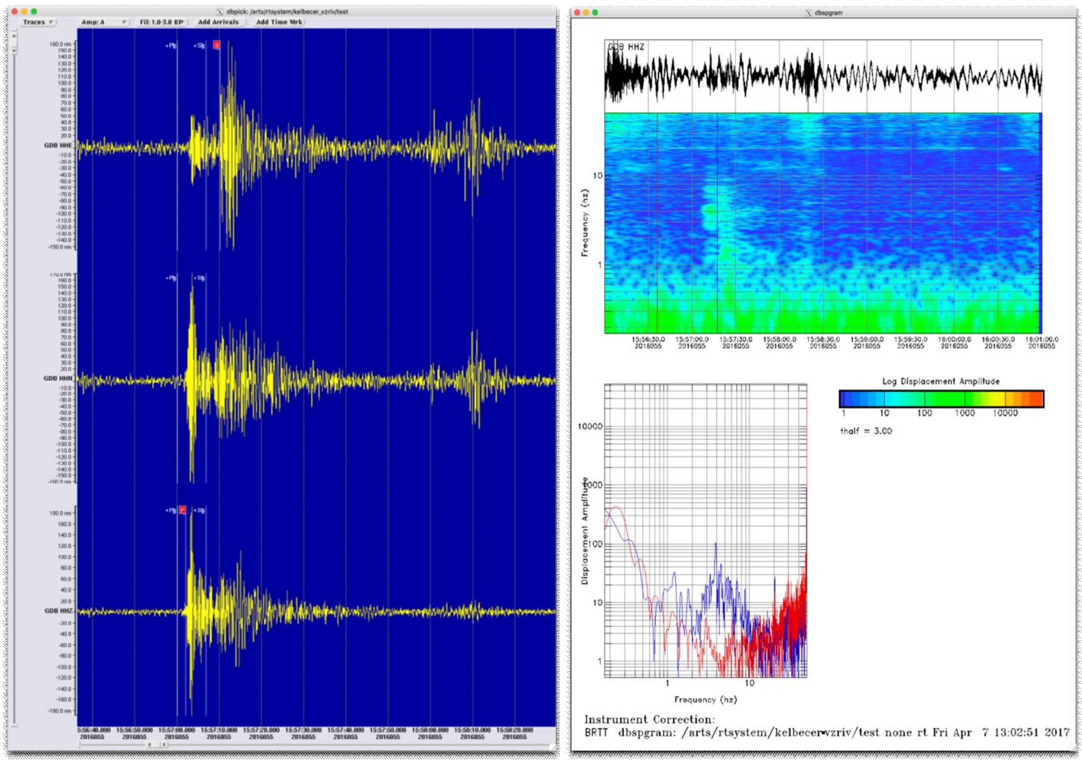

Figure 7. The wave pattern and the spectrogram at the station "GDB" of the explosion, produced on February 24, 2016 in the territory of Kalbajar district

Analysis of the time of explosions showed that they are produced mainly during working hours: for Kalbajar 11-16 hours, for Dashkesan 12-16 hours, for Iran 8-11 hours, for Zangezur 8-13 hours. Analyzing the seismic events in these zones, they found out that in 2016 earthquakes constitute 3.5% of the number of events in Kalbajar, i.e. from 180, 1.5% of those in the local area of north-western Iran, 5.4% in Dashkesan district and 1.6% in Zangezur district.

Conclusion

Taking into account the developed criteria, a separate database of explosions has been created. Creation of the cleaned catalogue of earthquakes in Azerbaijan allows to more accurately determining the spatial features of the distribution of weak seismicity in the territory of operating quarries, which is necessary to identify the seismic regime and the seismic risk of the studied territory. The monitoring of blasting operations makes it possible to determine the type of activity with which these explosions

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are connected, whether military exercises or civil works, and to reveal the facts of the use of our deposits in the occupied territory. The work will provide an opportunity to control the actions of military formations in the occupied territories of our republic.

The established criteria for the difference in explosions will make it possible to further distinguish the records and times of nuclear explosions conducted in the world and, thus, control them.

REFERENCES

[1] Габсатарова И. П. - Методика выявления взрывов в ряде районов, действующих карьеров Северного Кавказа // Землетрясения северной Евразии в 2000 году, Обнинск 2006

[2] Михайлова Р. С., Габсатарова И. П., Артемова Е.В. Проблема засоренности промышленными взрывами каталогов землетрясений Армении в 2006-2008 гг. //Землетрясения северной Евразии в 2008 году, Обнинск 2014

[3] Годзиковская А.А., Бесстрашнов В.М., Лабазина Е.Ю. Землетрясения и взрывы Восточно-Европейской платформы // Природные опасности России. Сейсмические опасности .- М.: Крук, 2000. – С. 46-53.

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ABOUT THE ECOGEOPHYSICAL RISKS AND RESEARCH ON THE IMMERSED MUD VOLCANOES

H.O.Valiyev[1], R.B.Muradov[1], M.K.Mammadova[1], J.K. Mammadov[1]

ABSTRACT. There are numerous known and immersed mud volcanoes in the Azerbaijani areas of the Caspian Sea. In the article was noted the increase in the number of accidents happened at wells during the exploration of oil and gas fields is directly related to immersed mud volcanoes. While volcanic activity in Azerbaijan is widely studied, almost no research has been carried out to study the immersed mud volcanoes.

In many cases accidents happen in the wells according to geodynamic changes that occur in the mud volcanoes fields as of place and time are not routinely studied up to now. In addition there are different problems in the seismic data acquisition and analysis, the determination of speed parameters. To eliminate situations like this, it is important to take into account the risk of natural hazards in the implemented projects.

Mainly it is recommended to consider the results of seismic research to ensure a normal, safe working mode of the technological processes in the exploitation and processed oil fields.

Key words: mud volcanoes, eco-geophysics, erosion products, composition of fluids, geodynamic tension, seismic recording.

Natural disasters (earthquakes, landslides, volcanoes, streams and etc.) that are not subject to human intelligence greatly damage the state economy and population by creating the extreme situations. Although it is not possible to prevent emergency situations, it is possible to achieve the reduction of consequences by taking the preventive measures.

There are many known and immersed mud volcanoes in Azerbaijan territory of the Caspian depression [2]. The study of destructive eco-geophysical consequences of mud volcanoes is one of the most pressing problems.

In many cases, it has been proven that recently the increase in the number of accidents in the wells during the exploration and exploitation of oil and gas fields is connected with the anomalous changes of geodynamic tension occurred directly in the zone of mud volcanoes.

The earthquakes, volcanic eruptions, streams, and floods can be examples of the factors that influence the environment. Problems in that area which are related to each other consist of two parts: a) studying of natural phenomena before the occurrence; b) taking the preventive measures and minimizing possible damages. The difficulty is that many of the natural phenomena are unexpected. They are related to the emergency dynamic processes that suddenly occur in nature.

The study of mud volcanoes which bring the actual examples from the deep layers of Earth, which cause ecological consequences and which is a beautiful natural monument, is one of the most pressing problems. So far, although the volcanic activity in Azerbaijan has been widely studied, almost no research has been done in the direction of studying immersed mud volcanoes.

During the mud volcanoes activity residential and farming areas near it, the transport-road junctions and etc. are in dangerous emergency situation and it is necessary to take some security measures. Besides all this, another problem is related to the research and exploitation works in the fields covered by mud volcanoes. As we know, there are mud volcanoes in the most of the oil-gas anticline type structures and in the most of oil and gas fields related to them.

Mud volcanoes create geodynamic-tension conditions in the oil field and when the collected potential voltage energy is reached to anomalous level the danger is expected every moment. So far, as of place and time the occurred geodynamic changes in the fields with mud volcanoes for not being

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

studied regularly, accidents occur in the drilling wells in many cases. In addition, the difficult problems are identified in the seismic data acquisition and determination of speed parameters. The projects implemented to eliminate such cases have shown that it is important to take into account the risk of natural hazardous events.

Mud volcanoes are unique areas that create geodynamic-tectonic tension in a certain area on the ground. There are over 2,000 known mud volcanoes in 26 countries of the world (Columbia, Italy, Romania, Russia, Ukraine, Pakistan, etc.). There are 350 mud volcanoes and volcanic manifestations in dry areas of Azerbaijan (Fig. 1) and in the Caspian Sea [2]. These are located on the Absheron peninsula, Gobustan, in the south-eastern Shirvan plain, on the Samur-Devechi lowland, Absheron and Baku archipelagoes. The largest of them is Galmas, Toragay, Great Kenizdagh and others. The most of their structure is in the cut cone form. The height is 20-400m; the diameter of the coverage area is 100-4500 m.

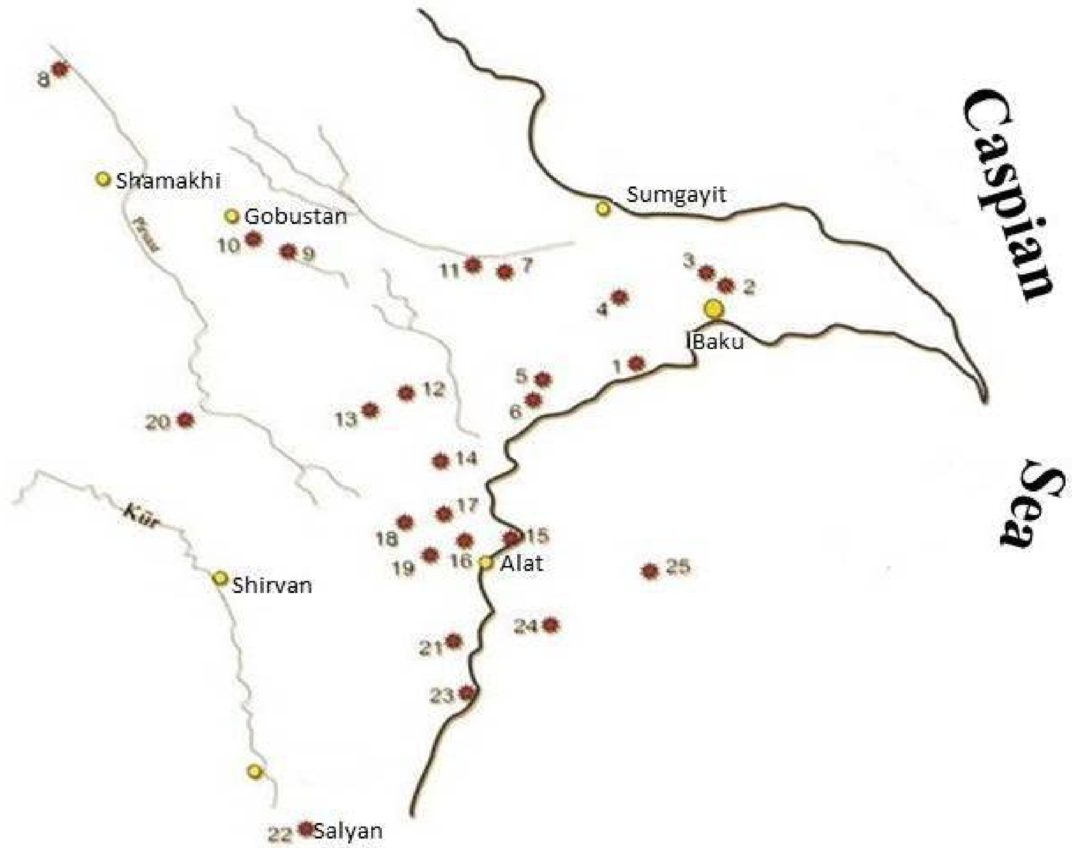

Figure 1.The map of mud volcanoes in Azerbaijan

During the eruption, mud emerges to the surface along with hydrocarbon gases (Fig.2), there occurs a 300-400 meters flame column (Fig.3), sometimes high percentage of carbon dioxide and at the same time the large amount volcano breccias emerge. During the quiet activity of the volcano again gas, mineralized water, slimy mud and in some volcanoes are extracted much oil and as a result, unusual saline soil and geochemical rare landscapes emerge in the volcano area and have an impact on the environment. The proximal and gryphon-salsa activity of widespread mud volcanoes in Azerbaijan forms rare landscapes, affects the environment and living organisms. The high concentration of chemical elements or lack of sufficient quantities, their unusual proportion for the biosphere cause certain changes in the status of an ecosystem in the mud volcanoes zones.

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One of the key issues is that the mud volcanoes areas are polluted and people settle down near the volcano. After the eruption of the Keyreki mud volcano near Binagadi settlement in February 2002, a largely residential area was built near the volcano and some buildings were built on the slopes of the volcano [2].

In addition to the mud volcanoes on the land, immersed and sea mud volcanoes are also known. There are more than 140 underwater mud volcanoes in the Caspian Sea. The eight islands (Khazar-Zira, Zanbil, Garasu, Gil, Sangi-Mugan, Chigmil and others) on the Baku archipelago are of mud volcano origin. The embedded mud volcanoes were found in the wells. The traces of their activity are found between various old layers. According to the data, the first activity of the mud volcanoes in the territory of Azerbaijan Republic is about 25 million years ago. Usually, mud volcano eruption begins with strong underground roaring and explosions. Gases emerged to the surface from the deep layer of the Earth flare up. Sometimes it was observed that the height of flame reached 1000 m (Garasu volcano) on the volcano. From 1810 up to now, 50 volcanoes have erupted nearly 200 times in the territory of Azerbaijan Republic. 19 eruptions were recorded in Lokbatan volcano. The mud volcanoes erupt solid, gas, and liquid. There are 100 times more mineral and up to 30 microelements (boron, mercury, manganese, copper, barium, strontium, lithium, etc.) in solid products. The mud volcanoes are related to the oil and gas fields. The rich oil and gas condensate deposits were discovered in the mud volcanoes areas (Lokbatan, Neft Dashlari, Garadagh, Mishovdagh and others).Their mud is a valuable raw material that used for the treatment. In 2007, the "State Nature Reserve of the Mud Volcanoes range of Baku and Absheron Peninsula" was created and 52 mud volcanoes had been given the status of state natural reserve.

It should be noted that the volcanic eruptions are one of the fascinating phenomena of nature, but also are dangerous to humans. Volcanic eruption can not only cause scattering and dissemination of mud volcano materials, as well as the contact of air and soil with other unwanted potential pollutants. On the other hand, the activity of mud volcanoes leads to the creation of a landscape that is accompanied by special type of salinization. The last one is sometimes absorbed by oil.

It is known that 40 volcanoes and volcanic manifestations in Azerbaijan produce much oil. Their positive or negative effect to the characteristic of the geochemical landscape, the volcanic rocks, and composition of fluids, microelements-boron, molybdenum, lead and etc. are determined by the anomalous amount in the new mudflow.

To assess the impact of mud volcanoes on the environment, different morphological content and activity of the volcanoes should be taken into account, as well as a comparative analysis of the number of microelements in the volcano breccias, soil, the ash of animals and plants must be fulfilled. (Fig. 2).

When the mud volcanoes are active, it is known that there are dangerous consequences. If there are residential areas, farming areas, the road-traffic junctions near the volcanoes and etc. it is important always to take into account the likelihood of having dangerous emergency situations and to take appropriate actions.

The main natural elements and compounds that pollute the atmosphere are thrown into the air in the form of nitrogen oxide, carbon dioxide, methane and other hydrocarbons, radon, radioactive elements and heavy metals (As, Cd, Cr, Pb, Mn, Hg, Ni, V), solid aerosols not only through ordinary volcanoes, as well as mud volcanoes. (Fig. 3).

Bozdagh-Guzdek volcano which erupted in 1902 led to the death of 6 people and 2,000 sheep. Also, the land splitting is related to the crater area of the volcano. Its effects cover the pressing of soil through cracks, mixes or collapses and around throat of earthquake faults. The mudflows can be 100 m wide and 1m thick. Furthermore, the soil sedimentation zones or displacement of the soil along cracks and faults can be extended to the studied areas from volcano throat.

So far, as of place and time the geodynamic changes in the mud volcanoes fields for not studying regularly, there have been accidents in the drilled wells in most cases. The causes of accidents were not often investigated and are shown either as a geological or technical reason. For

Figure 2. Durovdagh mud volcano, hydrocarbon gases emerge to the surface with mud.

Figure 3. Otman – Bozdagh 08.02.2017, 14:23

example, a terrible accident has occurred at the well 42 which drilled in the Dashgil volcano area on Baku archipelago. The 2500 m long steel pipes were thrown out of the well and became spiral. Then the mud flow had started from there.

In Indonesia, there was the more terrible event [3], an accident occurred during the digging of the gas well and the mud fountain from the well had covered the ground (Fig. 4). As a result, there were human casualties, the mud covered lots of residential areas and the material damage was great.

Figure 4. The situation created by the mud eruption during the drilling of gas well in Indonesia..

As it was mentioned above when the mud volcano is active, the damage to residential areas and other facilities is great; the exploitation regime is violated in the oil field. The dangerous effects of mud volcanoes include the volcanic breccias streams, collapses, faults and shifts of layers, manifestations of gases, burning of gases and formation of anomalous high-pressure zones.

In addition, there are difficult problems in determining speed parameters in seismic data acquisition and analysis:

-Since there is no reflective border within the cone of mud volcanoes a complex, chaotic seismic recording view is observed;

- Since going through from the wing of structure to the arch in section the follow of seismic horizon becomes difficult and etc.

Besides all this, the most pressing issue is related to the research and exploitation works in the oil fields covered by mud volcanoes. It is known that there is mud volcano mainly in most of oil-gas anticline type structures and oil-gas fields related to them. (Fig. 4). The mud volcanoes cause geodynamic tension in the oil-gas field and it is expected to be at risk every moment when the potential tension energy reaches the anomalous level (Fig. 5).

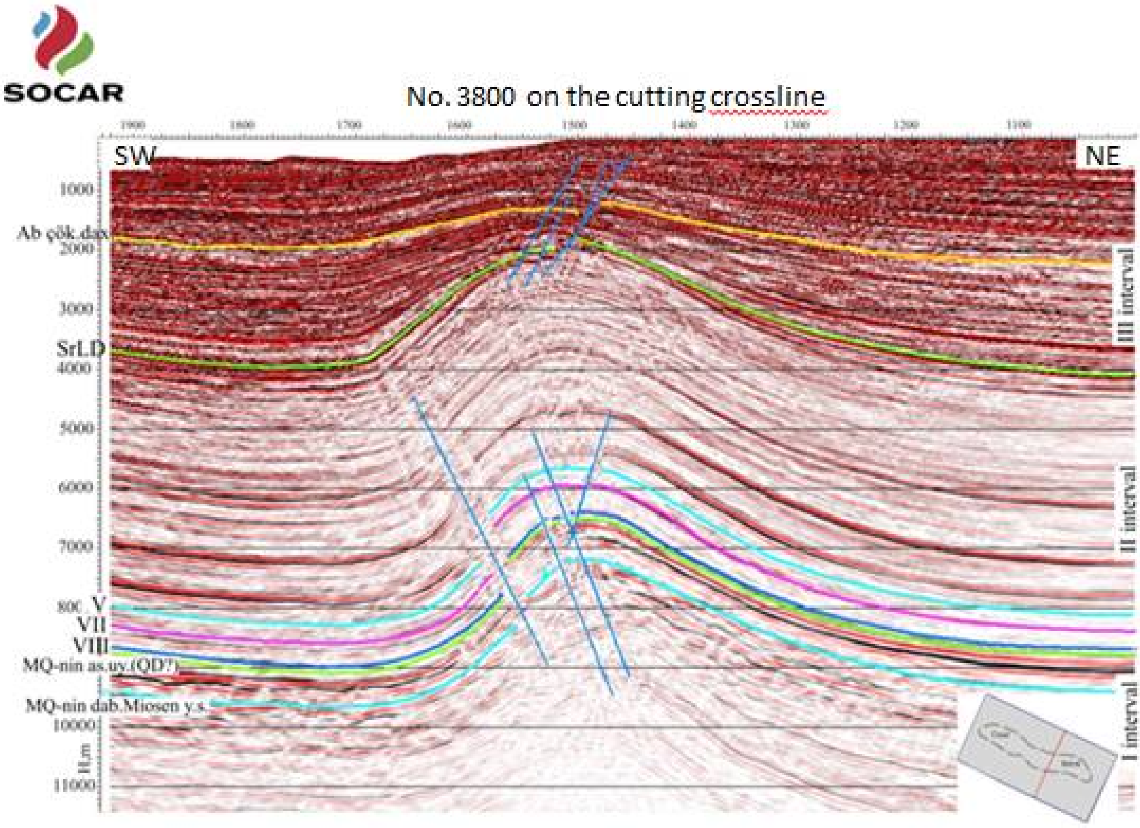

Figure 4. The description of mud volcano in 3D seismic section conducted on Umid-Babek area, Baku archipelago

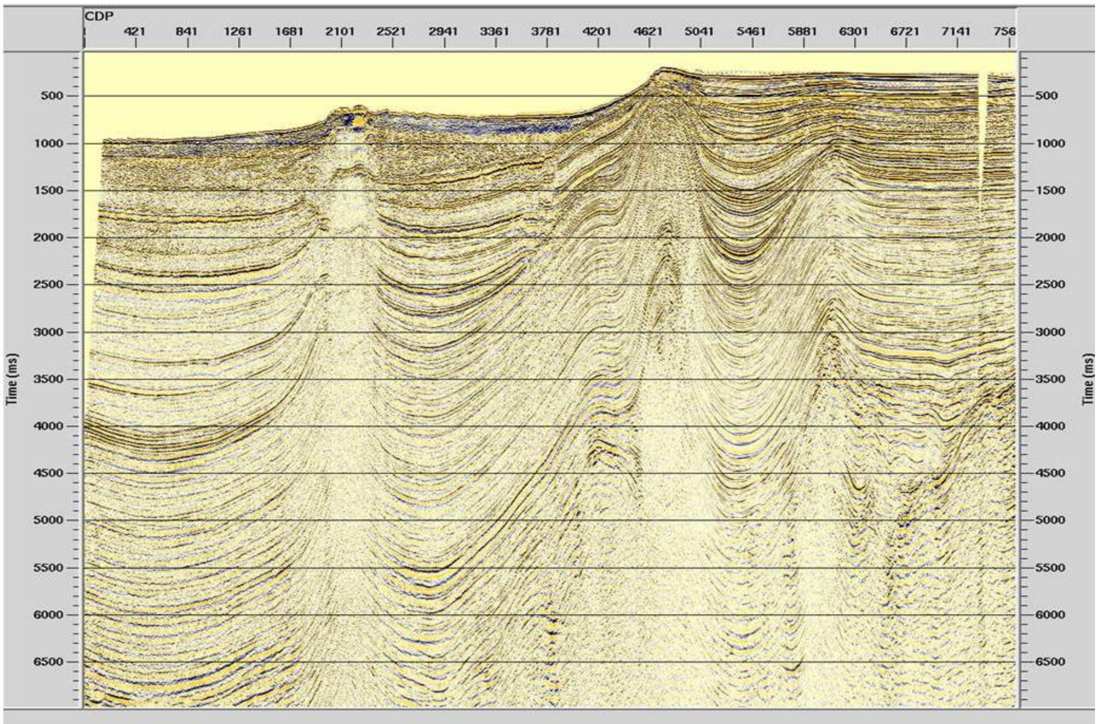

Figure 5. Description of the mud volcano in the migration section in Absheron structure

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To solve these problems correctly, mud volcanoes should be regularly studied by modern geophysical methods and devices. The research should be carried out by taking into account that the parameters of the seismic wave which pass through the mud volcano have changed according to the geodynamic tension condition in the environment. For this purpose, studying the work mentioned in the original variant, to study the likelihood of immersed mud volcanoes in the fields modern two-dimensional (2D) and three-dimensional (3D) seismic surveys are proposed:

1. To create a monitoring station within the 3 volcanoes surround that is in the operation and temporarily suspended, regularly monitoring changes in geophysical fields mainly speed parameters with satellite-related software devices.
2. To transmit the results of the research to a center operatively and determine the anomalous condition of geodynamic tension in the region, to determine the likely occurrence of events and take immediate security measures
3. To conduct a normal, safe working mode of technological processes by taking into account the monitoring results in the oil fields which is prepared for processing and operated and identify the risk.

Thus, the risk of natural hazardous events in the projects which are implemented in the oil fields surrounded by mud volcanoes should be mainly considered according to the results of the seismic research. At the same time, it is possible to estimate the riskiness (the impacts on oil and gas wells drilling and exploitation and environment) of the mud volcanoes by setting their eruption circulation (frequency) and to show the ways to minimize the negative impacts.

REFERENCES

[1] В.Н.Холодов. О природе грязевых вулканов. Природа, 2001, №11.
[2] A.Əliyev, R.Rəhmanov .Palçıq vulkanları və ətraf mühit, 2008.
[3] Жертвы грязевого вулкана в Индонезии. http://mirvkartinkah.ru/zhertvy-gryazevogo-vulkana-indonezii.html#ixzz4hDrjrG.
[4] Керимов К.М., Велиев Г.О., Ахмедов А.Г., О механизме образования и предсказании времени извержения грязевых вулканов. 2008. AZƏRBAYCAN NEFT TƏSƏRRÜFATI, BAKI, №5, S.63-66.
[5] Шнюков Е.Ф., Нетребская Е.Я., Глубинное геологическое строение грязевых вулканов Черного моря. 2014, ISSN 1999-7566. Геология и полезные ископаемые Мирового океана. №2, с.66-79.
[6] Шнюков Е.Ф., Нетребская Е.Я., О глубинном строении эруптивного канала грязевых вулканов. 2016. Геология и полезные ископаемые Мирового океана. №4, с.54-66.

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CONTEMPORARY SEISMOGEODYNAMIC SITUATION OF AZERBAIJAN

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

ABSTRACT. The article considers strong earthquakes that occurred on the territory of Azerbaijan for the period of 2003-2017. The connection between the observed seismicity and the tectonic structure of the region is revealed. The analysis of the mechanisms of strong earthquakes' sources is given to study the stress-strain state of the Earth's crust and to reveal the nature of shifts in active parts of deep faults.

For the period of 2003-2017 years seismicity was uneven both in magnitude of the released seismic energy and in the number of occurred earthquakes. The number of earthquakes has reached an anomalous value in 2015 due to an increase of weak seismicity.

From the map of earthquakes' epicenters (Fig.1, 2) it is clear that earthquakes are distributed unevenly, seismicity has a mosaic nature. The greatest concentration of epicenters is observed in Zagatala-Lagodekhi region, Oguz, Shamakhi-Ismayilli, Saatli seismically active zones, Talish, and the north-western part of Iran adjacent to Nakhchivan Autonomous Republic. In the water area of the Caspian Sea condensations are observed in the northern Azerbaijani part, around the Absheron peninsula, and also in the central part of the Caspian Sea. As can be seen from the map of epicenters seismic events have not been recorded on the Absheron peninsula. However, potentially dangerous are the earthquake sources located in the Caspian Sea around the peninsula. It is enough to recall the manifestations on the surface of the Caspian earthquake occurred on November 25, 2000 with M=6.2.

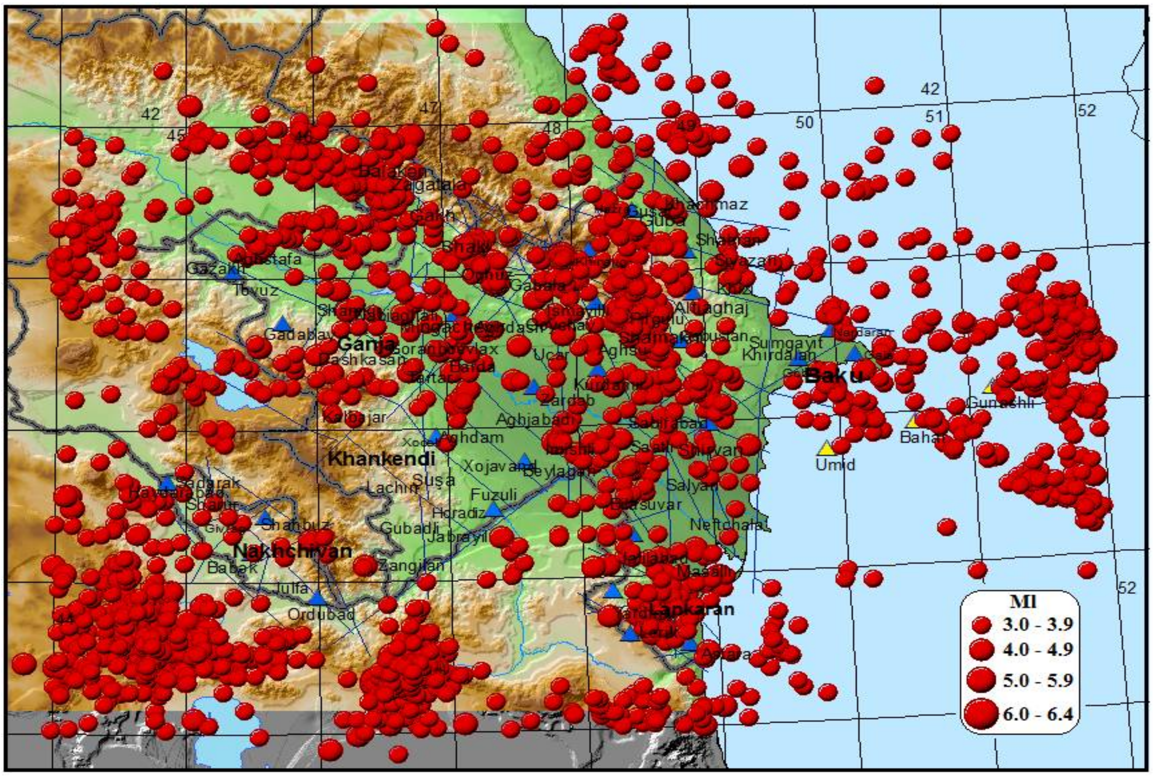

Figure 1. Map of earthquake epicenters of Azerbaijan for 2003-2017 with ml>3.0

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

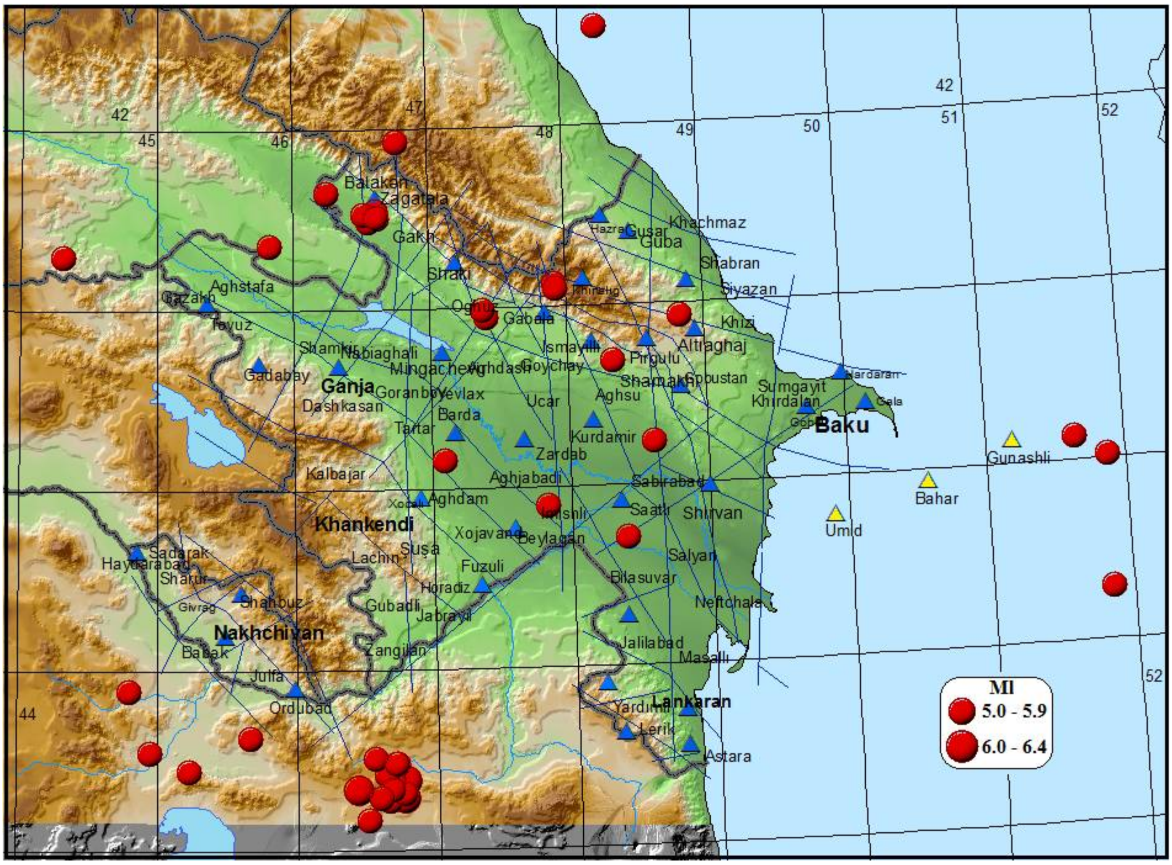

Figure 2. Map of earthquake epicenters of Azerbaijan for 2003-2017 with ml> 5.0. The fault tectonics [Kengerli TN, 2007]

As can be seen in the graph 3, the most interesting seismic energy values were in 2012 and 2014.

After some decline in seismic energy from 2007 to 2011, in 2012 the seismic situation sharply escalated. A number of earthquakes with an intensity of 5-7 points and ml≥5 occur on the territory of the republic. The value of released seismic energy reached $E=184*10^{11}$ J, in 2013 this value decreased to $E=6.56*10^{11}$J.

The activation began on May 7, 2012 at 04^h40^m and at 14^h15^m, when two strong earthquakes with ml = 5.6 and 5.7 occurred in the north-west of the republic in Zagatala region, which were felt with J_0=7δ points in the epicenter. They had a large aftershock activity: 170 aftershocks occurred during the first day, and more than 500 by the end of May. To study the seismic process, temporary stations – "ABL", "BZR" and "YSD" were installed in the area of the earthquake. In the tectonic plan, the earthquake sources are confined to the junction zone of two major geostructures of the Caucasus: Kura depression and the south-east immersion of the Greater Caucasus [Khain VE, 2005].

After Zagatala earthquakes on May 7, activation of these structures along the entire seam zone took place, namely: on May 14 and June 25 there are earthquakes in Sheki region with ml=4.1, J0=5δ points; 18 May-aftershock of Zagatala earthquakes with ml=5, J0=6δ points; October 7 - in Ismailli region with ml=5.3 (depth 41 km), J0=4-5δ points; October 14 - in Balakan with the magnitude ml=5.6, J0=6δ points.

In addition to those listed above, in 2012 was observed the activation in the territory of the NW of Iran, adjacent to Azerbaijan. Here strong earthquakes took place: on August 11 with ml=6.4 and on November 7 with ml=6, which were felt in the southern population centers of the republic with the intensity of 4-5 points.

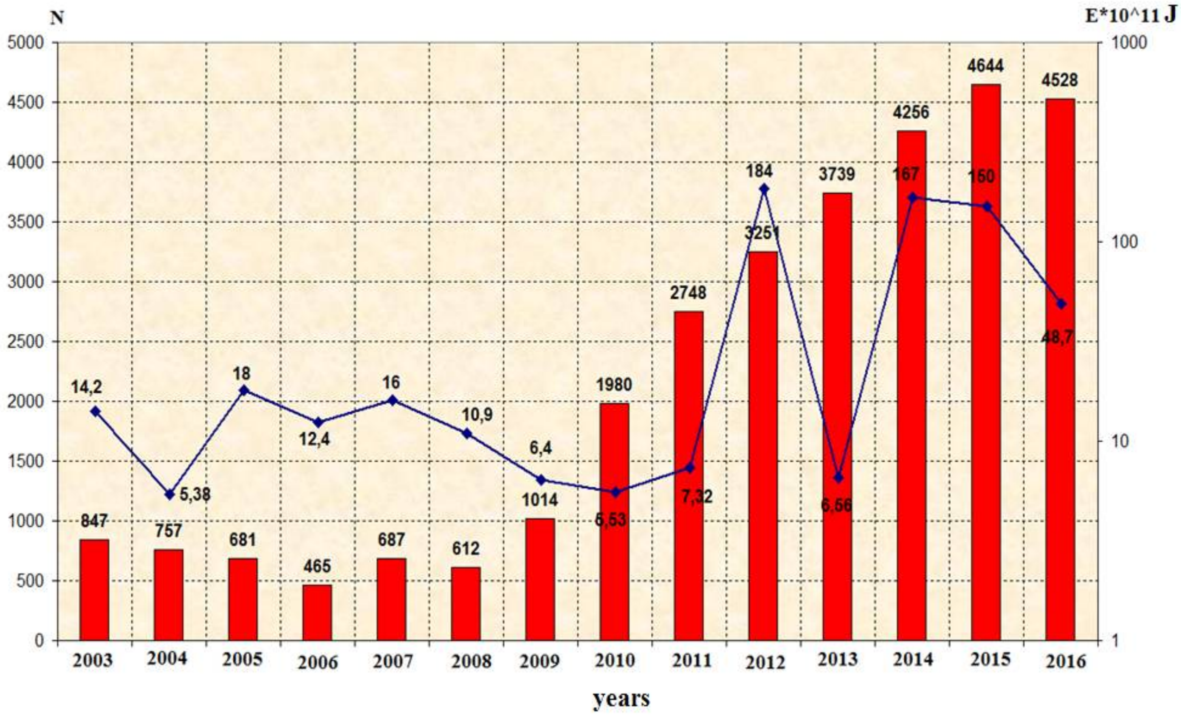

Figure 3. Graph of distribution of the number of earthquakes and released energy by years for the period of 2003-2016

In 2013, despite the fact that the number of earthquakes increased, the amount of released seismic energy (E=122*1011 J) decreased more than in 10 times. In 2013 earthquakes with ml ≥4 occur in a number of regions: in Samukh region, as well as in the regions of Sheki, Guba, and Gabala. In 2013, there were 24 significant earthquakes.

In 2014, the number of earthquakes and the amount of released seismic energy increased. There were recorded 25 perceptible events of which 6 earthquakes with a magnitude of ml≥5. The strongest of them can be noted the earthquake occurred in Hajigabul on 10.02.2014, at 16:06 local time with a magnitude of 5.8 (h = 56 km), felt up to 5-3 points and also an earthquake occurred in the Caspian Sea on 07.06, 2014, at local time 11:05 with a magnitude of 5.6 (h = 61 km), felt up to 3 points.

This earthquake did not have aftershocks and possibly played a role in further activation, i.e. in the acceleration of seismotectonic processes and the implementation of the coming sources of earthquakes this year, the epicenters of which are located in the south-east immersion of the Greater Caucasus. These are the earthquakes occurred on June 29 in Zagatala - Balakan region with ml=5.3 and two earthquakes - September 29 and October 4 with ml=5.5 and ml=5.0 respectively, to the north-east of Gabala.

On September 4, 2015 in the vicinity of Oguz region occurred one of the strongest earthquakes in the last 10 years with a magnitude ml=5.9. On the basis of macroseismic studies it was revealed that the earthquake was felt most intensively in Oguz and Sheki regions. Here, the earthquake intensity according to the MSK-64 scale was estimated at 7 points. The earthquake was accompanied by more than 80 aftershocks with a magnitude from 0.5 to 4.33 which occurred during the first day. Note that the total released seismic energy in 2015 almost coincides with the energy in 2014 and is equal to $150*10^{11}$J.

In 2016-2017 years the zone of the Lower Kura depression became active, namely Imishli-Saatli regions. On August 1, 2016 in Imishli region there was an earthquake with ml=5.6, with an intensity of up to 5 points. On May 11, 2017 in 24 km to south-east of Saatli region, an earthquake with ml=5.4 and intensity of 5 points in the epicenter was recorded.

In addition, we note that an increase in the number of recorded weak seismic events is associated with the opening of new digital stations and, thus, a decrease in the representativeness of the observed earthquakes. So, if in 2005 earthquakes with ml more or equal to 2 were observed, then from 2012 the on land earthquakes with ml ≥0.2, and the earthquakes in the Caspian Sea with ml≥1.5 are not passed through.

Activation of 2012-2017 can be explained by the accumulation of stresses and their subsequent discharge in the strip of the undercut junction of the Middle Kura and Vandam tectonic zones along the Ganikh-Ayrichay-Alyat deep thrust. Discharge occurs through a deep thrust in the most weakened sections-nodes of the intersection of violations. Analysis of the seismicity of the Azerbaijani territory in recent years has shown that there is a general distribution of the seismogenic zones examined along the Caucasian structures, however, in each of them, migration of epicenters in the anti-Caucasian direction is observed. Perhaps, the Zagatala earthquake was the first push, which caused a series of strong earthquakes in Balakan, Sheki, Oguz, Gabala, Ismayilli and Saatli regions. All these zones are in similar seismotectonic conditions [Mammadli T.Y., 2012].

To study the stress-strain state of the Earth's crust, mechanisms of earthquake foci with ml≥3, which occurred in 2004-2017 (Fig. 4), have been constructed.

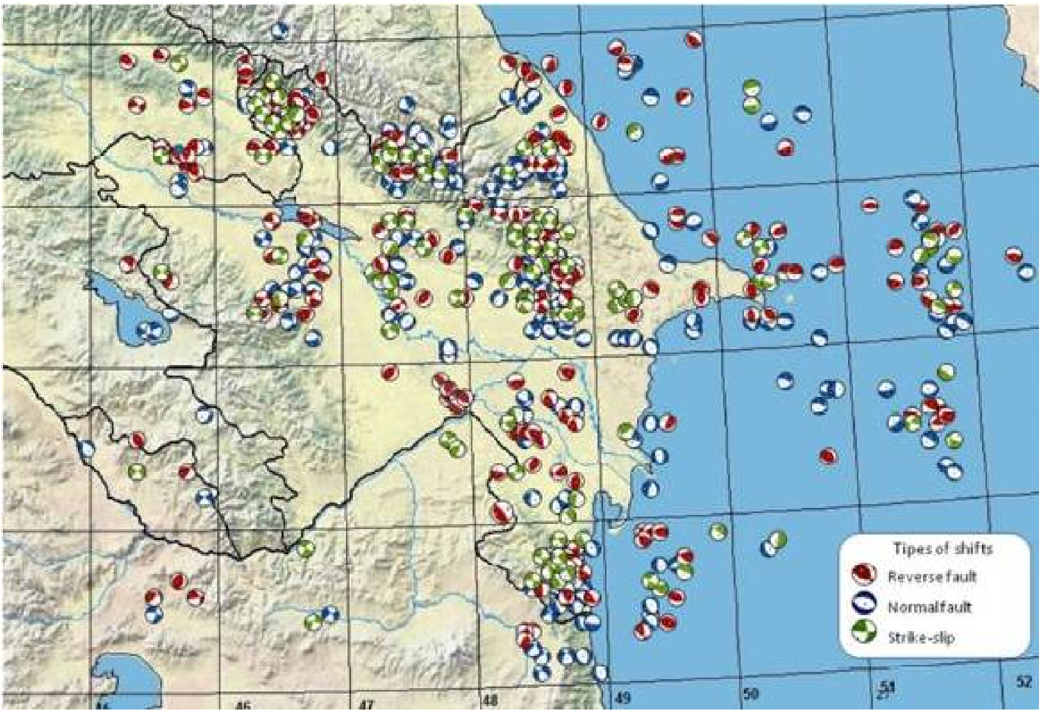

Figure 4. Map of distribution of earthquake source mechanisms for 2003-2017yy.

A comparison of the mechanism of earthquakes' sources that occurred in this period with a schematic model of the geodynamic regime of the south-eastern slope of the Greater Caucasus, cited in [Rzayev et al., 2013], indicates a predominance of tensile stresses, mainly associated with the activity of transverse faults. This is confirmed by earthquakes that occurred in Zagatala-Balakan region, characterized by near-horizontal compressive and tensile stresses. The mechanism of the source of this earthquake is the shift-fault with the left-side horizontal component, which is determined by the geodynamics of the pair of right-sided shifts - Gazakh-Signakh and Ganjachay-Alazan [Rzayev, Metaksas, 2012]. For Gabala earthquakes on September 29 and October 4, 2014, the type of motion along both steep planes is a shift with the elements of the discharge. The mechanism of the outbreak of Oguz earthquake on September 4, 2015 is a shift with the left-side horizontal component. Geodynamic situation of the formation of the Gabala sources in 2014 and Oguz in 2015 earthquakes is interpreted as a fault-shear deformation in the zone of geodynamic influence of Ismayilli-Sygyrly orthogonal and shear deformation with elements of dumping in the zone of influence of the left-sided Arpa-Samur transverse fault.

The geodynamics of the blocks of the Earth's crust to the east is determined, basically, by the zone of geodynamic influence of the West Caspian right-sided fault-shift. In this part of the studied region, torsions of the blocks counter-clockwise, bounded from the north by Hermian and Ajichay-Alyat thrusts, are observed, as well as the eastward displacement of the block between the Zangi-Kozluchay and the Hermian over thrusts, which, apparently, determines the features of the south-eastern immersion of meganticlinorium of the Greater Caucasus [Rzayev et al., 2013].

For the outbreaks of Saatli and Imishli zones, an uplift deformation is typical (probably along the plane of Kura fault-discharge, responsible for the formation of Kura depression starting from the Mesozoic) at a depth of 39-60 km. Moreover, the presence of Geokchay over thrust here, as well as the high velocities of horizontal movements in the Lesser Caucasus and the Kura depression, and their significant decrease in the area of the southern slope of the Greater Caucasus (Rzayev et al., 2013), also support this situation.

In recent years, the level of seismic activity of some parts of the Caspian Sea has increased. In 2014-2016 several earthquakes with ml≥5.0 have been recorded here. Analysis of the seismicity of this region showed that the largest part of the hypocenters of the Caspian tends to the thicknesses of the consolidated crust and upper mantle and are the result of active tectonic movements at the junction of the two largest structures of the Earth's crust of the region - the Turan plate and the Kopetdag-Caucasian folded mobile region. It is known that the Caspian region experiences geodynamic pressure from the south, from the Arabian and Iranian lithospheric plates. In conditions of submeridional compression of the region, the blocks are deformed and thicken, creating mountain structures. The most stable and practically inaccessible folding was a section of the oceanic crust of the South Caspian. Experiencing pressure from Elburs, it sinks under the continental crust of the Scythian-Turan plate in the central part of the Caspian Sea, throughout the Cheleken-Absheron threshold [Khain VE, 2005].

If we consider the spatial distribution of earthquakes in 3D format (Fig.5), then in the pseudo-subduction zone, clusters of earthquake sources are observed in three directions, probably confined to the manifestation of seismic activity of the longitudinal Central Caspian, Absheron-Nearbalkhan, Sangachal-Ogurchy, and also crosses the Central Caspian faults.

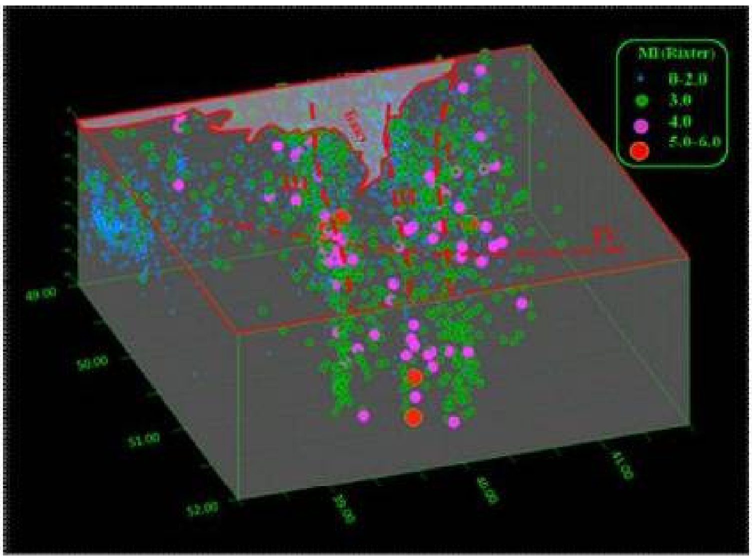

Figure 5. Volumetric model of distribution of hypocenters of earthquakes in the Caspian Sea
Faults: 1 - Central Caspian, 2 - Absheron-Nearbalkhan, 3 - Sangachal-Ogurchy, 4 - Central Caspian. The fracture tectonics of [Shihalibeyli E.S., 1996]

The continental crust of the Northern Caspian, which is involved in movement along the subduction zone, in turn, undergoes bending and the associated stretching in its upper part, resulting in tectonic movements such as faults. This is evidenced by the mechanism of seismic sources in the subduction zone, which are of a fault type here, in contrast to thrusts and shifts in the neighboring continental territory.

Conclusion

- Analysis of the seismic regime of the territory of the republic, revealed the main seismically active areas. This is the south-eastern part of the Greater Caucasus, mainly Zagatala-Lagodekhi, Oguz, Shamakha-Ismayilli, Saatli zones. Increased seismic activity is maintained in the northern part of the Lesser Caucasus (Talysh) and on the border territory with Iran - Nakhchivan Autonomous Republic. The central part of the Caspian basin is marked by increased seismic activity.

- The epicentral zones of most of the listed earthquakes are located in the foothill belt in Vandam structural zone and are confined mainly to transverse (north-western, north-eastern and submeridional strikes) disjunctive dislocations, but the epicentral zones as a whole have a "general Caucasian" elongation and are located in the Vandam tectonic zone along the Ganikh-Ayrichay-Alyat deep thrust;

- Zagatala-Balakan earthquakes' sources are characterized by a shift-fault type of movement with a left-sided horizontal component, which is determined by the geodynamics of a pair of right-sided shifts - Gazakh-Signakh and Ganjachay-Alazan. The sources of Gabala and Oguz earthquakes are confined to the stretching zone and their mechanism is determined as a result of right-sided shear deformation in the zone of geodynamic influence of the left-sided Arpa-Samur and Ismayilli-Sygyrly faults, creating torsion of this block.

REFERENCES

[1] 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.

[2] Маммадли Т.Я., Сейсмогенерирующие зоны Азербайджана и их глубинные структурные особенности. Сейсмопрогностические наблюдения на территории Азербайджана. Баку 2012 с. 287-295.

[3] Рзаев А.Г., Етирмишли Г.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

[4] Рзаев А.Г., Метаксас Х.П. Закатальские землетрясения 7 мая 2012 года: загадки геодинамического режима и сейсмомагнитный эффект // Azərbaycan ərazisində seysmoproqnoz müşahidələrin kataloqu, 2011, səh. 350-359

[5] Хаин В.Е., Ализаде Ак.А., Геология Азербайджана, Том IV Тектоника, ред. 2005. Баку, Из-во Nafta-Press, С. 214-234.

[6] Шихалибейли Э.Ш. Некоторые проблемные вопросы геологического строения и тектоники Азербайджана. Баку: Элм, 1996. 215с.

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STRUCTURAL-TECTONIC FEATURES OF THE SOUTH-EASTERN PART OF THE GREATER CAUCASUS THE PRE-CASPIAN GUBA AS AN EXAMPLE OF THE NQR

A.I.Khuduzade[1], A.Jafarov[1]

ABSTRACT. Determination of tectonic structure of mesocenozoic sediments, monitoring of various aged sediment complex based on well data, establishment of a dynamic depth cross sections and a study of geodynamic activity analysis in the Pre Caspian-Guba oil-gas region are pressing problems for the south-eastern part of the Greater Caucasus.

The article deals with the importance of determining geodynamic activity by formulating a detailed understanding of the region's tectonics. This is done by expanding geophysical, especially seismic exploration works and highly accurate study in the field of research subjected to active tectonic processes.

Introduction

The territory of the Azerbaijan Republic is situated in the eastern part of the Caucasian segment of the Mediterranean fracture zone and is characterized by high geological activity related to the dynamics of Arabian and Eurasian lithosphere plates.

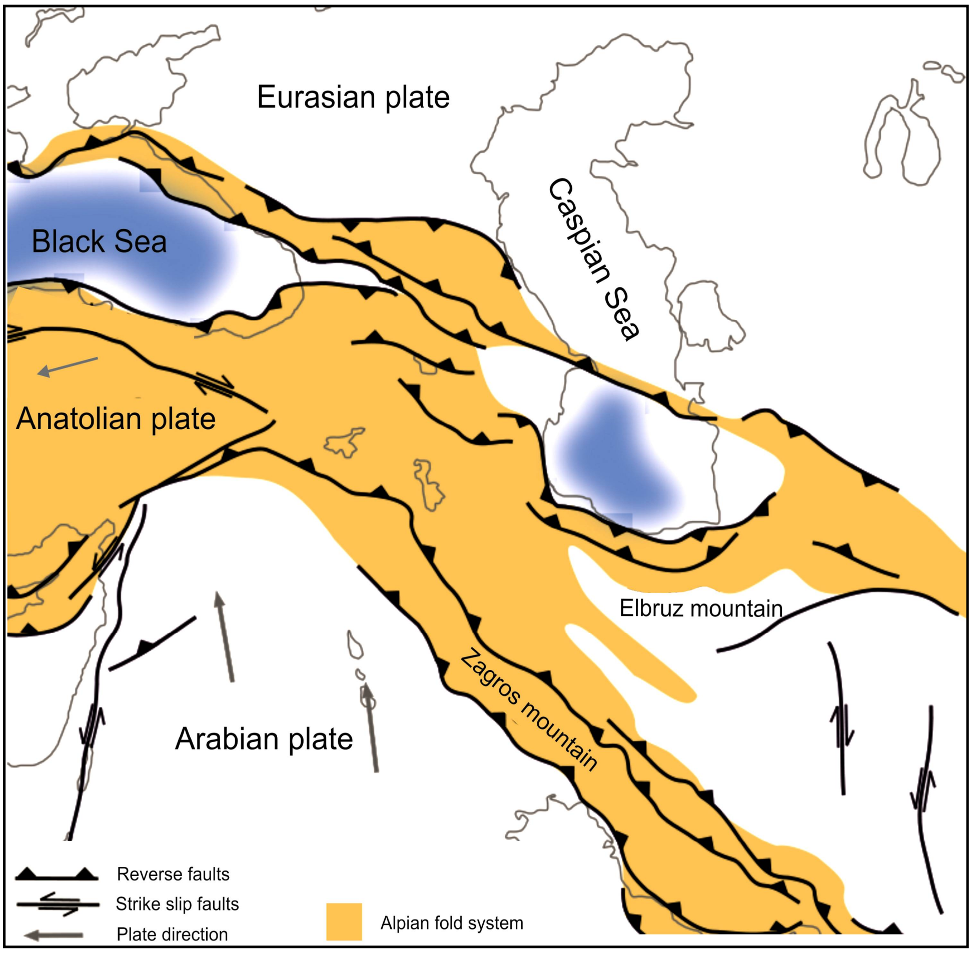

Figure 1. The dynamics of plates

[1] SOCAR, "Azneft PU"

The zone which has a complicated geological structure is characterized by high seismicity, modern magnetism and mud volcanism in all covered areas. As the geodynamic activity has different effects on the region, you can formulate certain ideas on geological cross-section based on seismic data. The complexity of the zone's tectonic structure is characterized by the extensive development of vertical and horizontal dislocation processes. Apart from the overlap and reverse faults the availability of areas that are complicated by transformation faults is undeniable. The research area considered in this paper is pre Caspian-Guba oil-gas region that covers the south-eastern part of the Greater Caucasus, and modern geodynamic processes are widespread here (Fig.2).

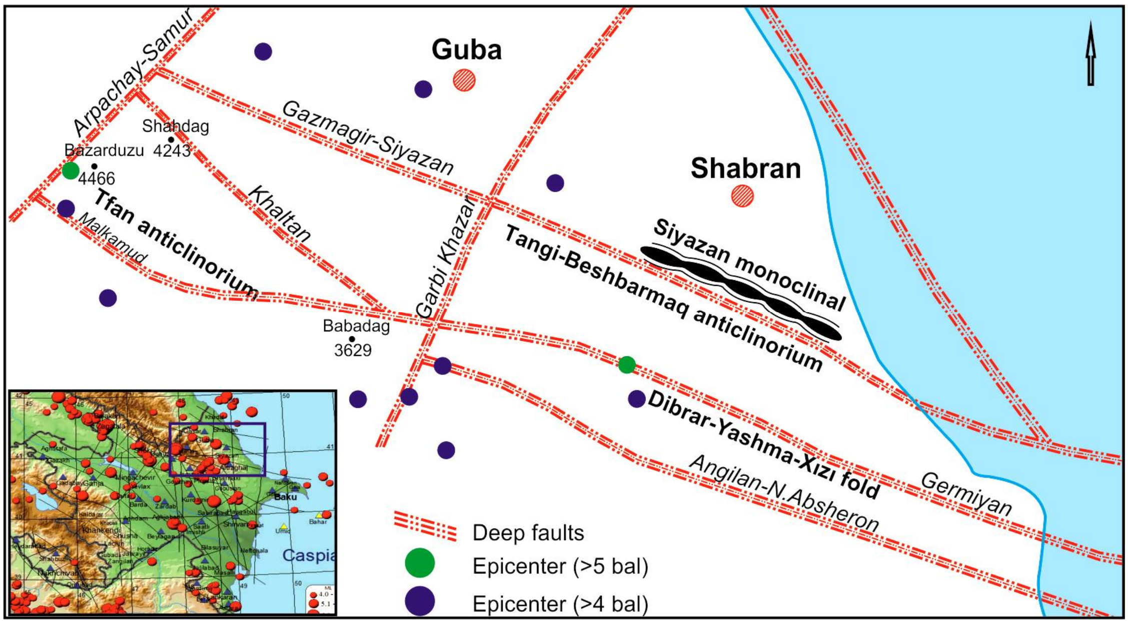

Figure 2. Tectonic scheme. (Based on tectonic zoning map of the oil-and-gas field of Azerbaijan, Baku 2002, Editor-in-chief: K.M. Karimov)

Geodynamic aspects

Earthquake origins are found to be at a depth of 20-30 km into the Earth's crust. The release of accumulated energy occurs suddenly within a few seconds leading to the formation of the embedding, uplifting, landslide in the horizontal direction as well as other types of complications. The active parts of deep faults are determined with the study of earthquake origin. The study of the geological characters of macroseismic area anomalies accompanied by a sharp decrease in the intensity of seismic effect in the researches, allows to guess the connection with tectonic fault zones where seismic waves are absorbed.

Structural-tectonic features

Due to the complex seismo-geological structure of the area, quality of geophysical research, especially seismic material is poor which makes it difficult to obtain a detailed understanding of the tectonics of local uplifts found on Mesozoic.

Mesozoic sediments distinguished by its activity in terms of data analysis consist of Gusar-Devechi basin and Khizi tectonic zone that are sharply different from one another because of their tectonic structure.

The near Caspian-Guba NGR consist of two tectonically different structural elements - Gusar-Devechi (Shabran) syncline and the north flank of the south-east set of the Greater Caucasus meganticline. Based on the seismic exploration and deep drilling data, three structural ages have been observed here.

Lower age covers Jurassic sediments and according to the accurate seismic data The North Charkhi, Charkhi, The North Aghzibirchala, Aghzibirchala, Southern Aghzibirchala have been

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discovered. The most explored one of them is Aghzibirchala structure. In this uplifted anticline deep drilling has been conducted and the presence of Jurassic and Triassic sediments has been confirmed based on obtained drilling information.

The medium structural age is detected with a seismic horizon reflecting the surface of Cretaceous.This horizont has a monoclinal subsidence in south-east direction. There are found to be present Khudat, Khachmaz and South Khachmaz anticlines, East Khachmaz, Charkhi and Devechi (Shabran) structural pinchout in this subsided region. Pliocene sediments which are deposited on the top layer in this area have monoclinal subsidence as well in the south-east direction and it is characterized by poorly followed pinchouts matching with the Mesozoic uplifts.

The south-western slopes of the Gusar-Devechi syncline are characterized by intense and sharp-shaped folds of Neogene sediments. Anticlinal structures of Neogene sediments have been studied in Talabi, West Gaynarja and Gaynarja by means of geophysical planning and drilling works.

Tectonically the Talabi structure is an asymmetrical anticlinal fold extending along latitude scope. Its north flank is steep (35-40^o), while its south flank is relatively less steep (15-20^o).

As well as the structure of Gaynarja is an asymmetrical anticlinal fold lying in north-west direction. It is characterized by a relatively steep south-west flank (25-40^o) and slightly less inclined north-east flank (14-20^o). The hinge zone of the fold is complicated by longitudinal fault which has an amplitude of 100-150 m and therefore the south-western limb of the fold has been exposed to uplifting.

The structure of Gaynarja that has got steep limbs in the upper part (60-80^o) and relatively less inclined flank towards the lower parts (30-40^o). There is a tectonic fault that is along the fold axis which is originated from mud volcano processes.

Several anticlinal elements were found apart from the above mentioned structures in this area and of them Dashdemirli anticline which is located in the north of Gaynarja is to be highlighted. This upward fold is contoured by 3700-3800 m isohypse according to the Mesozoic surface.

Khizi tectonic zone is bordered by Garabulag in the north-east, Germian faults in the south-west and mainly is consisted of synclines of upper Cretaceous sediments. Beyimdagh-Tekchay-Sitalchay-Yashma anticline chain has been overlayed Beyimdagh fault. There are Keshchay and Shurabad to the north-east of it and Germian anticline to the south-west of it.

According to geological-geophysical data Beyimdagh–Tekchay upward fold of Khizi syncline is a north-west-south-east oriented anticlinal structure of cretaceous sediments.

The north-east flank has become complicated by a reverse fault on Beyimdagh-Tekchay-Sitalchay areas, while south-west flank is complicated by normal and reverse faults of Germian zone that is reflected on the surface as well.

Complex researches, geological-planing, structural mapping have been conducted for a long time, and as a result it is obtained that, Sitalchay anticline fold extends in the direction of SE and NW. Its north-east flank is of moderate dip angle (25-40°), while the south-west flank is steeper (40-55°). The north-east part of the hinge zone of the anticline is complicated by a transverse fault of 100-120 m amplitude. The south-west flank of anticline has more complex structure and it is divided into ladder-like tectonic blocks as a result of transverse faults. Gadisu anticline is an asymmetric brachianticline lying in the north-west-south-east direction, its south-west flank has dip angle of 30-40°, while north-east flank is steeper (50-60°). The north side which has a high dip angle is overlaped by the Greater Caucasus. According to the structural mapping data, south-east periclinal of Gedisu structure's sediments is limited to the Sumqayit horizon and is embedded within only Caspian Basin without changing its direction. The north-east flank of anticline is complicated by a huge fault and its amplitude reaches to 240 meters in the south-east periclinal. According to the bottom and top of the Lower Cretaceous, Gedisu anticline is divided into two parts: West Gedisu and Gedisu uplifts.

Generally, the deep tectonics of the region, in particular the Mesozoic sediments have been studied poorly.

The territory of Caspian - Guba NQR belongs to the south-east flank of the Greater Caucasus meganticline in the sketched tectonic schemes (V.E.Khain et al.).

Spatial distribution of macroseismic field anomalies of the well-researched earthquakes within the boundaries of the Azerbaijani part of the Greater Caucasus helps to distinguish positive and negative anomally zones distinctly. Comparison of the selected anomalies with the structure of the Azerbaijani part of the Greater Caucasus demonstrates that, all of them are related to distortion dislocations (Fig.2). Geological and geophysical researches conducted in Caspian-Guba NGR allowed to distinguish several large structural-tectonic zones in this region. Tengi-Beshbarmag anticlinorium and Khizi zone are notable by the complexity of tectonic structure.

Available deep faults and epicenters of recorded earthquakes in Caspian-Guba NQR are depicted in Fig.2. Earthquake epicenters are mostly observed on the deep fault lines.

Conclusion

Results of geological-geophysical researches

Tectonics of the field have been analyzed in detail as a result of seismic exploration conducted in 2014. Numerous faults have been detected as a result of geological activity in the structure. The I-I fault mentioned as Germian fault in geological literature and the other parallel faults (Fig.3), as well as the north-east flanks of structures with the high dip angle leads us to speak about the dynamic activity of the field in the south-west-north-east direction.

The Sitalchay structure is demonstrated as different tectonic blocks that have become much more complex by longitudinal faults along the hinge. The weakening of correlation properties of the

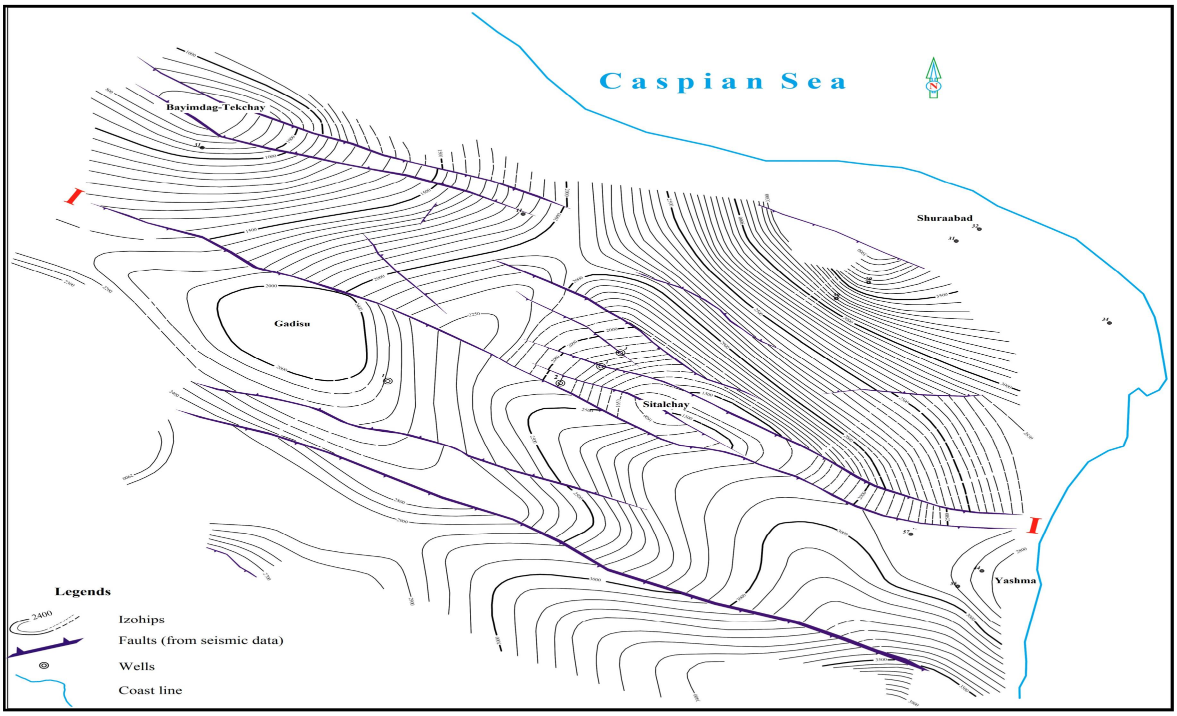

Figure 3. Structural map on Valanginian stage [5]

reflections has been observed in the seismic cross sections that characterizes the part of the structure between faults. As mentioned earlier, macroseismic field anomalies are associated with the seismic wave absorption occuring in tectonic fault zones.

According to this approach, it is assumed that these zones are also seismically active. Germian fault is recorded in the south of the structure that in the center of this fault an earthquake epicenter with >5 points (Fig.2).

In order to clarify the geological-tectonic structure towards the research area and in the sea

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and also for clarifaction of the geological nature of observed gravity force anomalies a joint analysis of seismic and gravimetric data, continuation of three-dimensional (3D) seismic works, as well as other research works, construction of three-dimensional geological models, tectonic structure of Mesozoic sediments would be expedient.

REFERENCES

[1] N.P.Yusubov, A.A.Cəfərov, O.O. İsmayılov "Gədisu-Sitalçay sahəsində aparılmış kompleks geofiziki tədqiqatların bəzi nəticələri haqqında".
[2] G.J.Yetirmishli, R.R.Abdullayeva, S.S.Ismayilova, I.E.Kazimov "Stress-straıned state of the Earth's crust of Azerbaıjan for 2004-2016 yy".
[3] https://www.gia.az/view.php?lang=az&menu=45&id=568
[4] "Geochemistry and tectonics of Cenozoic volcanism in the Lesser Caucasus (Azerbaijan) and the peri-Arabian region", International Geology Review, May 2002.
[5] Xəzəryanı-Quba NQR-in Gədisu-Sitalçay sahəsində aparılmış 2D seysmik və qravimaqnitometrik kəşfiyyat işlərinin hesabatı, GGİ, Kəşfiyyatgeofizika İstehsalat Bölümü, Bakı-2014.

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GAS-CONTENT OF THE UPPER PART OF THE SHELF ZONE SECTION OF THE SOUTHERN CASPIAN ACCORDING TO SEISMO-ACOUSTIC DATA AND GAS AND OIL MANIFESTATIONS

A.V. Poletayev[1], Y.V. Poletayeva[1]

ABSTRACT. Data from 160 seismo-acoustic profiles, sections of interval velocities as well as data on oil and gas manifestations within the shelf zone of the Southern Caspian served as the actual material for the present study. As a result of data interpretation, it was established that the intensity of gas manifestations varies both in area and in depth. In the zones adjacent to the deep-water part of the Southern Caspian, the presence of anomalies typical for gas zones increases as compared to near flank zones. Analysis of velocities along the profiles of the shelf zone showed that the velocities and petro physical conditions vary depending on the territorial location. The analysis of gas and oil manifestations by wells indicates that the upper part of the Southern Caspian section is highly enriched with gas, whereby the intensity of gas manifestations in the lower part is higher.

The obtained results enable to predict the inflow of significant volumes of fluids into the upper part of the section of the deep-water part of the Southern Caspian.

Key words: gas, oil, seismo-acoustic profiles, Southern Caspian, oil and gas fields, gas content.

Introduction

Despite the large amount of factual material available in various organizations, the upper part of the section, in connection with the evaluation of gas content, is the least studied and described in the literature zone.

This is due to the fact that the main survey interval in the Southern Caspian is concentrated in areas with high oil and gas potential [4-10]. This interval is the productive stratum and underlying deposits which are included in the zone of intensive generation of oil and gas. The more recent deposits, accumulated before the Absheron regional stage, mainly consisting of clayey sediments were of no interest. In many works this zone is described as unbroken series of Quaternary sediments [9]. In order to study the gas hydrate zones and predict the oil and gas content of the quaternary deposits of the deep-water part of the Azerbaijani sector of the Southern Caspian, there emerged a necessity of generalizing existing data on the adjacent zones of Baku and Absheron oil-gas bearing regions, which enabled to approach the studies of the undrilled deep-water part of the Southern Caspian. The main purpose of this work is to identify, refine and specify the main gas sources available in the upper part of the offshore section, using geophysical data and data on gas and oil manifestations.

Material and methods

Acoustic survey within the Southern Caspian started in 1956. Since that time, a small number of articles have been published on that topic [1, 2]. A total of 160 seismo-acoustic profiles were used, and from 3 to 8 profiles for different areas (Table 1, Fig.1).

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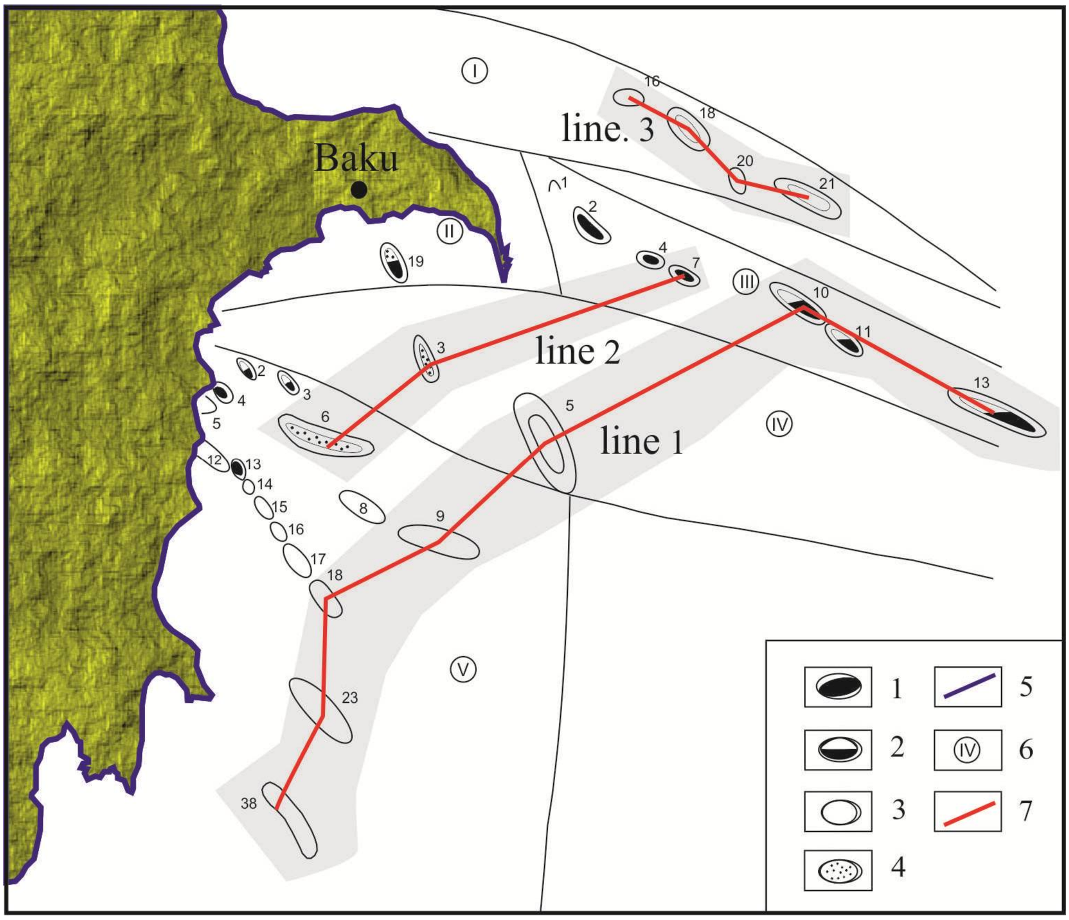

Figure 1. The location of the main groups of seismo-acoustic profiles (the map is based on the tectonic zoning of oil and gas areas of Azerbaijan) [6]

Legend: 1 - oil fields, 2 - oil-gas fields, 3 - gas fields, 4 - oil-gas condensate fields, 5 - sea shore, 6- number of region, 7 - cross-section line.

I. - 16.Arzu, 18.Dan ulduzu, 20.Aypara, 21.Ashrafi; **II. -** 19.Gum deniz; **III. -** 1.Khali, 2 - Chilov island, 4.Palchig Pilpilyasi, 7.Neft Dashlari, 10.Guneshli, 11.Chiraq, 13.Kapaz; **IV. -** 3.Bahar, 5.Shakh-deniz; **V. -** 2.Duvanniy-deniz, 3.Khara-Zirya, 4.Alyat, 5.Gil island, 6.Bulla-deniz, 8.Umid, 9.Babek (D-1), 12.Khamamdag-deniz, 13.Garasu, 14.Sangi-Mugan, 15.Ulfat, 16.Aran-deniz, 17.Dashli, 18.Sabayil, 23.Shirvan-deniz, 38.Inam.

To study the presence and gas ingress into the upper part of the section, an interpretation of seismo-acoustic data was carried out by the method [8].

Gas and oil manifestations were studied by well data on 21 deposits (Fig. 1, 6). Generalized geological section of oil-gas manifestations for these fields of the Southern Caspian was compiled. It should be noted that the numbers of the columns in Figure 6 correspond to the numbers on the map (Fig.1).

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Table 1
The volume of the seismo-acoustic material

Field	Number of profiles	Field	Number of profiles
Pirallahi	4	Sabayil	5
Gum deniz	9	Byandovan-deniz	2
Khali	5	Inam	6
Neft-Dashlari	10	Absheronbankasi	3
Gyuneshli	4	Arzu	4
Chiraq	28	Dan ulduzu	3
Kyapaz	6	Aypara	3
Bakhar	6	Ashrafi	4
Shakh-deniz	18	Regional profile (deep-water of the Southern Caspian)	4
Shirvan-deniz	6		
Khara-Zyrya	7		
Bulla-deniz	8		
Umid	6		
Babek	9	**Total**	**160**

should be noted that the numbers of the columns in Figure 6 correspond to the numbers on the map (Fig.1).

Results

Zones with mud volcanic structures, as well as numerous gas manifestations, gas flares were established on the seismo-acoustic profiles. Gas flares can be traced in Umid, Sabayil, Kapaz, Neft-Dashlari and other fields. The gas manifestation in the form of gas flares is not the only criteria for assessing the presence of gas. Vertical columns of chaotic wave recording typical for gas, as well as anomalies peculiar to gas zones were established on the profiles. It should be noted that in fact the entire area of the Southern Caspian, especially its upper part, is an intensive zone of accumulation and gas degassing. The maximum interpretation interval is 400 m. Certain changes are also observed in the wave field depending on the territorial belonging of the areas. The alternation of sandy-clayey deposits in the Neft Dashlari field has a more pronounced wave pattern as compared to the Gum island field. More intensive gas manifestations were fixed in the zones of mud volcanic manifestations within Kapaz, Shah-deniz and other fields.

Considering changes in the wave pattern over the area, it can be concluded that the ingress of gas into the upper part of the section is not only due to the presence of mud volcanic structures and fault zones, but also with vertical discharge of fluids.

This allows us to talk about the flow of gas from oil and gas structures to the upper part of the section. Obviously, the presence of a thick clayey stratum in the upper part of the section is not an ideal insulating factor.

Seismo-acoustic profiles were studied for the purpose of a detailed analysis of the change in the gas content of the deposits, both on area extent and section (Table 1). The available volume of seismo-acoustic data was conditionally divided into three groups (cross-section lines).

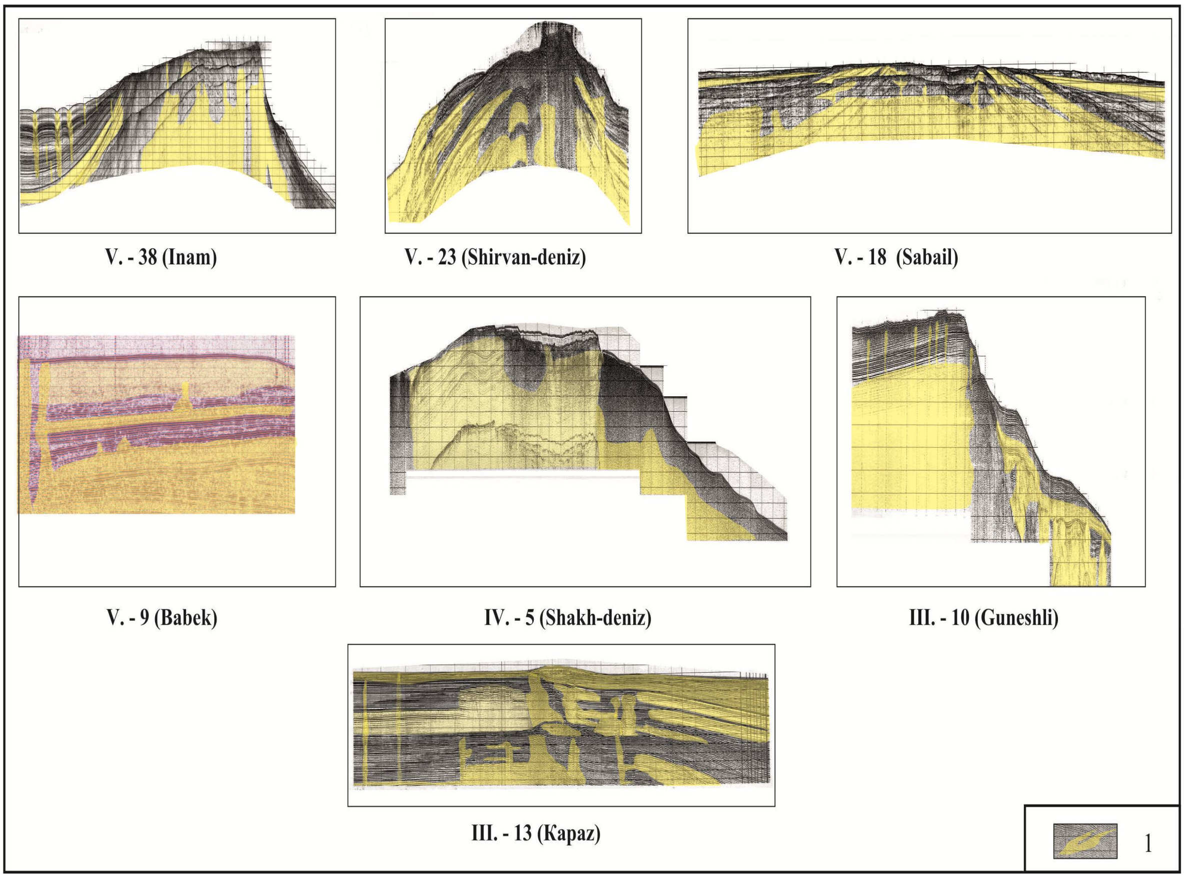

Figure 2. Results of interpretation of seismo-acoustic data (by profile 1)
1- area of anomalies, which correspond to gas manifestations

The first group includes profiles (Fig. 2), adjacent to the deep-water part of the Southern Caspian. The second group of profiles (Fig.3), conventionally called the intermediate zone, includes the Bulla-Deniz-Bakhar-Neft Dashlary fields, and the third is the final group (line) includes the Ashrafi-Aypara-Dan ulduzu-Arzu zone (Fig. 4).

Thus, we can analyze in detail the changes in the wave pattern for these profiles and for the fields as a whole. The first profile covers the Inam-Kapaz zone. The geological structure of structures along the profile is not the same. Reflecting horizons corresponding to Quaternary age can be traced by seismo-acoustic profiles. The geological structure of these deposits is well described in the works [1-4]. Clay deposits are predominate deposits within the upper part of the section. However, for some areas one can observe an increased content of sandy material. This conclusion is based on drilling data.

As can be seen from Figures 2 - 4, the maximum gas saturation of the deposits is determined on the profile 1, gradual decrease in the gas saturation of the deposits is observed on subsequent profiles.

Analysis of the velocities [11] by profiles (Fig. 5 a, b, c) showed that the velocities and petrophysical conditions vary both on area extent and section. Similar zones, highlighted by distinctive color are established on the sections. The detected intervals (dashed lines) correspond to zones of fluid accumulations (rocks highly saturated with gas). This conclusion is based on a comparison of the data obtained during drilling and investigating the profiles. The features of the velocity pattern in different profiles indicate significant volumes of fluids that can fill the upper part of the section. Profile crossing point and depth intervals indicate to identity of anomalies formed in single stratigraphic zones.

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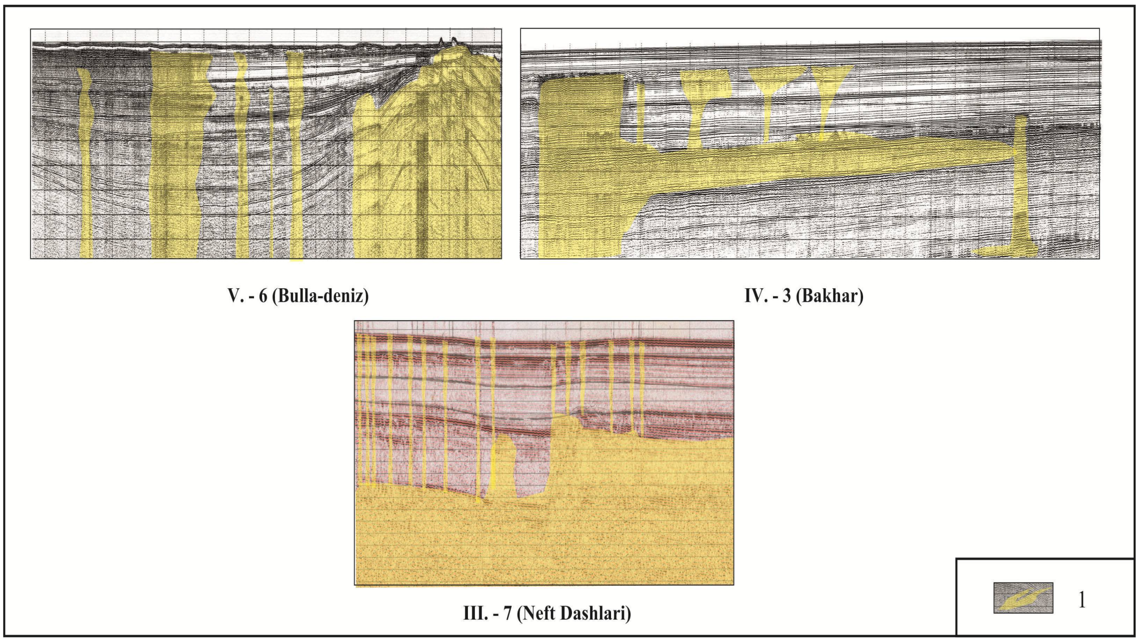

Figure 3. Results of interpretation of seismo-acoustic data (by profile 2)
area of anomalies, which correspond to gas manifestations

1. Inam - Shirvan-deniz - Sabayil - Babek - Shah-deniz - Guneshli-Kapaz
2. Bulla-deniz - Bahar-Neft Dashlari
3. Ashrafi-Aypara- Danulduzu-Arzu

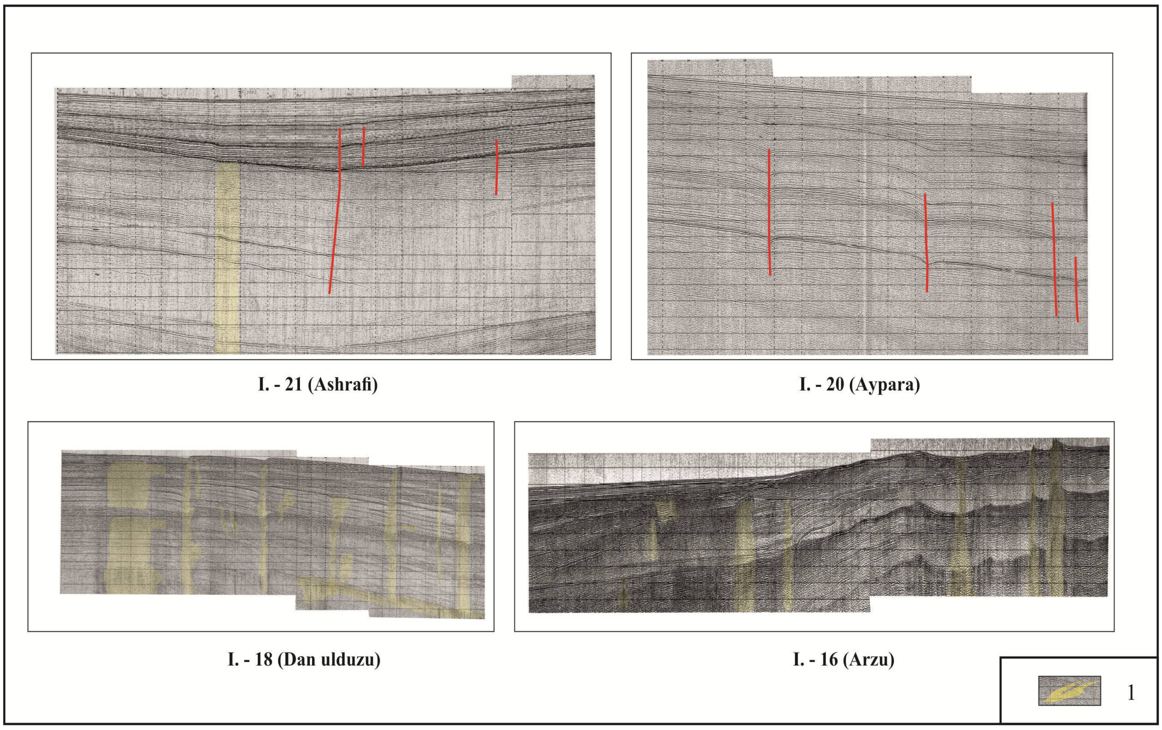

Figure 4. Results of interpretation of seismo-acoustic data (by profile 3)
area of anomalies, which correspond to gas manifestations.

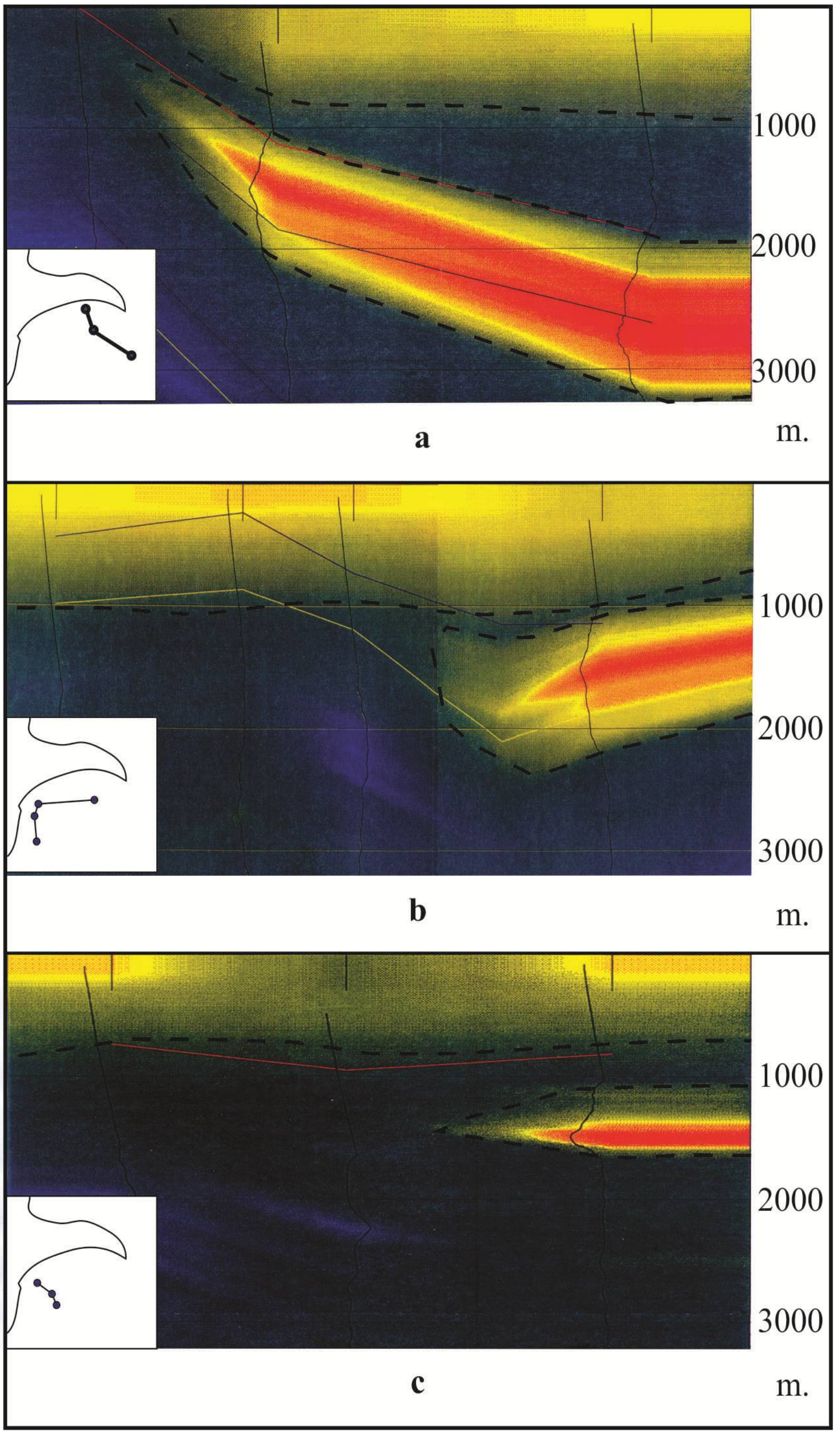

Figure 5. Average velocities by profiles (a, b, c)

Sections with gas manifestations of different intensity, as well as the presence of oil, formation water or the smell of hydrogen sulfide are fixed on Fig.6 by different legend. All data are ranked by area that enables to track changes in fixed gas and oil manifestations both horizontally and vertically within the established depths. As can be seen from Fig. 6, the maximum gas saturation of the sediments corresponds to the underlying deposits. Generalized section shows that the upper part of the section is mainly represented by clayey deposits with sandstone bands of low thickness. The presence of strata water within the investigated zone is the main focus of interest. It is observed in the depth interval from 0 to 200 m in the East Absheron region, whereas in the oil and gas bearing area of Baku archipelago its presence is fixed within wide range of depths from 0 to 2800 m. It should be pointed out that it is gas-cut water.

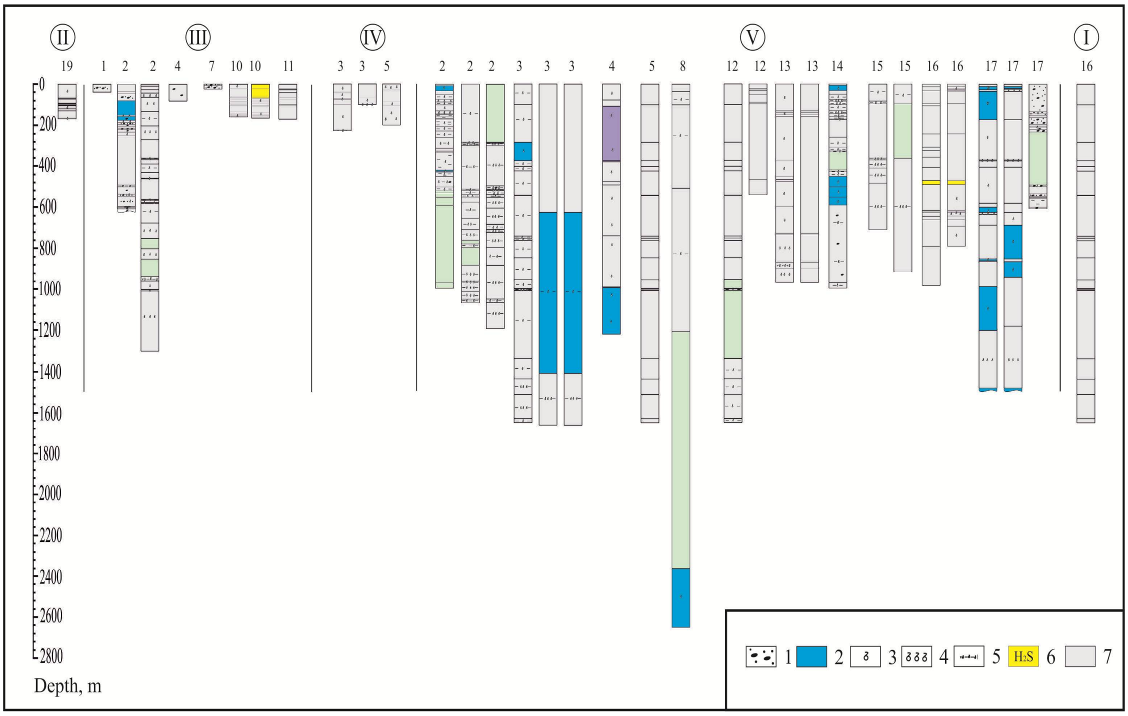

Figure 6. Gas manifestations within the Southern Caspian

Legends: 1. - presence of oil, 2. - presence of strata waters, 3. - least intensive gas outlets, 4. - most intensive gas outlets, 5. - mud-volcanic breccia, highly saturated with gas, 6. - presence of H_2S, 7. - predominantly clayey deposits.

Water also fixed the Chilov island field located in the East Absheron oil and gas region. A large amount of factual material on the Baku archipelago enabled to characterize this zone in the most detailed manner. Significant volumes of stratal water were established at the Duvann-deniz field, Khara-Zira, Alat-deniz, Sangi-mugan, Dashli. At the Umid field, water inflows were fixed at deeper horizons - within depth interval from 240 to 2800 m. Gas manifestations have been established in almost all fields except for Chirag, Gil Island, Aran-deniz, Arzu. The presence of H_2S was fixed in Dashly and Aran-deniz areas. At the Aran-Deniz field, the presence of H_2S was found at a depth of 100 m, while at the Dashly field - at a depth of about 500 m. Oil manifestations were established in the upper part of the section on the Khali, Chilov Island, Palchig Pilpil, Chirag structures of the East Absheron oil and gas bearing areas. It should be noted that the Palchig Pilpil field up to depths of 600 m is characterized by more sandy deposits compared to other structures of Baku archipelago. This area in the upper part of the section is most saturated with oil. At the Bulla-Deniz field, tributaries of strata waters are fixed in different intervals
of the section from depths of 600 to 6310 m. In the stratigraphic plan they cover almost the entire section.

In the Apsheron and Akchagyl regions, as well as the tops of the PS, the mineralization of water is 49 to 129 g/l.

Conclusion

Results of study on 160 seismo-acoustic profiles of the main oil and gas fields in the Southern Caspian are given in the paper. As a result of the interpretation of seismo-acoustic data, it has been established that anomalies typical for gases have been established almost on all profiles. The intensity of gas manifestations varies both in area and in depth. In the zones adjacent to the deep-water part of the Southern Caspian, the presence of anomalies typical for gas zones increases as compared to near flank zones.

1. As a result of data analyses on gas manifestations of the upper part of the section, one can come to the conclusion: The upper part of the section of the Southern Caspian is highly enriched with gas, and the intensity of gas manifestations in the lower part is the highest.
2. Oil manifestations on Khali, Chilov Island, Palchig Pilpil, Chirag structures indicate that these structures are more favorable for oil deposits prospecting.
3. Strata waters are fixed within wide range of depths.
4. The obtained conclusions enable to predict the inflow of significant volumes of fluids in the upper part of the section of the deep-water part of the Southern Caspian.

REFERENCE

[1] Şıxəliyev Y.A., Əhmədov A.M., Zeynalov A.Z., Əbdiilxakova Z.N. Xəzər dənizinin Azərbaycan sektorunda kəsilişin üst hissəsinin qazlılığı və dənizdibi qaz çıxışları: təhlil, ümumiləşdirmə və təkliflər. Azərbaycan Neft Təsərrüfatı, 9 - 15, 2015

[2] Xəzər dənizinin Abşeron arxipelağı və Bakı arxipelağının şimal hissəsində Azərbaycan sektorunda kəsilişin üst hissəsinin qazlılığı və dəniz dibi qaz çıxışlarının (qaz-hidratlar) öyrənilməsi məqsədilə geoloji-geofiziki və qazma məlumatlarının ümumiləşdirilməsi, ARDNŞ. Bakı, 2012

[3] Dadashev F.G., Muradov Ch.S. et al. 1980. Assessment of oil and gas content prospective within Shakhov-Sea-Bulla-Sea water areas using gas geochemical methods and the trend of further prospecting works. Baku. Foundation of Geology Institute of National Academy of Sciences Azerbaijan. 20 p.

[4] Geological and geochemical conditions for the conservation of hydrocarbon fluids in the South Caspian basin. Geology Institute of National Academy of Sciences Azerbaijan (2004-2007).

[5] Geology of Azerbaijan. Volume VII, Oil and gas. Baku: Publishing House «Nafta-Press», 2008. 380 p.

[6] Geology of Azerbaijan. Volume VIII, Hydrogeology and engineering geology, Baku: Publishing house «Nafta-Press», 2008. 380 p.

[7] Guliyev I.S., Dadashev F.G., Poletayev A.V. Isotopes of hydrocarbon gases of Azerbaijan/Baku, «Nafta-Press» 2013. 107 p.

[8] Guliyev I.S., Levin L.E., Fedorov D.L.. Hydrocarbons potential of the Caspian region (System Analysis), Baku, “Nafta-Press”, 2003, 120 p.

[9] Methodology of study and developing the Bulla-Deniz field, the National Academy of Sciences of Azerbaijan, the Institute of Deep Problems, Baku, 1995

[10] South-Caspian Basin: geology, geophysics, oil and gas content. Baku, “Nafta-Press”, 2004, p.333

[11] Velocity study of the Baku archipelago. Joint Research Program. Phase II. IDOGD - UNOCAL, 1994

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THE REFLECTION OF STRONG EARTHQUAKES OCCURRED IN KURA DEPRESSION DURING 2016-2017 YEARS

G.I.Bakdemirova[1], N.N.Ismayilova[1], T.A.Kazimova[1]

ABSTRACT. In the article were considered the analyses of kinematic informers before the earthquakes that occured during 2016-2017 years. It was shown in the seismoprognostic curves constructed on some seismic stations that, anomalous changes were observed before the earthquake. Analysis of spatial distribution maps of kinematic informers shaws that epicenters of earthquakes are located in the gradient zones of the Vp/Vs parameter.

Key words: earthquake, activity, informative, gradient zone, prognostic curves.

Introduction

Every year hundreds of natural disasters occur in the world, seismic events take a special place among them. In recent years, increase of seismic activity has been observed worldwide. Strong and catastrophic earthquakes accompanied by great destructions and human deaths occur in different parts of the earth.

In Azerbaijan which is part of the Alpine-Himalayan seismic zone, various magnitude earthquakes (M≥5) have occurred. Before such earthquakes, investigation of kinematic informers allowed to have interesting results.

Overview of the issue

Most of the strong earthquakes in the territory of Azerbaijan occur in mountainous areas, especially on the southern slope of the Greater Caucasus (Fig.1). Such earthquakes are recorded in other areas as well.

The increase of seismic activity is observed during 2016-2017 years in the Kura depression. There were 3 strong earthquakes.

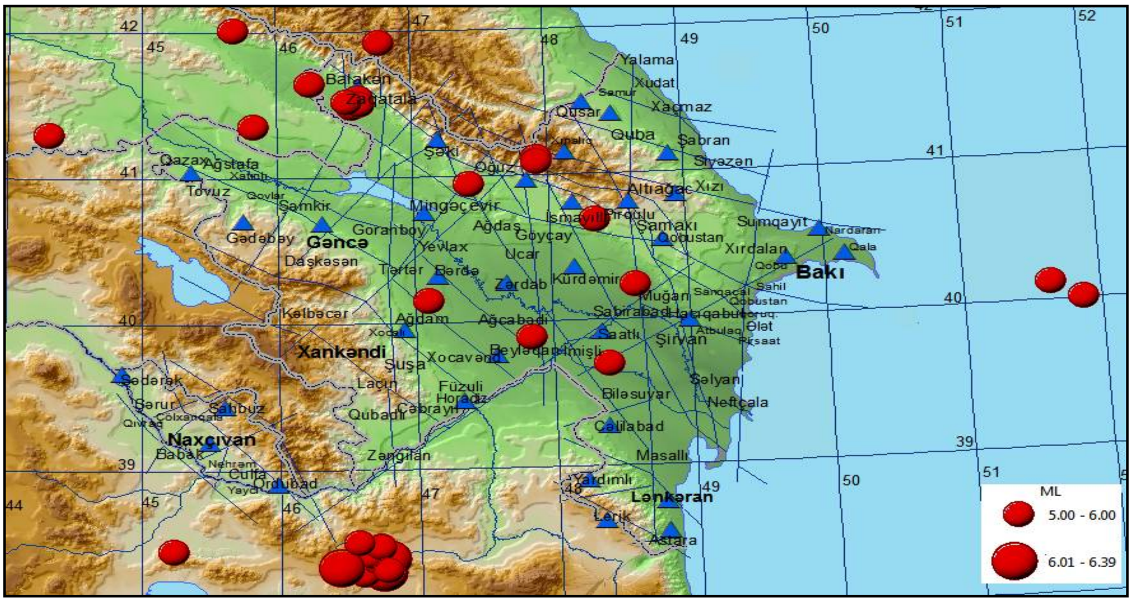

Figure 1. Map of the earthquake sources with magnitude 5.0 in Azerbaijan and adjacent territories during 2012-2017 years

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

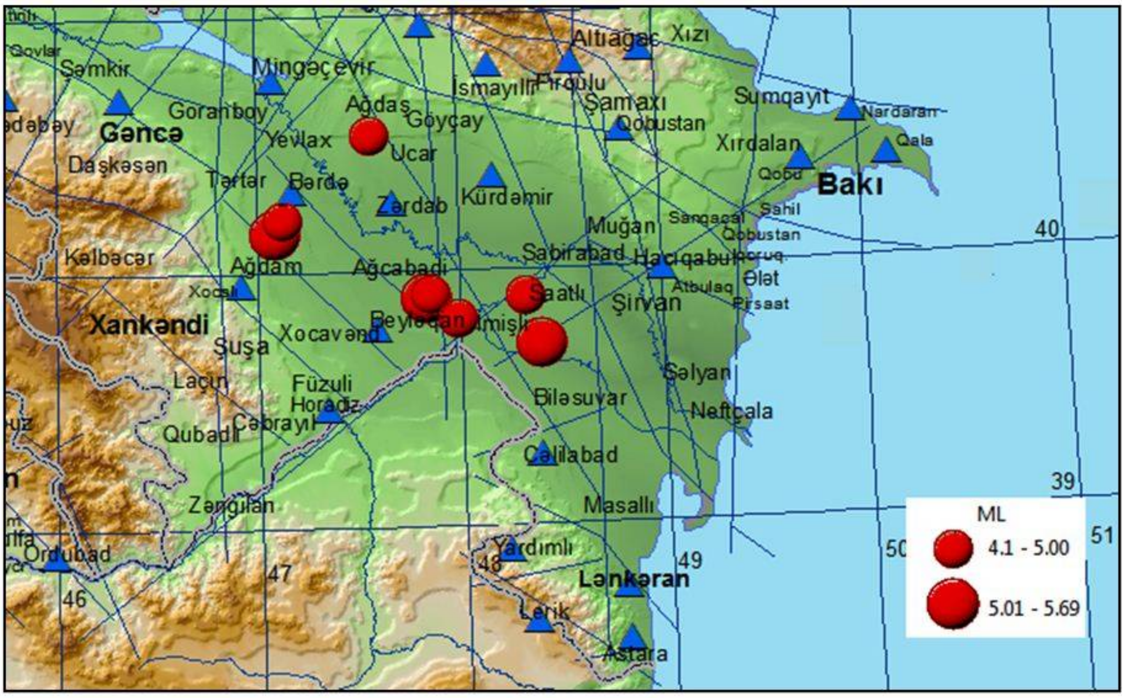

Figure 2. Map of the earthquake sources with magnitude 4.0 in Kura depression during 2016-2017 years

Researches show that changes in the velocity ratio of seismic waves (Vp/Vs parameter) occur before strong seismic events. To detect the prognostic properties of these changes, monitoring of this parameter is carried out at RSSC of ANAS [Gasanov et al., 2009].

Change of Vp/Vs parameter over time before the strong earthquakes in the seismoprognostic curves has been identified in previous studies [Abdullayeva et.al, 2016].

Anomalous changes on Vp/Vs parameter have been registered in several stations before the Imishli earthquake that occurred on August 1, 2016 with magnitude 5.6. The diagrams of seismoprognostic curves that were established by seismic stations of Aghdam and Altıagach are shown as an example. It appears from the Altiagach seismic station graphics that, 5 times more anomalies than the background are observed 10 days before the earthquake (Fig.3). It appears from the graphics created by Aghdam seismic station that, 4-5 times more anomalies from the background have been registered before the earthquake.

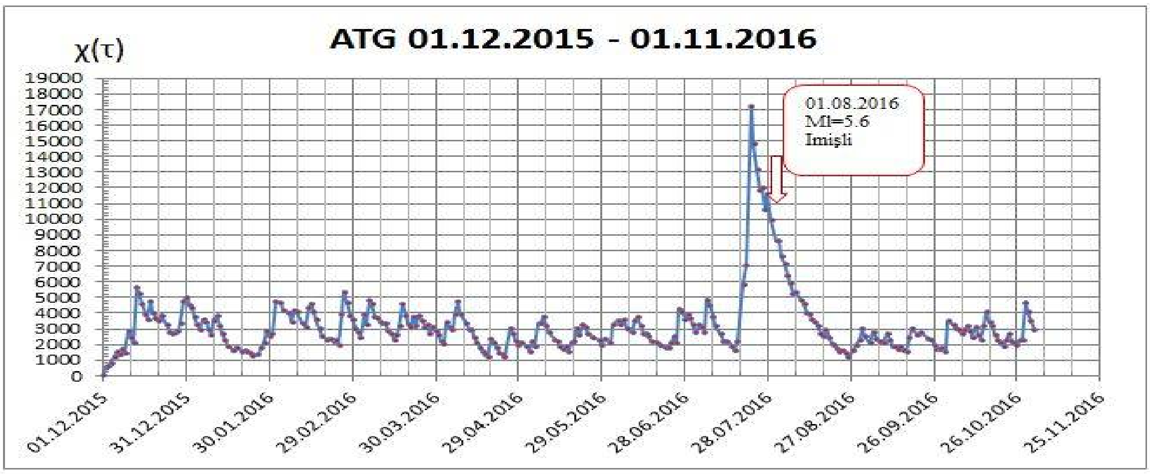

Figure 3. The graphic of Vp/Vs parameters curve established on "Altiagach" seismic station.

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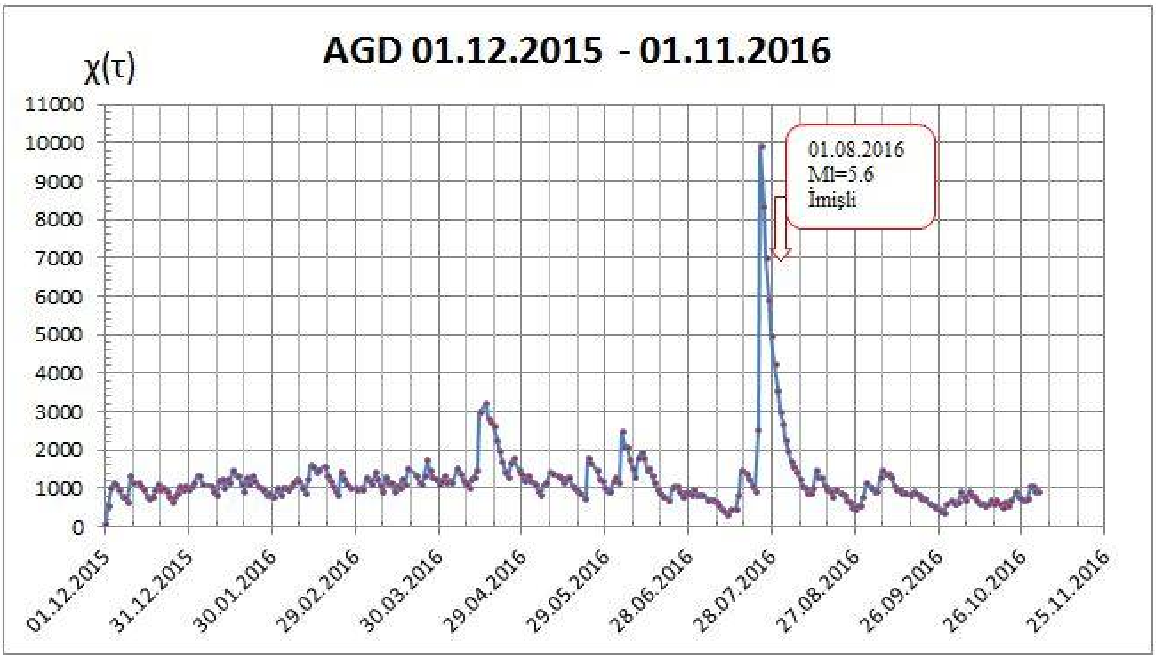

Figure 4. The graphic of Vp/Vs parameters curve established on "Aghdam" seismic station.

It is shown in the graphics of seismoprognostic curves created on Gazakh seismic station that anomalous changes have been recorded 3 times more than the background 2 days before the earthquakes that occurred on 11.05.2017 with magnitude of 5.4 (Fig. 5).

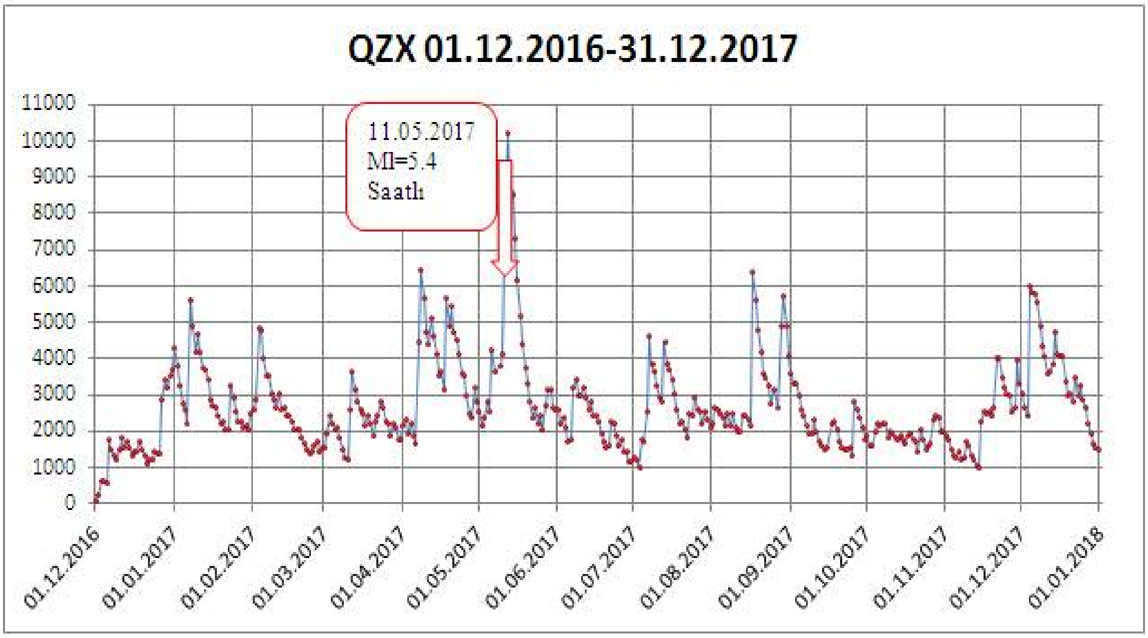

Figure 5. The curve graphic of VP/Vs parameter on the basis of seismic station "Gazakh"

The graphic created by Heyderabad seismic station shows that anomalous change is 3 times more than the background that have been registered 9 days before the Aghdam earthquake occurred on 15.11.2017 with magnitude of 5.7 (Fig. 6).

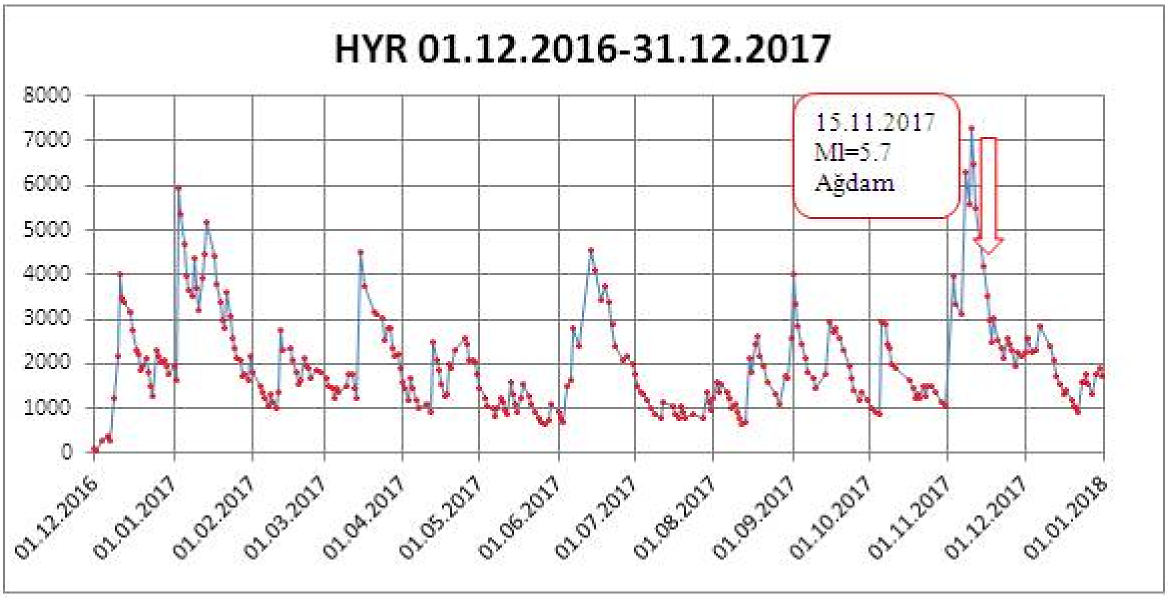

Figure 6. The curve graphic of Vp/Vs parameter on the basis of seismic station "Heyderabad"

Thus, anomaly changes have been reflected in the seismoprognostic curves before the strong earthquakes in Imishli, Saatli and Aghdam during 2016-2017 years.

Change of kinematic information – Vp/Vs parameter is calculated for the purpose of identifying potentially strong earthquake zones, as well as predicting seismic activity [Slavina et.al, 2012]. The maps that reflect spatial distribution of this parameter have been created. It appears from the map created for the Aghdam seismic station for 2015 year, increase of the seismic tension is observed in seismo active zones of Kura depression (Fig.7).

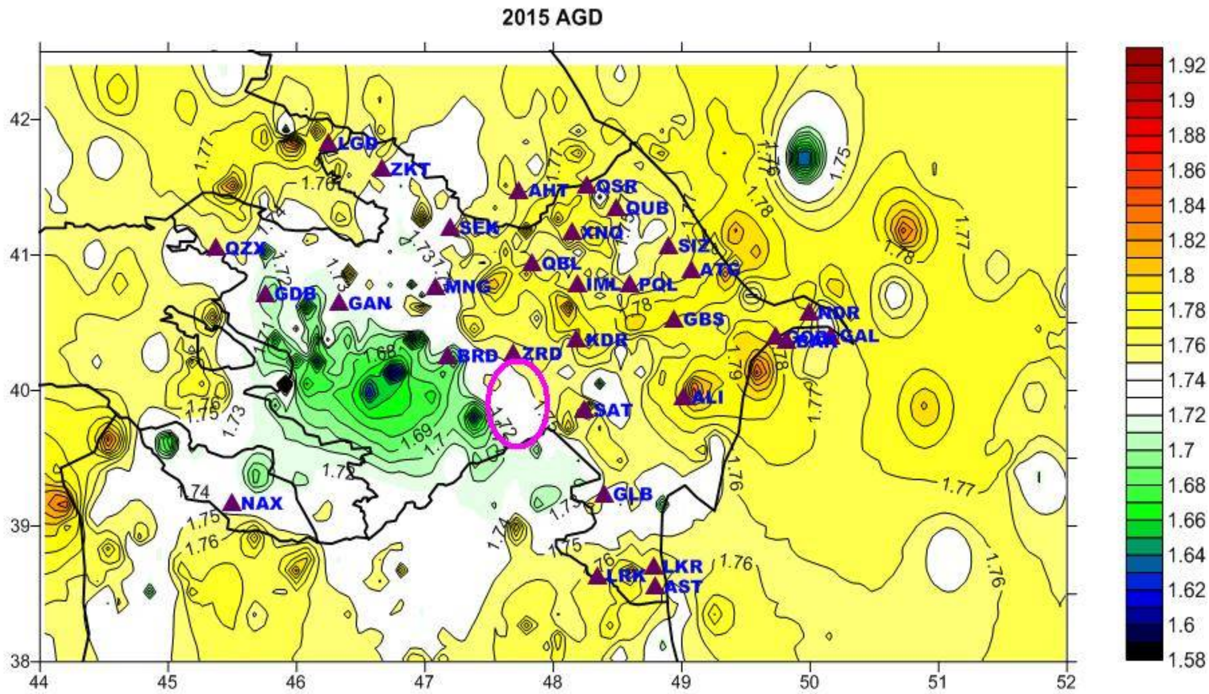

Figure 7. Change of the Vp/Vs parameter on the area according to Aghdam station data for 2015 year.

This zone had been identified on the map as a gradient zone that was created on the basis of 2015 year's data and the strongest Imishli earthquake (Ml=5.6) occurred in 2016 here. There were 6 strong earthquakes with magnitude 3.5 in the area of the lower Kura depression and Talysh mountainous system. Among them there is a powerful Saatli earthquake with magnitude 5.4 that occurred in 2017. It should be noted that tense geodynamic situation had been detected in the area of the lower Kura depression in the Vp/Vs maps based on the data of 2016 year. As you can see, Saatli and Aghdam earthquakes are located in the gradient zone (Fig. 8).

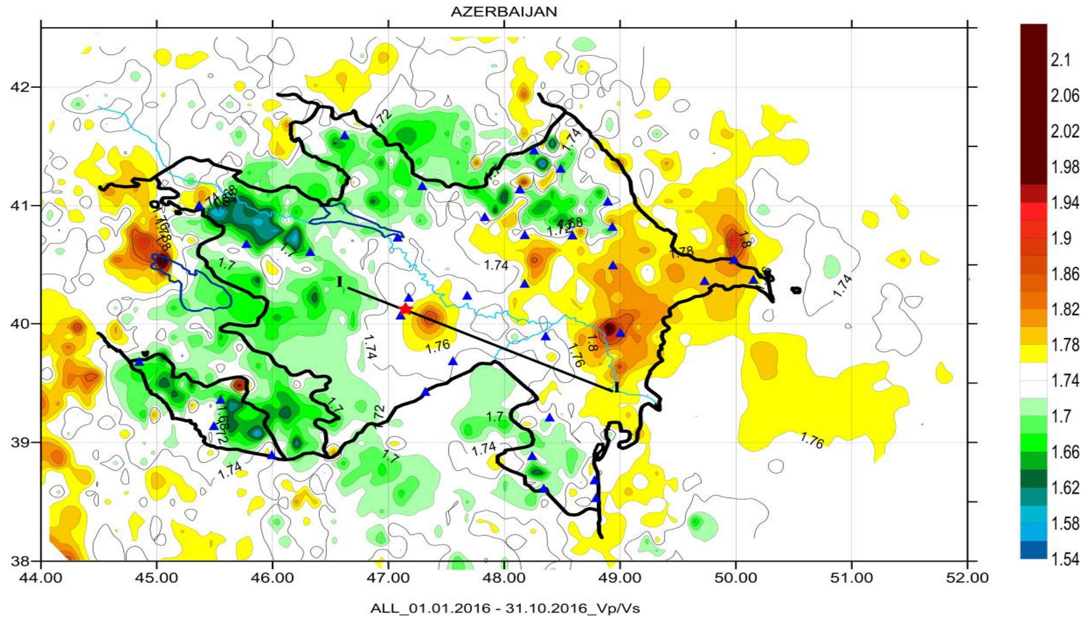

Figure 8. Change of Vp/Vs parameter on the area based on all seismic stations' data of 2017 year

Analysis of the map created on the basis of the Aghdam seismic station's data in 2017 shows that the gradient zone passes through the Kura depression area and this zone is registered as a tension zone.

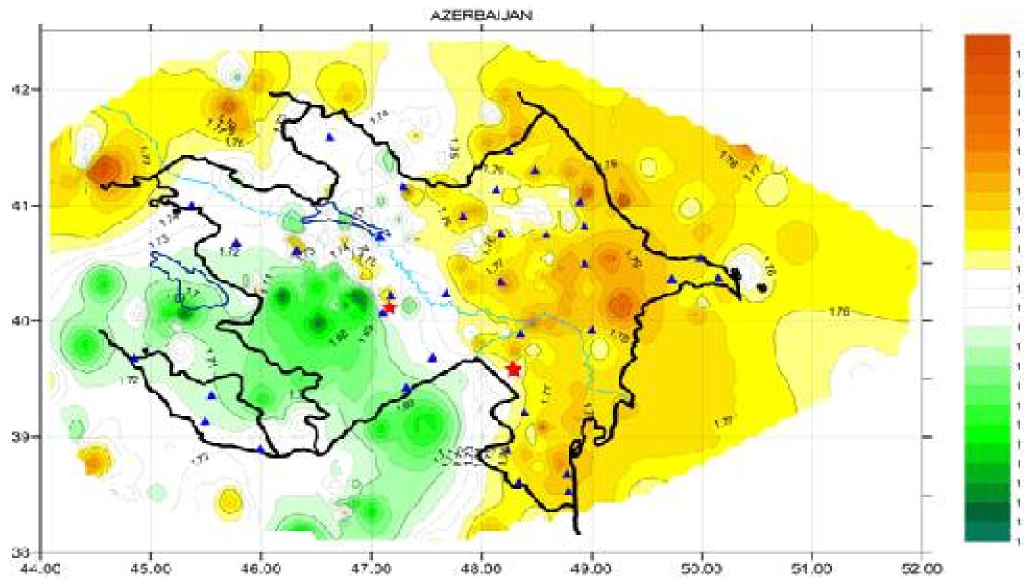

Figure 10. Change of the Vp/Vs parameter on the area according to Aghdam seismic station data on the basis of 2017 year

Conclusion

The analysis of the maps shows that anomalous changes had been observed in the created curves according to Altiaghac, Aghdam, Heyderabad, Gazakh seismic stations, before strong Saatli, Imishli and Aghdam earthquakes.

The maps of spatial distribution of Vp/Vs parameter have shown a tense of geodynamic situation in the Kura depression and there were strong earthquakes with magnitude of 5 in this zone in 2016-2017 years.

The researches allow the assessment of the seismic condition in future and to detect the existence being of geodynamic condition of environment.

REFERENCE

[1] Гасанов А.Г., Славина Л.Б., Етирмишли Г.Д., 2009. Результаты наблюдения в реальном времени за краткосрочным кинематическим предвестником TAU в Азербайджане. //Сб. "Каталог сейсмопрогностических наблюдений на территории Азербайджана в 2008г. Баку. С.92-97.

[2] Славина Л.Б., Етирмишли Г.Д., Абдуллаева Р.Р., Мячкин В.В. 2012. Картирование долгосрочного предвестника TAU (VP/VS) для выявления областей повышенной вероятности возникновения сильных землетрясений на территории Азербайджана и Прикаспия. //Сб. "Каталог сейсмопрогностических наблюдений на территории Азербайджана в 2012г. Баку. С.386-401.

[3] Абдуллаева Р.Р., Славина Л.Б., Бекдамирова Г.И., Акберов Э.Р., 2016. Отражение подготовки и реализации сильных землетрясений в сейсмологических полях, полученных по данным телеметрической сети станций Азербайджана.// Современные методы обработки и интерпретации сейсмологических данных. Обнинск. С.15-19.

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LITHOLOGY AND PALEOGEOGRAPHIC CONDITION OF PRODUCTIVE SEDIMENTS IN BAKU ARCHIPELAGO BULLA-SEA FIELD

N.K. Mehemmedhesenzadekh[1], P.C.Abasova[1]

ABSTRACT. In the Caspian basin, especially in Baku archipelago, specification of the paleo structure of the productive layer sediments, monitoring of the sediment structure throughout the area and studying of the gathering condition is an actual problem.
The results of the analyzes in order to determine the abundance boundaries of different types of facies and to study the lithological variability of productive layer sedimentary throughout the area based on 2D seismic data in the Bulla Sea structure have been presented in the article.

Introduction

Bulla Sea uplift is brackianticlinal folded with the NW-SE direction and has asymmetrical structure. Productive layer sediments that relieved thickness through wells drilled in the field according to the lithological structure consist of mainly sand, clay, aleurite and sandstone. The sand is gray, light gray, small-grained, tiny, lime and quartziferous. Clays are composed of gray, light gray, sometimes green, brown, dense, solid cemented, sandy, carbonate and micaceous clasts. The sandstone is the small, medium and small-grained, light-gray, sometimes brown, blue, clayey-lime, micaceous and quartziferous. Sandy rocks consist of loam, sand, aleurite [1, 2].

VIII Horizon of the MQ is expressed lithologically small and medium-sized, weak limestone sand aleurite and clays. The VII horizon of the MQ consists of the quartz, partly fieldspars and rock crumbs. The noted horizon is represented by lithologically medium, coarse quartziferous sands and in addition to medium-sized quartz sand, light colored sandstone, clay intermediate layers.

The thickness and sandiness of the V horizon of MQ increase from NW-SE direction (in connection with the activity of the paleoriver). Thus, lithologically research interval of the section consists of clays with aleurites and clayey aleurites and alternation of sand layers that have low thickness.

It is considered that, the main oilfield facilities are V, VII and VIII horizons of MQ [1].

Analysis of the main sedimentation condition of the area

Formation of the structure occurred in the complex seismogeological condition is characterized with lithological – facies changing throughout the area (lateral, also vertical direction).

To study the lithofacies changing, seismic facies analysis has been conducted as interval speed of seismic reflection and continuous monitoring of the amplitude and configuration of the seismic waves. The analyses of these parameters have been allowed to study the sedimentation condition throughout the area and to separate the boundaries of the abundance areal of different facies.

Restoration of sedimentation condition has been carried out on the basis of the characteristics of the seismic reflection. Thus, the configuration of the waves allows defining the main features of the bedding and on the basis of this it is possible to express an opinion about the sedimentation, erosion and processes with paleorelief characteristic. The incessant reflection, that have boundary of the continuous layers, confirms the equal distribution of the layered sedimentation throughout the area.

Amplitude of the reflection indicates the change of density and velocity in the separation boundaries of the rocks. The complex analysis of all these parameters have been allowed to separate the seismofacies, to mapping and at the end to restore the sedimentation condition, to predict the source of the materials and the geological condition of their collection.

[1] SOCAR Geophysics and Geology Department

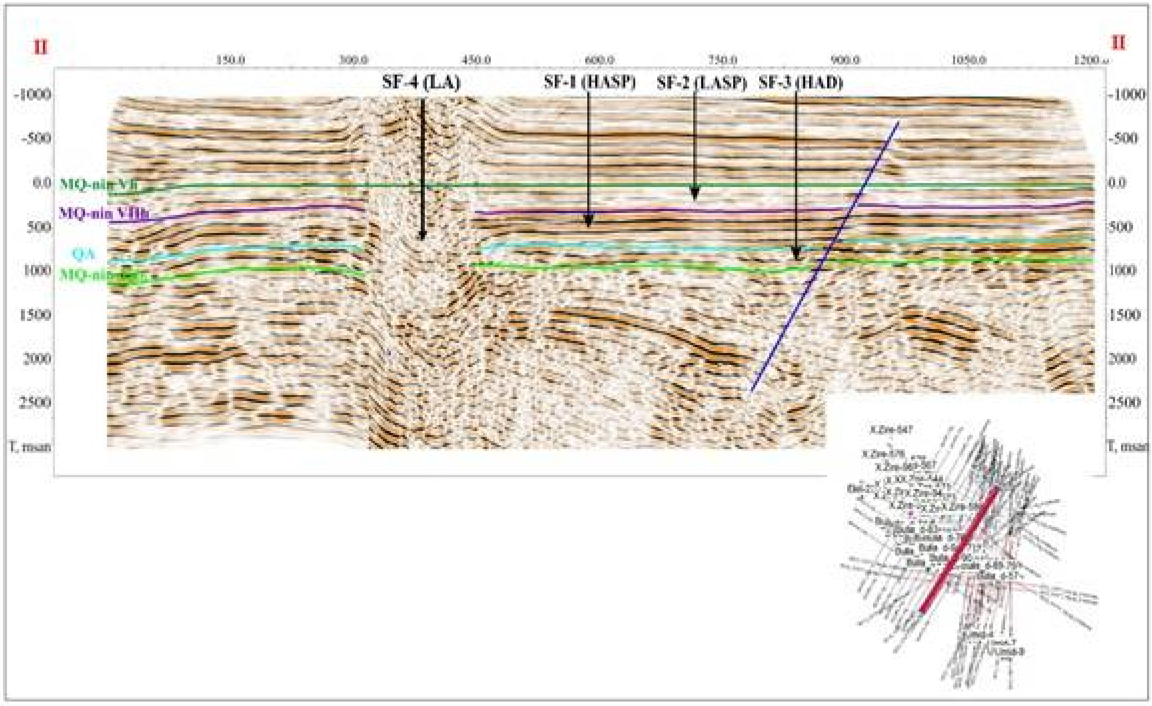

Figure 1. The separation of the facies and time section on the I-I line

As the result of the seismic facies (SF) analysis, three intervals have been allocated (Fig.1,2) from the MQ heel to V horizon and the thicknesses, interval speeds and seismic facies maps have been created for each interval (Fig.3,4). As a result, 4 SF have been allocated in the interval that investigated in the area.

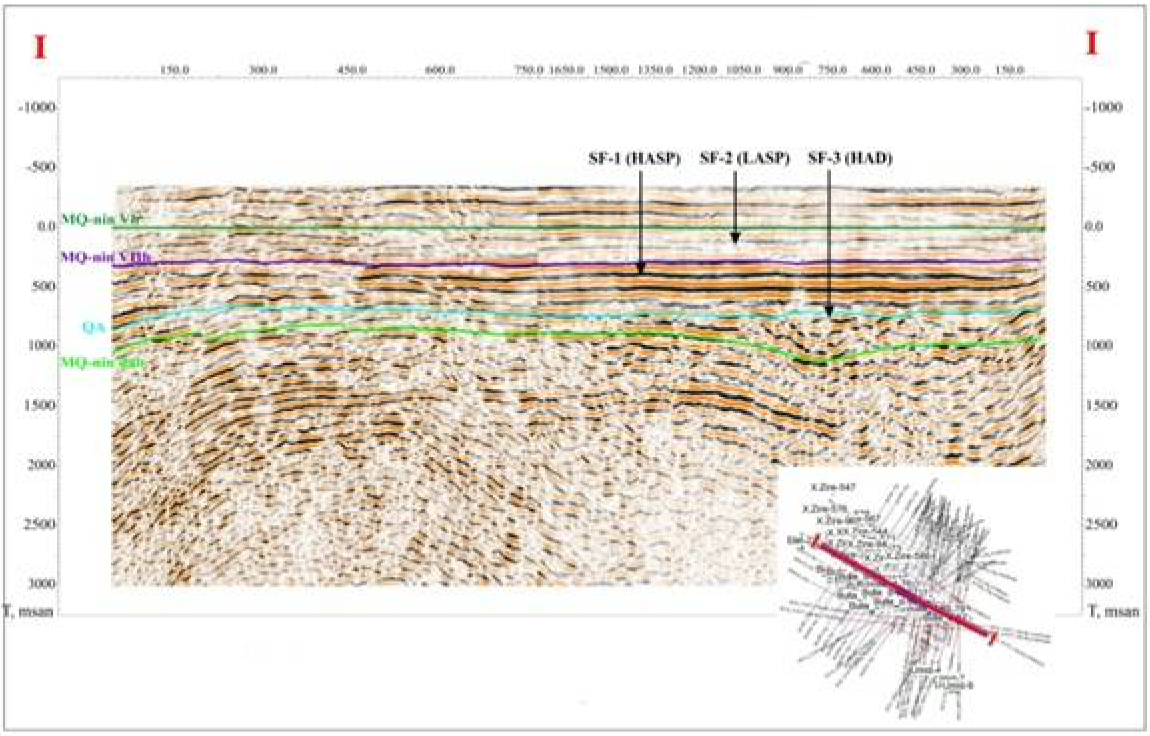

Figure 2. The separation of the facies and time section on the II-II line

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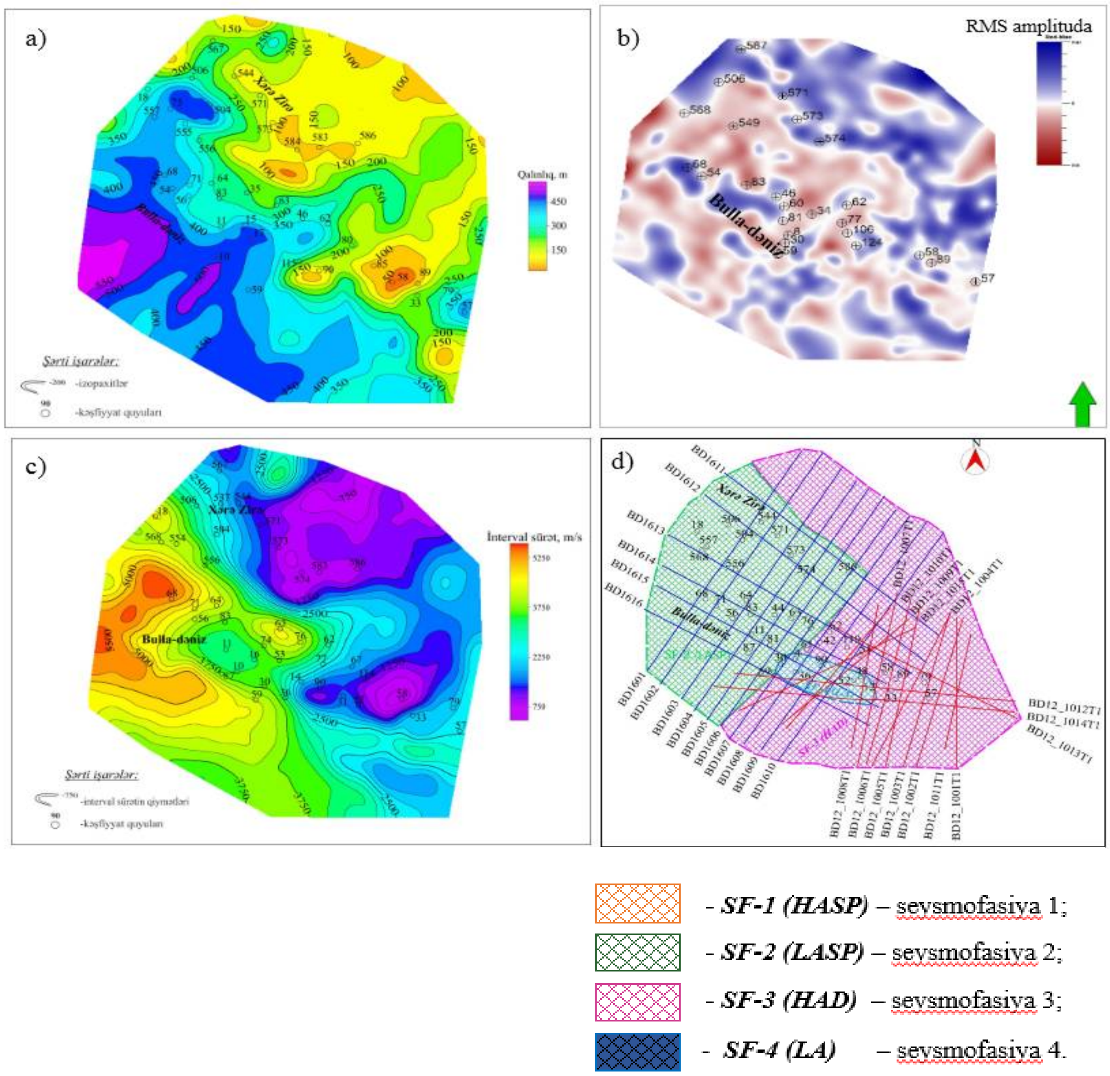

Figure 3. Between the Girmaki 6 layer groups and the MQ Horizon VII have been established a) equal thicknesses map; b) map of mid-square amplitudes; c)map of interval speeds; d) seismic facies map.

SF1 (seismic facies 1) – is characterized with incessant and intensive reflection, clear parallel waves. These reflections allow assuming that sedimentation goes in calm condition in the shelf (see fig.2-3).

SF2 (seismic facies 2) - being a small amplitude, is characterized with only continuous and parallel reflection. These reflections are with lower amplitude although they are expressive in SF1 seismic facies. This is more related to changing of the lithological content of the rocks. In some cases it may be related to changing of the sedimentation condition or temp (see fig. 2-3).

SF3 (seismic facies 3) – is characterized with clear, intensive, only unstable reflection. These reflection allow assuming that the being sedimentation at the expense of non-marine crumbs collected as a result of mountain's erosion ("Greater and Lesser Caucasus") and the action of the ancient river, fluid rocks (see fig. 3).

SF4 (seismic facies 4) – is characterized by unstable, unusual, amplitudes with lower reflection. This facies indicates that being the sedimentation in the condition of relatively high tension. It is also possible to associate these facials with complex dislocations and intensive destruction zones (see fig.3.).

Thus, SF analysis conducted on three intervals has been allowed to determine the change of SF in the lateral and vertical direction on the section in the area. In the first interval, there is a claying of the sedimentation from the NW-SE. In the second interval, the increase of the sandiness has been observed from the center to the NE direction. In the third interval, the sandiness increases in CQ direction from the Bulla-Sea and Khere-Zire Island.

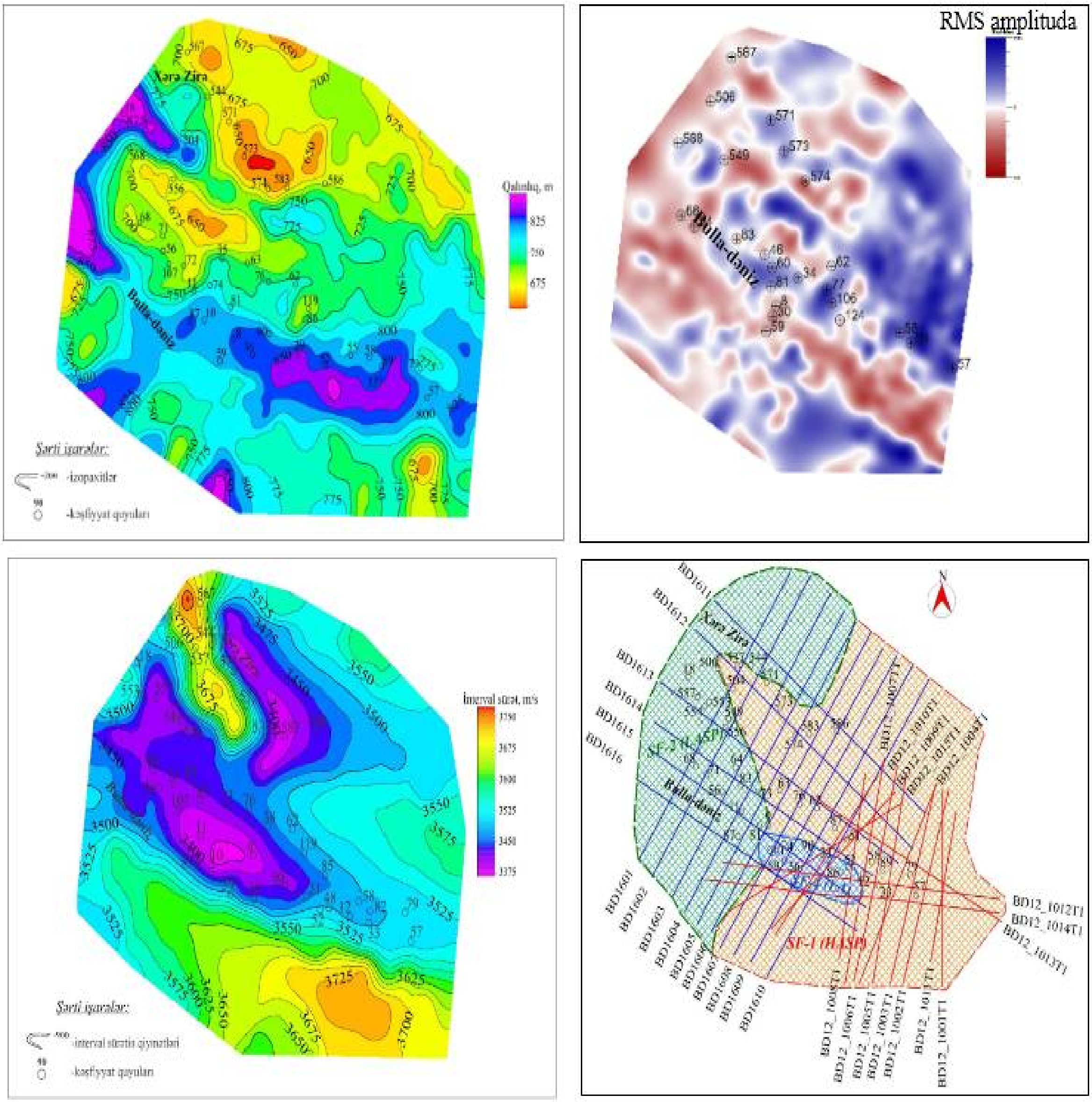

Figure 4. Between the Girmaki 6 layer groups and the MQ Horizon VII have been established:
a) a map of the same thickness; b) a map of medium squares;
c) display of interval velocities; d) seismic map.

Eventually, when analyzing received data with Kern samples together, in the area the mixed facies (Absheron and Gobustan) are dominated in the Lower Pliocene sediments.

The presence of two different types of sedimentary shows that, sources of nutrition and delivery of the terrigenous materials are different. Thus, accumulation of the sediments in the VII horizon at the Bulla-Sea is recorded that it is going in the deep basin.

Thus, the complex analysis of QGT and seismic exploration works allowed to study the sand mass associated with the river bed, condition of sedimentation, boundary of the claying zones and to determine the oil and gas prospect of Bulla-Sea structure [2, 3].

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Conclusion

1. On the basis of complex analysis of QGT and seismic, lithofacies changes of the Bulla-sea structure have been assessed. Mentioned lithofacies variability taking into account the results of the analysis (amplitude of seismic waves, interval speeds, configuration and its unstable monitoring) of conducted seismic facies associated with increased clayness in the CQ direction.

2. Four seismic facies (SF) have been allocated within the Lower Pliocene sediments on the basis of the dynamic and kinematic characteristics of the seismic wave field observed in the time section.

3. Valuable scientific ideas have been said about having the different genesis (tea, sea and mixed) of Lower Pliocene sediments in the research field and as a result of the conducted seismic facies analysis the sedimentation condition on the three stratigraphic intervals (MQ heel –QAD,QAD-n- VII horizon, VII horizon-V horizon) have been studied.

REFERENCE

[1] Əbilhəsənova L.C., Məmmədova S.R., Allahverdiyev E.Q. "Bakı arxipelaqı ANQR-in Bulla-dəniz sahəsində aparılmış ikiölçülü (2D) seysmik kəşfiyyat işlərinin"KGİB hesabatın mətni. Bakı, 2017.153 s.

[2] Quliyev Z.İ., Şirinova S.Ə. və s. "Səngəçal-dəniz – Babək qalxımlar zonasında (8 Mart və Ələt-dəniz sahələri də daxil olmaqla) qumlu horizontların sahə və kəsiliş üzrə öyrənilməsi və neft-qazlılıq persprektivliyinin qiymətləndirilməsi" KMAİB hesabatın mətni. Bakı, 2014. 494 s.

[3] Н.П. Юсубов, Т.Н. Шихмамедова. "О некоторых петрофизических особенностях нижнего разреза продуктивной толщи в зоне поднятий Сангачал-дениз – Булла-дениз". Azərbaycan Neft Təsərrüfatı, №3, 2016

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