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SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN

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Republican Seismic Survey Center of
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SEISMOPROGNOSIS OBSERVATIONS IN THE TERRITORY OF AZERBAIJAN

ASSESSMENT OF SEISMIC HAZARD IN THE TERRITORY OF "TAKHTAKORPU" RESERVOIR OF AZERBAIJAN

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

Takhtakorpu reservoir and the relevant dam complex's territories are located in the Darachay valley (Takhtakorpu), 3.5 km south-west of Shabran. The area of the dam and reservoir is characterized by smooth heights that are not too high, numerous ravines, complicated hills and sloping plains. The absolute height of the surface is within 60-2500 m, here. There is Gaynarcha mud volcano with an absolute height of 180 m in the abyssal mountain shore of Takhtakorpu river, 2 km from the dam. The volcano is located on the northern wing of the anticline with the same name.

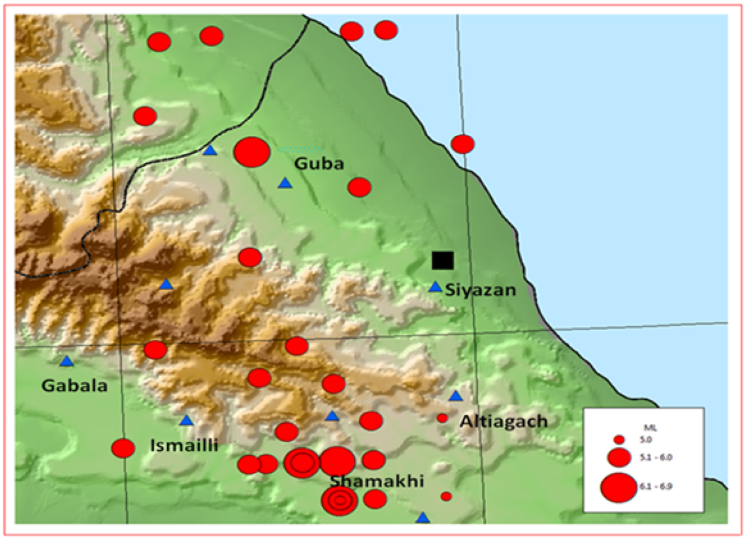
The tectonic elements of the northern part of the large Tangin-Beshbarmag anticline are observed in the area1.5-2.0 km south of the Takhtakorpu reservoir.

The territory of the dam is within the north-eastern wing of the Gaynarcha anticline of the Gusar-Davachi synclinorium. Gaynarcha anticline extends from north-west to south-east being 7 km width and 70-80 km length. The east extremity of the anticlinal folded have been exposed to fault within the research area. The formation of the Gaynarcha mud volcano that is located 2 km south-west of dam axis on the right bank of the Takhtakorpu river is associated with this fault.

The fault cannot harm the durability of the dam because the fault direction of the folding is consistent with its way that means the fault is directed parallel at a great distance to the dam.

The Takhtakorpu reservoir is located in the north-eastern extremity of the Greater Caucasus and this area isn't seismically characterized by high activity. However, regularly occurrence of relatively weak seismic shocks are observed here.

Directly, strong and destructive earthquakes have not been recorded in the research area till now (Fig. 1). The strongest earthquakes occurred mainly in the north, west and south from the Shabran region (Takhtakorpu reservoir) [1,2,3]. These earthquakes that are quite strong were felt at high intensity certainly in the territory of Shabran district.



■ – The Takhtakorpu reservoir

Figure 1. Map of the strong earthquakes epicenters in the north-east of Azerbaijan during of 427-2018 years.

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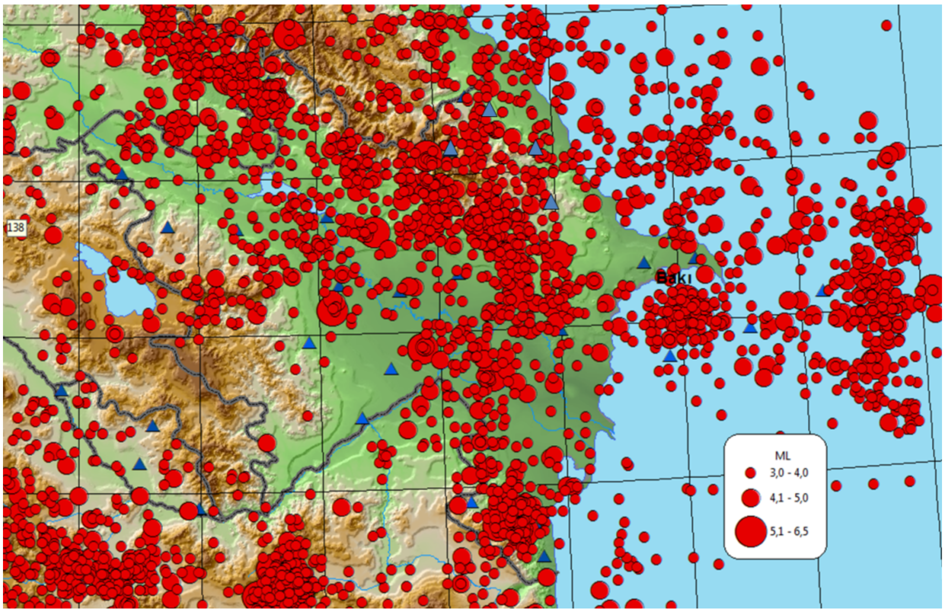
An analysis of the isoside schemes of the strongest earthquakes in Azerbaijan shows that an earthquake with an intensity of 6 points on the MSK-64 scale has not been recorded in the Takhtakorpu reservoir area of Shabran district until now. Seismic vibrations with this intensity is mainly result of the earthquakes occurred in Shamakhi region. It should be noted that, only the strong earthquake occurred in 1963 in the Caspian Sea was felt by the 7 point intensity in the narrow territory along the coast of Shabran.

At first glance in Figure 1, the research area presents an asymmetric zone. But it is not so.

Epicenter map of earthquakes with M≥3,0 recorded in Azerbaijan and adjacent territories during 1980-2018 [3]years indicates that there are small but weak seismic shocks in the research area (Fig.2). Note that, recording of the large number of weak seismic shocks in Azerbaijan is associated with the operation of digital seismic stations with very wide frequency-dinamic range in Azerbaijan mainly since 2003, produced by the US , “Kinemetrics” company.



▲ – Seismic stations

Figure 2. Earthquakes with ml>3 recorded in Azerbaijan and adjacent territories during the period 1980-2018 years.

As mentioned above, earthquakes maximum with magnitude intensity 6 on the scale MSK-64 has been recorded in the territory of Shabran district till now. Seismic vibrations with this intensity are mainly result of the earthquakes in Shamakhi region. Just the strong (M=6.2) earthquake [4] occurred in the Caspian Sea in 1963 year had been felt at the 7-point intensity in the narrow area along the seashore of the Shabran district.

However, the result obtained by these observations doesn’t mean that the earthquakes with the more intensity will not occur in the Shabran region in the future. To determine the spatial position of potential source zones in the territory of Azerbaijan, abundance (both lateral and vertical) of the strong and weak earthquakes on the point of this area and relation of the large depth faults with the zones of the tense concentration of the seismic shocks have been investigated [5,6].

It is clear from research that, strong earthquakes occur not everywhere but in the areas where weak earthquakes are concentrated. Based on this factor, T. Mammadli developed a method for identifying source zones of strong earthquakes based on weak earthquake concentrations [5,6]. This method, unlike the methods used so far in seismoactive areas, allows for the detection of potential seismic hazards in seismoactive areas before any fault zone and seismic data of strong earthquakes,in advance, without pre-adapting to any fault zone and seismostatistic data of strong earthquakes. The application of the method revealed that there are numerous and various sizes of active fault zones (or potential source zones) in the territory of Azerbaijan (Fig.5).

The spatial position of these fault zones shows that the seismic area of Azerbaijan Republic has a mosaic structure.

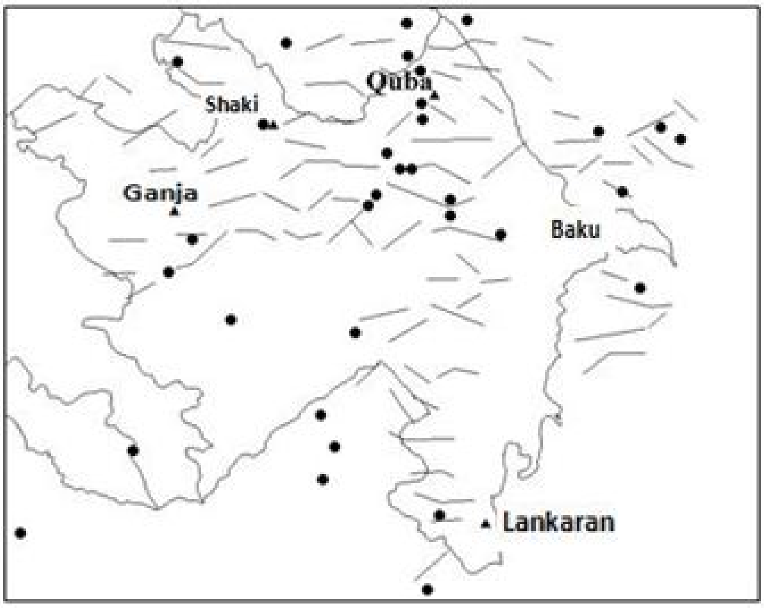


Figure 3. Scheme of seismic and strong earthquake zones of the Azerbaijan Republic

Conventional signs:
● – epicenter of earthquake; ▲ – Seismic stations;

——— – active fault or potential source zones;

In order to identify the characteristics of the earthquakes distribution on depth, the seismic sections on II-II profiles with the south-west and north-east directions and I-I profiles with the west-east directions have been compiled in the research area (Fig.5 and 6)

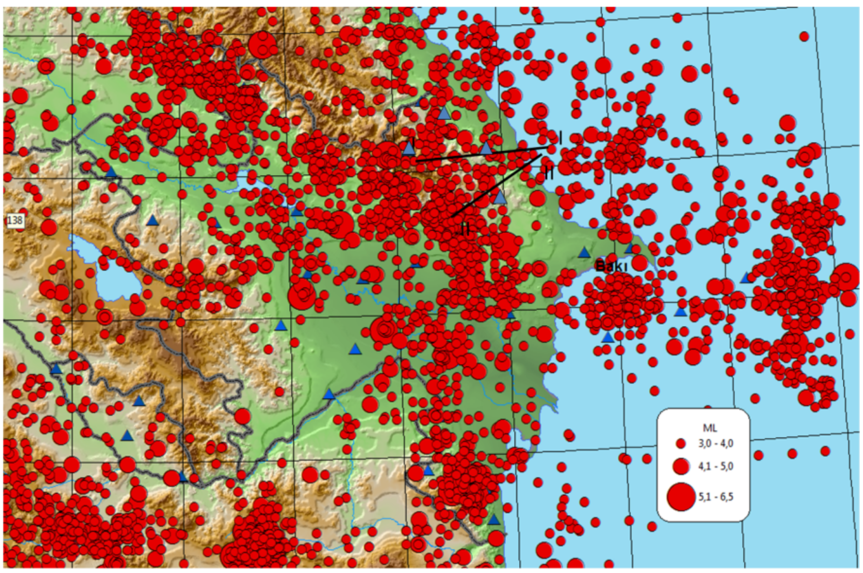
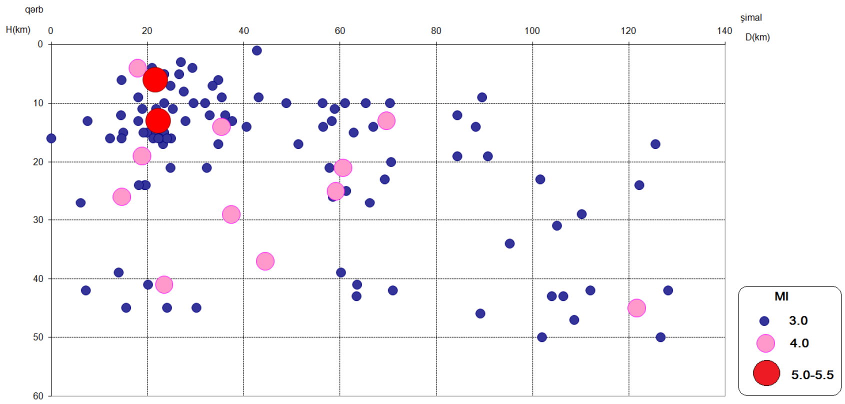
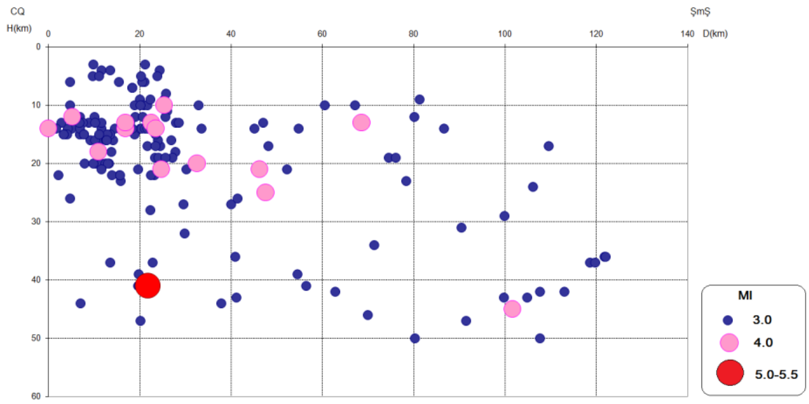


Figure 4. Location map of profiles I-I and II-II



I-I profile



II-II profile

Figure.5. Seismological transects by profiles

As can be seen seismic transects, seismic shocks are densely concentrated mainly in the west and south-west part which corresponds to the Shamakhi-Ismayilli zone of transects. Although these hypocenters are from 3km to 20-25 km depth but the depth of some shocks is 40-45 km. Strong earthquakes(M≥5,0) occur in the depth (10-15 km) near the surface of the crystalline foundation here, as in other parts of the Greater Caucasus. Note that, the number of weak seismic shocks is low in 40km depth in these parts even though it is observed that they tend to occur frequently. The strong (M = 5.3) earthquake (M=5.3) had been occurred on October 7, 2012 in Ismayilli, at this depth. Interestingly, the strong earthquake (M = 5.8) occurred on February 10, 2014 in Hajigabul at the same depth. For this reason, it is considered expedient that investigate more extensively the manifestation features of seismicity at such depth in these areas in future.

Although the number of seismic shocks decreasing gradually to the east and north-east by section, it is observed that they tend to occur frequently at the 10-15 km and 40-45 km depth in separate parts of the area.

As you can see from Fig.4, active faults with Caucasian direction that is larger than the surrounding source zones and anti-Caucasian direction or potential source zones is different from others. The maximum magnitude (Mmax) of probable earthquakes in these source zones have been determined in [6] and they are M_{max} = 7.4 and M_{max} = 6.7, respectively. near the research area active

It is possible to determine the macroseismic effect created by the probable strong earthquakes in these source zones on the surface using the assessments of coefficients of macroseismic field equation [8] that assigned by F.T.Guliyev for this region and macroseismic field equation that assigned by N.V.Shebalin [7].

The conducted calculations show that, if maximum magnitude earthquakes occur in the above-mentioned potential source zones, seismic hazards with an intensity of 8-9 points on the MSK-64 scale may occur in the “Takhtakorpu” reservoir area where the research is being conducted.

Conclusion

1. The Takhtakorpu reservoir area is not seismically characterized by high activity. No earthquake with a magnitude greater than 6 on the MSK-64 scale has been recorded so far ,here. The seismic vibrations with this intensity are mainly spread by earthquakes in Shamakhi region.
2. Researches show that, there are two sufficiently large-sized active faults (or potential source zones) in the area near the reservoir. According to calculations, the probable earthquakes with maximum magnitude in the such source zones can create seismic hazard with 8-9 point intensity on the MSK-64 scale in the territory of Takhtakorpu reservoir.

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ANOMALOUS CHANGES OF MAGNETIC FIELD BEFORE THE ZAGATALA EARTHQUAKE ON 05.06.2018

A.G.Rzayev[1], L.A. Ibrahimova[1], N.B. Khanbabayev[1], M.K. Mammadova[1], V.R. Huseynova[1]

Introduction: Researchers know that the strong earthquakes in seismoactive areas are frequently accompanied by geomagnetic effect. Magnetometric investigations allow in many cases can help to clarify boundaries of geological structures (Rzayev, 2006; Yetirmishli et al. ,2013).

The accumulation of stress-strain energy at the different depths of the Earth is related to local, ionosperic and cosmogenic factors (Finkelstein et al., 2012). Mechanical, physico-chemical and the other features of the environment of the earthquake sources in the area of the north and southern slopes of the Greater Caucasus, Kura Depression and Lesser Caucasus where anomalous stress-strain energy is accumulated, changes with characteristic features. Effects of the such active processes on the surface are studied in the seismoactive regions of the world as the earthquake warning factors and geophysical areas: gravitational, electrical, magnetic and geochemical anomalous changes. [1,2,3]

The first information about earthquakes in the north-western region of Azerbaijan in the Greater Caucasus dates to 1850 year. Strong earthquake in the region occurred in 1936 and 1948 years (m l≥5) (Aghamirzoyev, 1987). In the recent years, the earthquake with magnitude of 7 is occurred on 07.05.2012 in the Zagatala-Balakan zone (ml = 5,6 h=9 km φ = 41,50ºN, λ = 46,58ºN) and in the Zagatala area in 2018 year.

The earthquake with 10 km depth and magnitude of 5.5 had been occurred in the Zagatala region on 05.06.2018. In the article, the mechanism of the earthquake source is mentioned as a main factor in the occurrence of the seismic events as a warning element of anomalous seismic effects. According to the results of observations of the geomagnetic regime, there is detailed information for the interpretation and analysis of the characteristic gradient and increasing of the geomagnetic field tension , during the preparation of seismic event at the Shamakhi-Sheki-Balakan geodynamic polygon.

It can be noted that the coverage of the Zagatala earthquake area is in the southern sunset of the Greater Caucasus mega anticlinorium from a geological perspective (Pleistocene zone).

This can be evaluated as Zagatala tension zone. This zone is surrounded by the west of Gasakh-Signakh fault and to the east by the Ganjachay-Alazan fault (Shikhalibeyli et al. 1978).

The area in the magnetic field is recorded to as the Shamkhor-Zagatala transverse magnetic anomaly. Within this anomaly, two large significant positive magnetic anomalies are distinquished: Alazan and Gutan (Metaxas, 1979).

These large-scale anomalies are located in the intersection zone of the lengthwise Caucasus and transverse tectonic structure. These anomalies are considered as the elements of the Anticaucasus megazone. The Alazan and Gutan anomalies are characterized by strong magnetic field gradient, which is indicated in the south and north directions. Such zones can be considered as normal fault characteristic areas.

The depth of the upper layer of the excited magnetic mass of the Guton magnetic anomaly is 2 km, and for the Alazan magnetic anomaly is 4 km (Метахаs, 1979). Thus, these anomalies belonging to the Alpine basis area are of the highest level and this area is considered as a high risk area.

It should be noted that, the rise of the foundation up to Alpine in the transverse Shamkhor-Zagatala sructure and being closer of thrust to the surface are the basis of seismic events in this area. The seismicity of this area that is characteristic of normal fault depend on the being the lengthwise blocks up to Alpine with the south-north direction and the effect of transverse

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movements. There are also seismogenic slip-strike structure elements in parallel with the normal fault in the foundation up to Alpine exposed benching grounding directed to the east from the Ganja-Alazan transverse fault.Thus, it is thought that, the earthquake occurred in Zagatala city to have a direct relationship with the presence of transverse and cross-section faults in the movements of Earth's crust along with the formation of a geodynamic regime. In addition to above mentioned, the main cause of earthquakes in this area is presence of the Gazakh-Signakh and Ganja-Alazan right-sided faults.

The purpose of the research: coordinates of the Zagatala earthquake occurred on 05.06.2018 was φ = 41.50ºN, λ = 46.67 ºE, magnitude was ml = 5.5 and the depth of the source was h = 10 km.

The coordinates of this earthquake are partly consistent with the earthquake coordinates occurred in 2012 year (φ = 41.56ºN, λ = 46.63 ºE; ml = 5.7; h = 12 km) - (Rzayev, Metaxas, 2012).

It is advisable to provide detailed information about the earthquake with the magnitude of 5.5 in the city of Zagatala. Changes in seismomagnetic effects in Sheki city and Ismayilli city points have been continously monitored a month before the seismic event, in the time of the event and a month after the event .Geomagnetic observatons at both these sites were observed at the background level month ago.

Abnormal changes caused by strong earthquakes occurred in the Shamakhi-Sheki-Zagatala-Balakan zones, estimated by high seismic risk and geodynamic activity are recorded by modern geophysical devices installed on the seismic stations data are transmitted to RSSC. The data is operatively analyzed and the change graphs depending on the time of seismomagnetic effect are created. Changes of the seismomagnetic effect have been remarkable before and after the strong Zagatala earthquake.

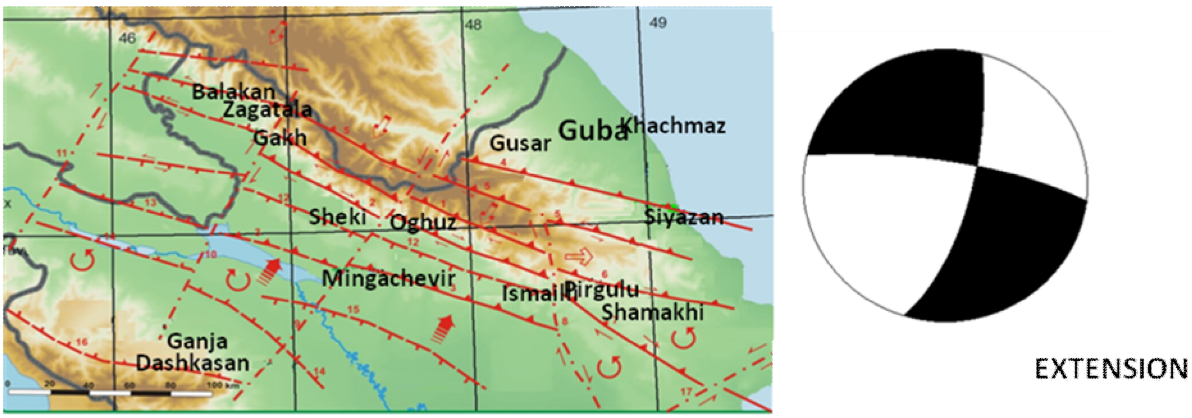

Figure 5. Mechanism of the Zagatala earthquake (ml=5.5) on June 5, 2018 year (with the extension character) (compiled by S.E.Kazimova)

This indication proves that the geodynamic regime of the seismogenic zone of Zagatala didn't changed which was determined by the movements of blocks on the Earth's crust in relation to the cross-section and transverse faults. The mechanism of the earthquake occurred on 05.06.2018 is estimated as a left-sided normal fault component. It is supposed that it is mainly formed by the right-sided movements of the Gazakh-Signakh and Ganjachay-Alazan zones (Rzayev and Metaxas, 2012).

Geomagnetic observations have been formed due to increments 10 days before the event and have been increased to a maximum value of 20÷30 nT. This process continued 10 days after the gedoynamic event.

As can be seen from the compiled curve, the seismomagnetic effect have been observed with the chaotic oscillations of 20÷25 nT and it have been continued with increases. In both sites, the changes of seismomagnetic effects have been occurred during the earthquake (Fig.2).

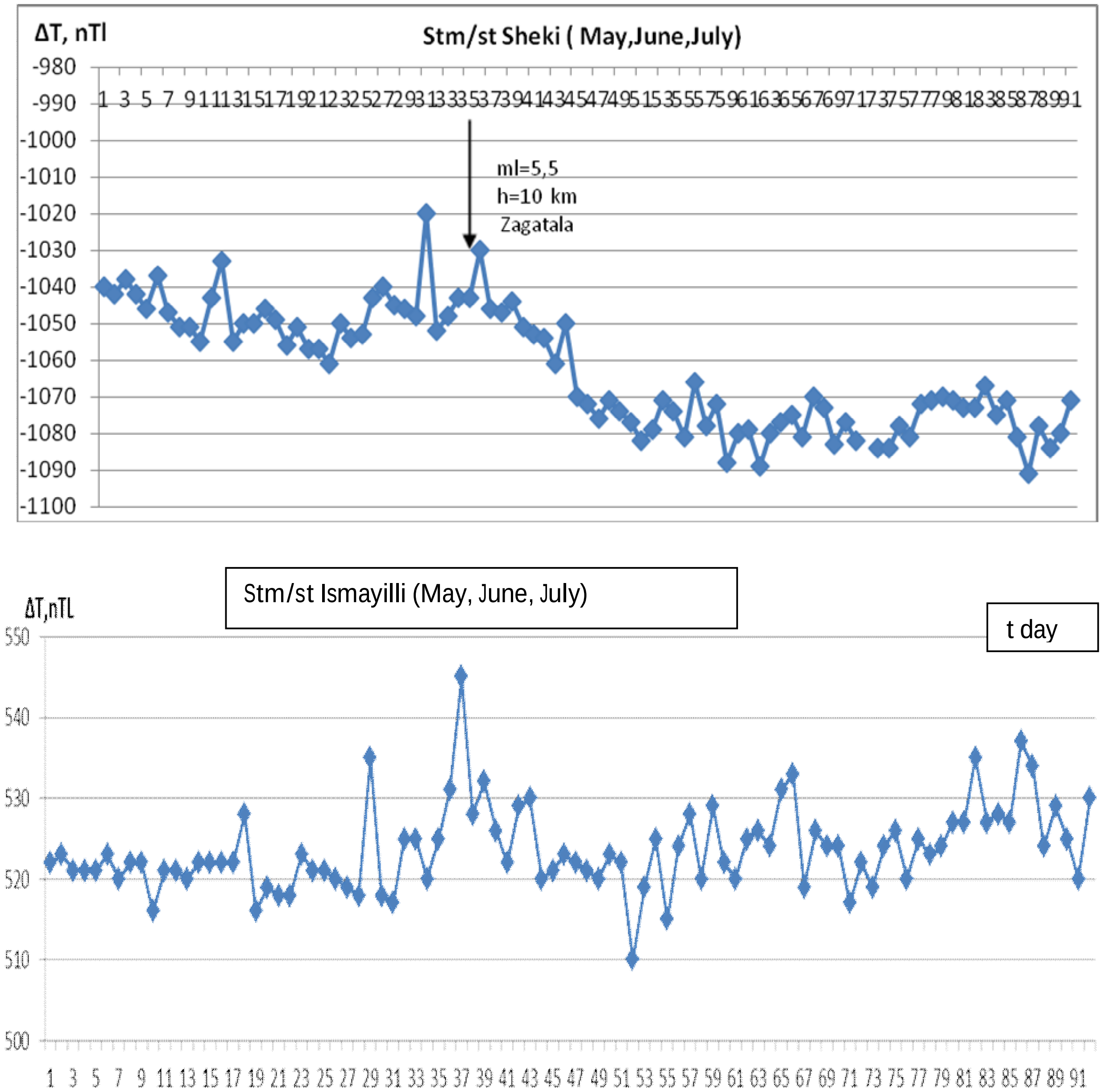

Figure 2. Manifestation of seismic effect of the Zagatala earthquake occurred in 2018 year.

The spatial-time increase in the geomagnetic field tension have been analyzed and allowed us to assess the regularity of dependence on seismic activity.

As can be seen from the created map, seismomagnetic effect is quite in the Gabala –Ismayilli geodynamic polygon, whereas the geodynamic field tension in the Balakan-Sheki is more active. The maps complement one another.

In the map created in 3D format, the increases are remarkable in the effect due to geodynamic field in the Balakan-Sheki polygon.

In the map created in 2D format, it is specifically mentioned that the complexity of the 50-100 nT values by closing of isometric line of the geomagnetic effect observed by seismic activity in the Qabala-Ismayilli zones (Fig. 3)

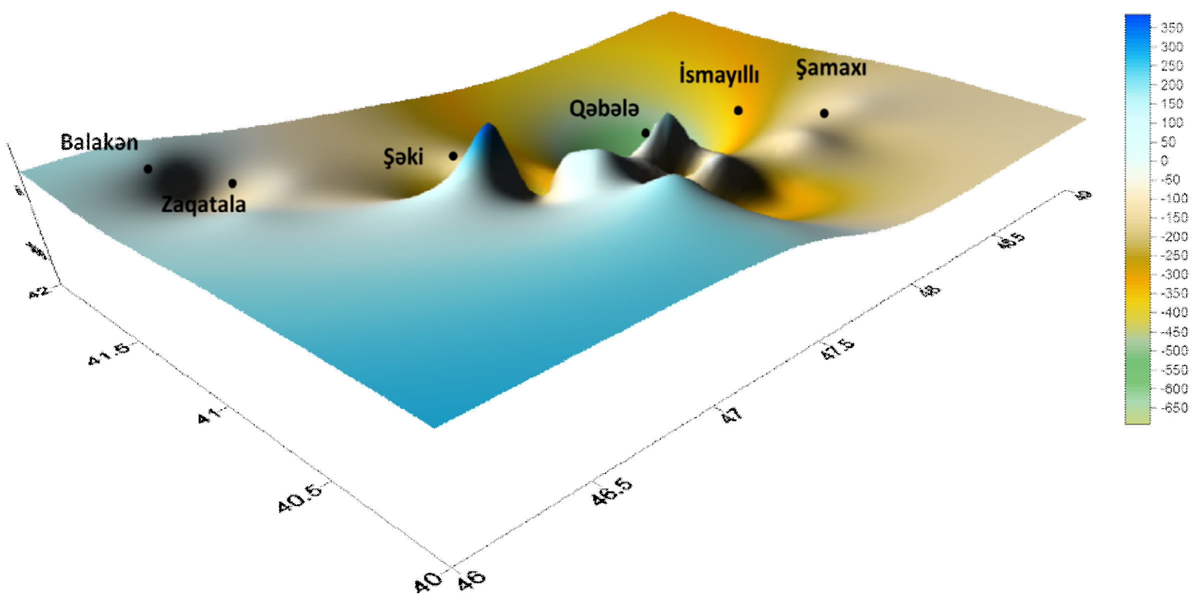

Figure 3A. Tension-deformation condition of geological environment based on the magnetic data observed in the Sheki-Shamakhi polygon (in 3D format, June 2018).

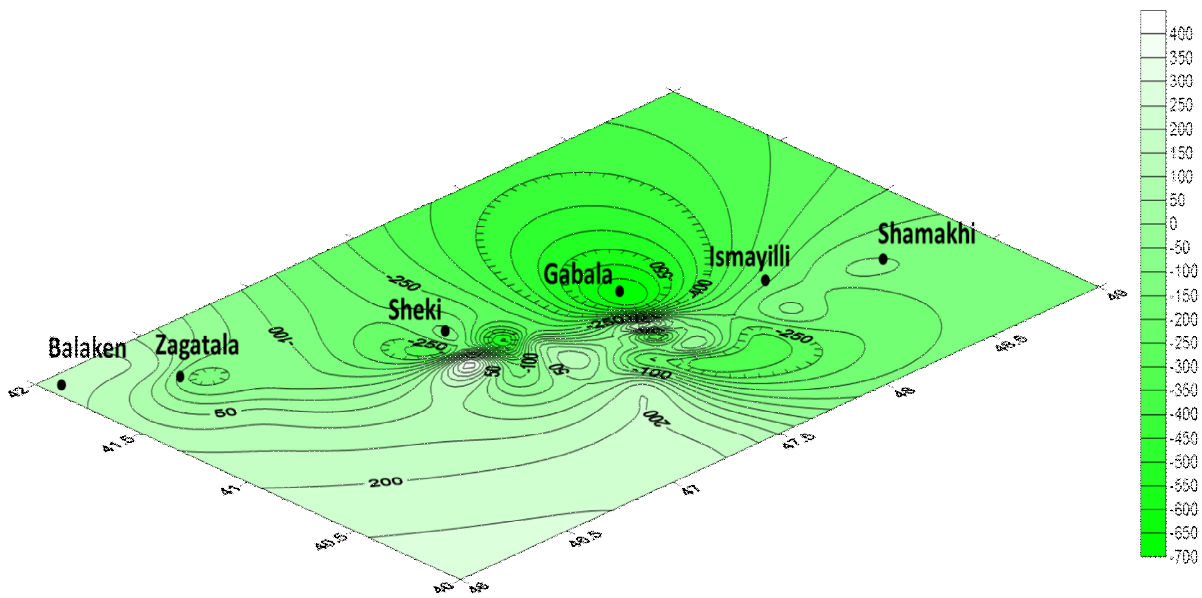

Figure 3B. Tension-deformation condition of geological environment based on the magnetic data observed in the Sheki-Shamakhi polygon (in 2D format, June 2018).

Conclusion

Analysis of the source mechanism and the module of the full vector of T temporal variations, spatial-time variations of geomagnetic field tension gradient, the dynamics of the tension-deformation conditions generated in the Shamakhi-Sheki-Balakan polygon have been clarified. It was accepted as a warning factor of the seismoanomal geomagnetic effects revealed before the Zagatala earthquake with ml = 5.5 occurred on 05.06.2018.

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1D VELOCITY MODEL BY LOCAL EARTHQUAKE DATA

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Introduction

In this study, one-dimensional (1-D) *P*- and *S*-wave velocity structures of upper crust in the Azerbaijan region and precise hypocentre locations are recorded by the Republican Seismic Survey Centre's stations, during the period 2003 – 2018. We performed an analysis to find the best P-wave one-dimensional velocity model for the crystal structure of the study area, using the **VELEST** algorithm. We used 5423 *P*- and 4478 *S*-arrival times of 2650 events recorded at 30 stations. We found eleven distinct layers within the upper 60 km of the crust. We studied the area from seismological and geological point of view and we analyzed the influence of the velocity model on the earthquake locations. We analyzed the instrumental seismicity of the Middle Kura Depression region recorded by the Republican Seismic Survey Centre's stations, during the period 2003 – 2009[9]. We used standard seismological methods to compute the Vp/Vs ratio, one-dimensional velocity model, and station corrections for earthquake relocations.

Earthquake location can be improved using a reference 1D model close to the true earth model and station corrections that mitigate the effects of the structure close to the receiver and deviations from the simple, homogeneous model. Kissling proposed that the natural solution to this problem is the least square solution. They called this solution the minimum 1D model. Following this approach, we first established the starting 1D models using the available information on the crystal structure. Starting velocity values were selected considering available data and the results of Gasanov A.(1989)[1]. We used four layers each for the crust and the uppermost mantle for a total of eight layers.

COUPLED HYPOCENTER VELOCITY MODEL PROBLEM

The travel time of a seismic wave is a non-linear function of both hypocentral parameters and seismic velocities sampled along the ray path between station and hypocenter. This dependency of hypocentral parameters and seismic velocities is called the coupled hypocenter-velocity model problem (Crosson 1976, Kissling 1988, Thurber 1992)[4, 9]. It can be linearized and in matrix notation is written as (Kissling et al. 1994):

$$\mathbf{t} = \mathbf{Hh} + \mathbf{Mm} + \mathbf{e} = \mathbf{Ad} + \mathbf{e},$$

t vector of travel time residuals (differences between observed and calculated travel time); **H** matrix of partial derivatives of travel time with respect to hypocentral parameters; **h** vector of hypocentral parameter adjustments; **M** matrix of partial derivatives of travel times with respect to model parameters; **m** vector of velocity parameter adjustments; **e** vector of travel time errors, including contributions from errors in measuring the observed travel times, errors in the calculated travel times due to errors in station coordinates, use of the wrong velocity model and hypocentral parameters, and errors caused by the linear approximation; **A** matrix of all partial derivatives; **d** vector of hypocentral and model parameter adjustments.

In standard earthquake location algorithms the velocity parameters are kept fixed to a priori values - that are assumed to be correct - and the observed travel times are minimized by perturbing hypocentral parameters. Neglecting the coupling between hypocentral and velocity parameters during the location process, however, can introduce systematic errors in the hypocenter location. Furthermore, error estimates strongly depend on the assumed a priori velocity structure. Precise hypocenter locations and error estimates, therefore, demand the simultaneous solution of both velocity and hypocentral parameters. The optimal 1D model will be achieved by simultaneously inverting for hypocenter and velocity parameters [10]. The minimum 1D velocity model obtained

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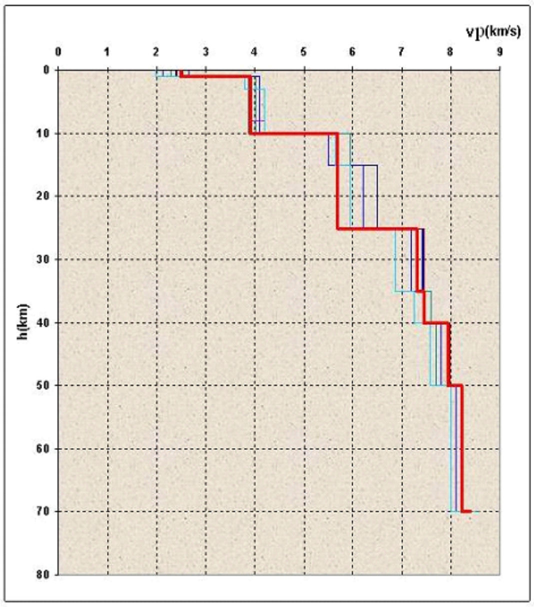
by this trial-and-error process represents the velocity model that most closely reflects the priori information obtained by other studies, e.g. refraction studies, and that leads to a minimum average of RMS values for all earthquakes.

BUILDING A 1D VELOCITY MODEL: DATA SELECTION AND INITIAL MODEL

We performed an analysis to find the best P-wave one-dimensional velocity model for the crystal structure of the study area, using the **VELEST** algorithm [9]. This approach incorporates iterative simultaneous inversion of hypocenters and 1-D velocity model.

The calculation of a minimum 1D model requires a set of well constrained events. Uncertainties in hypocenter locations will introduce instabilities in the inversion process, because of the hypocenter-velocity coupling. The largest azimuthal gap of observations (GAP) and the minimum number of observations per event are very good criteria to reliable and robust earthquake locations [5-8]. This reduces the data set used for the P-wave inversion to a total number of 2650 events.

After 9 iterations, we obtained a variance improvement of about 86%, and a final RMS of 4.2 s. The computed P and S-wave 1D-velocity model is shown in Fig.1 with red lines.



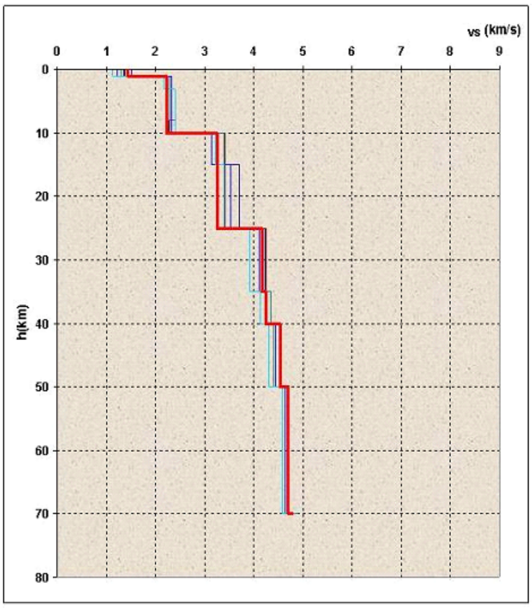


Figure 1. Final 1D velocity models after 9 iterations by Velest program

S-wave phases add important additional constraints on hypocenter locations because partial derivatives of S-wave traveltimes are always larger than those of P waves by a factor equivalent to VP/VS and they act as an important constraint within an epicentral distance of 1.4 focal depths. The use of S waves will in general result in a more accurate hypocentre location, especially regarding focal depth. On the other hand, a large S arrival time errors at a station close to the epicentre can result in a stable solution with a small RMS, but is actually significantly mislocated even for cases with excellent azimuthal station coverage.

A schematic 1D model used to approximate the unknown velocity structure for earthquake location and used as the reference model for 3-D tomographic inversions is shown in Fig.2.

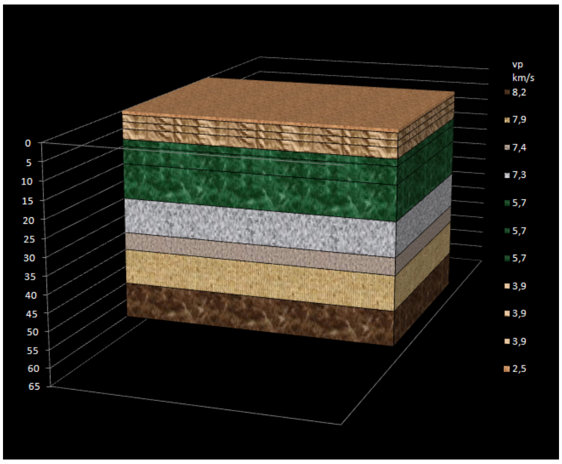


Figure 2. Final schematic 1D velocity model

Discussion

Figures- 3 and- 4 show the final and preliminary locations respectively of 2650 events. Average differences between final and preliminary locations in latitude, longitude, depth and origin time are ±5-10 km, ±5-10 km, 6-11 km and 2 ± 4 s, respectively. The shifting of the hypocentres systematically in one direction, for example focal depth, is a good test for the robustness of a minimum 1-D model. The systematic shift is on the order of ±5-10 km in longitude. This eastward shift is likely due the N–S linear array orientation of the RSSC network. The depth values of final locations indicate that the majority of events occur between 5 and 10 km for the region, while preliminary locations have both more shallow and also deeper events.

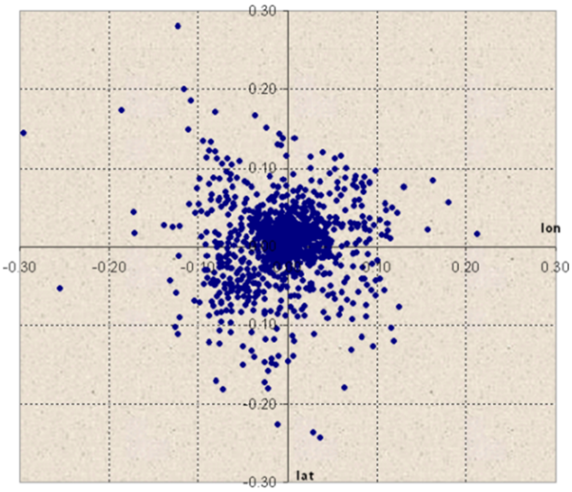


Figure 3. Difference in latitude and longitude between the first location(a) and Velest relocation(b)

After shifting all events to a greater depth by 10 km, two inversions were performed, one with slightly damped and one with strongly overdamped velocities, the results of which are shown in Fig.5, respectively. Since we have solved a coupled hypocentre–velocity problem, the initial bias in the hypocentres may be compensated by adjusting the velocities, or by relocating the events to their original position, or by a combination of these methods.

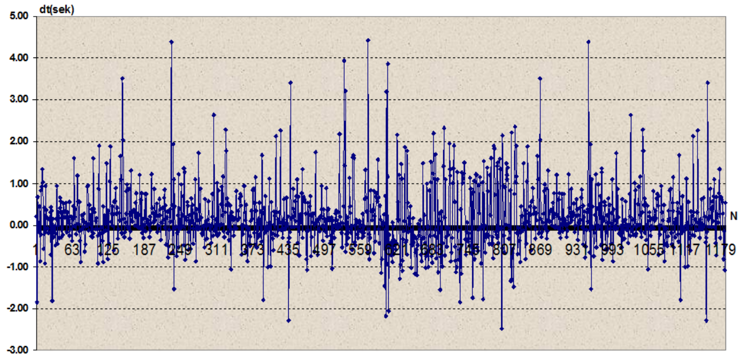


Figure 4. Difference in origin time between the first location(a) and Velest relocation(b)

We note a consistent decrease of RMS values for the relocated earthquakes. Moreover, residuals at the stations within 180 km of the epicenter are greatly reduced. Although hypocentral errors are for some cases larger with the new model, we are satisfied with the relocations, because of the reduction of RMS and the fit of *P*-wave arrivals at close distance from the epicenter.

Conclusions

This paper has focused on the simultaneous determination of the 1-d *P*- and *S*-wave velocity models in the Middle Kura depression, Central Azerbaijan, using the travel time inversion algorithm Velest. We have created a more accurate and stable 1-d *P*- and *S*-wave velocity models which give rise to new locations of aftershocks with minimum errors in RMS values and station corrections for the *P*- and *S*-wave arrival times. It is found that the *P*-wave velocities are quite low (<10 km/s) for the 12 km thick unconsolidated sediments of the Middle Kura depression. The *P*-wave velocity at a depth of 12 km increases to nearly twice that of the upper sedimentary layer. This result is consistent with the *P*-wave velocity model obtained by the results of 3-d seismic tomography given by Gasanov A.G. (1989). The *P*-wave velocity value reaches to 6.3 km/s from 10 to 25 km depth with an increasing gradient a thick layer was defined with a *P*-wave velocity of 7.2 km/s at depth range of 25-45 km [2].

After several tests and trial solutions, 1-D *S*-wave velocitiy model was obtained for the optimum values of *V*P/*V*S ratio. Although, the *V*P/*V*S ratio is very low at shallow depths (<10 km), it gradually decreases in the layers deeper than 10 km. The sudden increase of the *V*P/*V*S ratio at 2 km depth is consistent with a high *P*-wave velocity at that depth.

Several tests on the stability of final velocity model prove that the final 1-D *P*- and *S*-wave velocity models found in this study represent the most acceptable model for future relocation processes in the area. Graphical patterns of RMS residuals, depth, latitude, longitude and depth using the new crustal velocity model confirmed that the event locations have been improved.

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ASSESSMENT OF MODERN GEODYNAMICS OF AZERBAIJAN BY GPS MEASUREMENT DATA

G.J.Yetirmishli[1], I.E. Kazimov[1], A.F.Kazimova[1]

Introduction

From the standpoint of plate tectonics, the existence of any lithospheric plate gives rise to certain geological processes at its borders. The nature of these processes, first of all, depends on the type of interaction with neighboring plates, in other words, on the type of interplate boundary. In turn, the type of interaction between the plates is determined by the directions and velocities of their movements, that is, their kinematics. Over time, the kinematics of lithospheric plates were determined using paleomagnetic, paleoclimatic, geological, geomorphological, seismological research methods that record the effects of plate interactions and their movements. Over the past decades, space geodesy methods have been actively developed, which make it possible to determine the location of objects on the Earth's surface with high accuracy. Changes in the position of such objects in time tell us about their kinematic characteristics. GPS satellite positioning system, at the moment, is the most developed among such systems. It has the necessary resolution for the quantitative assessment of a wide range of geological processes and, including, to identify the processes themselves. The use of satellite geodesy methods made it possible for a new approach to determine the motion parameters of lithospheric plates. Based on the results of GPS measurements, employees of the Massachusetts Institute of Technology built new models of instant kinematics of Mediterranean and Caucasian region plates (Fig. 1 a, b).

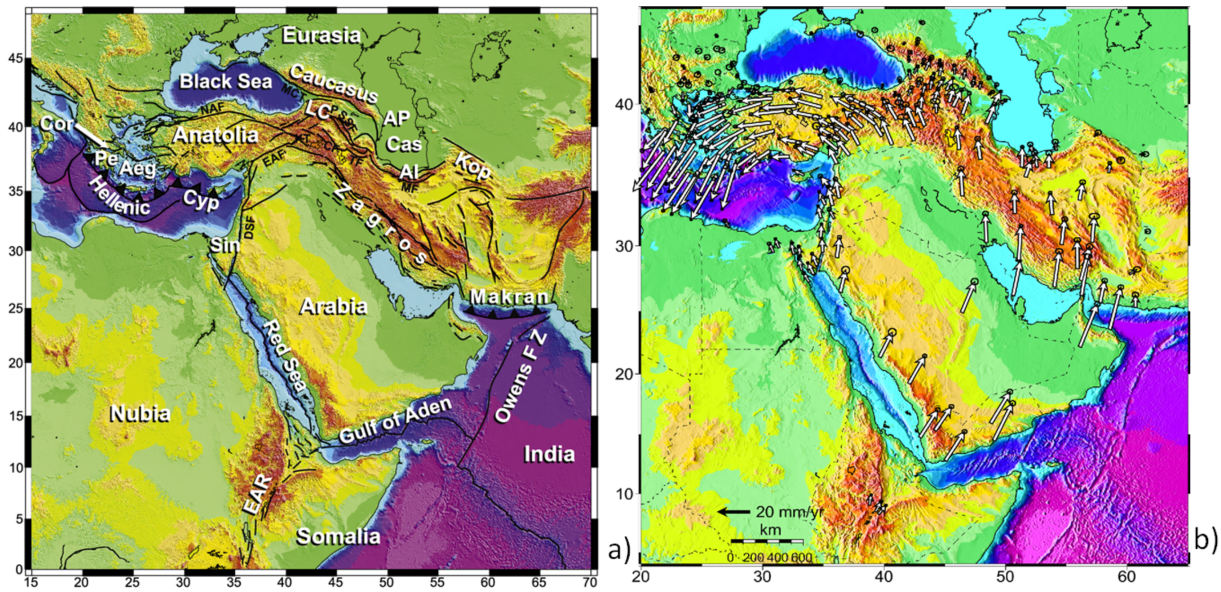

Figure 1a. Simplified topographic/bathymetric (SRTM30 PLUS; http://topex.ucsd.edu/WWW_html/srtm30_plus.html) and tectonic map of the study area, including the zone of interaction of the Nubian, Somalian, Arabian, and Eurasian plates. Abbreviations are North Anatolian fault (NAF), East Anatolian fault (EAF), Dead Sea fault (DSF), Mosha fault (MF), Pembak-Sevan-Sunik fault (PSSF), Tabriz fault (TF), Chalderan fault (CF), Gulf of Corinth (Cor), Peloponnesus (Pe), Aegean (Aeg), Lesser Caucasus (LC), Cyprus trench (Cyp), Karliova Triple junction (KT), Sinai (Sin), Caspian Sea (Cas), Main Caucasus Thrust (MCT), East African rift (EAR), Kopet Dag (Kop), Apsheron Peninsula (AP), Alborz Mountains (Al).[7]
Figure 1b. Map showing decimated GPS velocities relative to Eurasia determined in this study. For clarity, we plot 1s velocity uncertainties (see Table S1 for a complete tabulation of the velocities determined in this study). [7]

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

As you know, Azerbaijan is part of the Alpine-Himalayan mountain belt, formed in the Cenozoic on the southern edge of the East European platform as a result of a collision between the Eurasian and Arabian plates, which over the past five million years has experienced a rapid rise. The advance of the Arabian (also called Arab) plate to the north is partially offset by the displacement of the Anatolian block to the west. The tectonics of this vast region are mainly determined by the collision of the Arabian and African plates with the Eurasian plate. Models based on the global analysis of data on the movement of various plates show that, relative to the Eurasian plate, the Arabian plate moves in the north-north-west direction at a speed of about 18-25 mm / year (averaged over the past 3 million years). The African plate moves north with a lower speed of 10 mm / year, which causes a left-side shift along the zone of the Dead Sea faults. The advancement of the Arabian Plate to the north is also responsible for the formation of the Zagros mountain structure, the formation of the high plateaus of Eastern Turkey and the growth of the mountain structures of the Lesser and Greater Caucasus [3, 7].

The aim of our research was to calculate the velocities of modern horizontal displacements of individual tectonic blocks throughout the republic and to analyze their influence on strong earthquakes that occurred in 2017 and 2018.

Methods of studying horizontal modern movements of the surface of the Earth's crust

The study of modern movements and deformations occurring in the massif requires the monitoring mode of high-precision geodetic measurements of the displacements of the benchmarks of specially equipped observation stations - geodynamic ranges [1].

In the past few years, in our Center (RSSC), along with traditional geodetic observations, methods of satellite geodesy have been used. The combination of traditional ground-based and satellite measurements allows us to quite successfully solve the tasks. Due to its high performance, satellite technologies made it possible to obtain information on deformations of the Earth's surface at bases from a few meters to several tens of kilometers with high frequency, which was difficult using traditional measurement methods and, very important, to ensure the safety and efficiency of mining. To carry out satellite geodetic measurements, 24 GPS-receivers of the geodetic class from Trimble were used [2,4].

Thus, in the study of geodynamic processes using GPS technologies, two spatio-temporal modes are mainly used for a one-time redefinition of the initial coordinates of points of geodetic networks, and displacements of the reference values of deformations [5].

The data obtained as a result of experimental work on the current stress-strain state of the Earth's crust and the patterns of its change in time, on the one hand, provide new fundamental knowledge about the nature of the natural deformation processes that occur in the upper part of the Earth's crust and the effect on the formation of a stress state.

Azerbaijan's geodynamics assessment based on GPS measurements for 2017-2018 years

In recent years, Azerbaijan has been characterized by active seismic activity, in which the accumulated tension in the collision zone is released. In general, the seismic activity of the territory of the republic in 2017 varies in the range of 0.2-0.6. As in previous years, the maximum values were noted in the Gabala, Shabran and Shamakhi-Ismayilli districts (A = 1.0-2.0). However, it should be noted that the seismic activity of the Kura Depression in the Saatli and Agdam regions has increased. On May 11 at 07:24:19 in the Saatli region there was an earthquake with a magnitude of 5.3 and felt up to 4-3 points. On November 15, local time, 23:48:02 in the region of Agdam, an earthquake occurred with ml = 5.7 felt up to 6 points. The area of constant released tension, where in the absence of strong earthquakes many weak ones occur - the Talysh region, as in previous years, is characterized by maximum seismic activity (A = 1.6-2.0) [8].

In 2018, 16 tangible earthquakes with Ml = 3.2–5.5 occurred in the study area. Two significant earthquakes with Ml> 5.0 were recorded, which were felt at the epicenter with intensities of 5 and 6 points. Increased seismicity was observed in the Talysh mountain region, where there were 6 tangible earthquakes with Ml = 3.4 - 5.0, which were felt at the epicenter with an intensity of 3 to 5.5 points.

Based on said above, we analyzed the data of GPS stations for 2017-2018 years. The velocity estimates are based on the analysis of the time series of GPS station coordinates calculated from the primary data, which are sets of phase and code measurements at two frequencies lasting 24 hours with a recording interval of 15 s.

Thus, horizontal speed maps were constructed according to the data of the geodetic network of GPS stations in Azerbaijan for 2017 and 2018 years. (Fig. 2,3). As the analysis of the velocity distribution shows, the average values of the velocities of horizontal displacements of points to the north and east are not constant, and the processes of shortening the surface of the Earth's crust in the study region are also not constant. In addition, strong tangible earthquakes that occurred during these periods were plotted on the map. As can be seen in the Figure 2, the maximum values of the horizontal movements of individual blocks are characterized by increased seismic activity.

Detected increase in velocity in 2017-2018 years at Lerik, Lankaran, Jalilabad, Agdam and Saatli stations (Fig. 4), compared with other years, is the most significant feature of the velocity field in the study region. On the comparative velocity chart between 2017 and 2018 years (Fig. 4) a direct proportional dependence is observed. In addition, over the course of these two years, the speed value at Gusar station has noticeably decreased.

In conclusion, it should be noted that the use of modern methods of traditional and satellite geodesy for observing the process of movement of the Earth's surface allows us to conduct research at a qualitatively higher level. The results of the studies, as well as the GPS measurement data, can be used to determine the kinematics of lithospheric plates, identify and clarify their boundaries, in the zone of influence of which are located sources of strongest earthquakes, to highlight the main fault systems and the most seismically dangerous zones, to track the progress of the change of stress-strain state of the environment and the accumulation of elastic deformations in the zones of such faults.

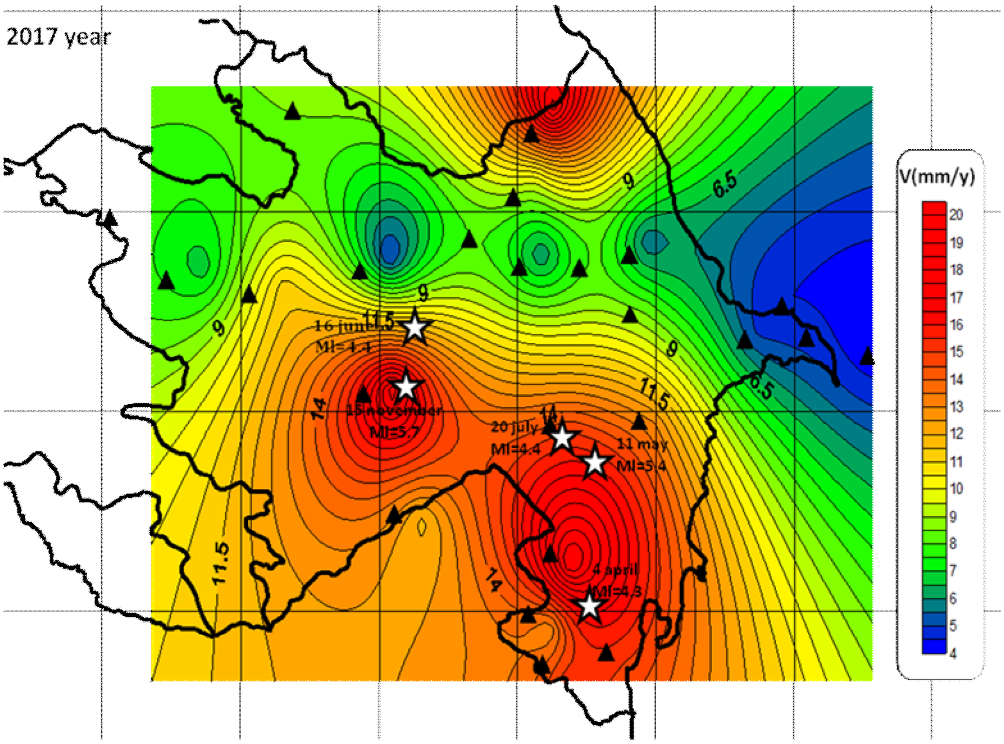

Figure 2. Velocities of horizontal movements of the Earth's crust surface according to the data of the geodetic network of GPS stations in Azerbaijan in 2017

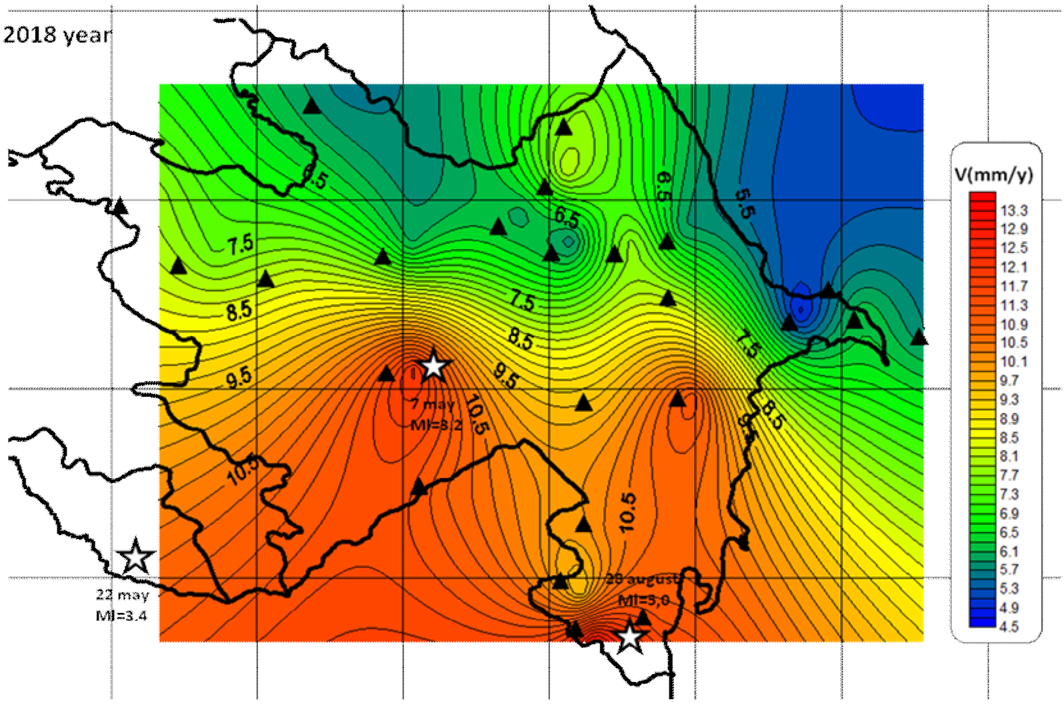

Figure 3. Velocities of horizontal movements of the Earth's crust surface according to the data of the geodetic network of GPS stations of Azerbaijan for 2018

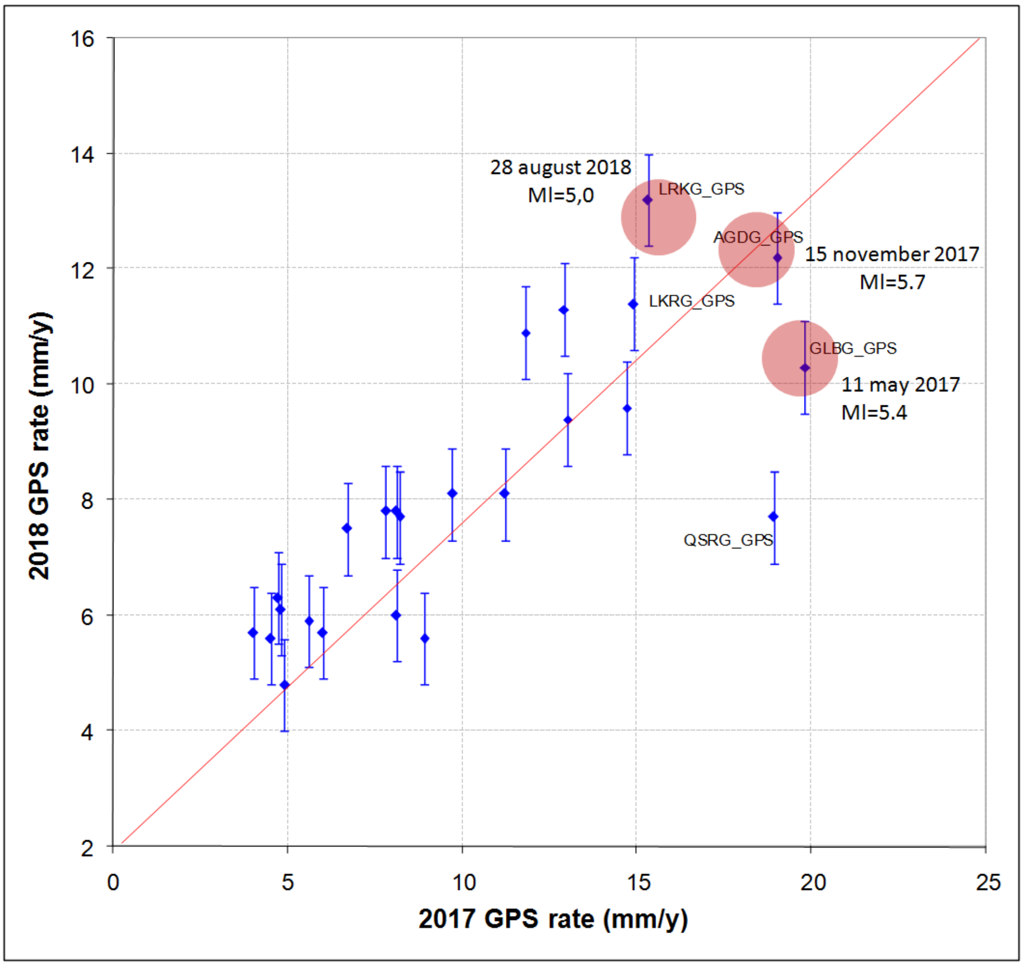

Figure 4. Comparative graph of the velocities of horizontal movements of the surface of the Earth's crust for the period 2017 – 2018 years

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FOCAL PARAMETERS OF THE OGUZ EARTHQUAKE SEPTEMBER 4, 2015 with ml = 5.9

S.E. Kazimova[1], S.S. Ismayilova.[1]

Studying the conditions for the formation of the earthquake source is of great importance for understanding the essence of seismic phenomena and developing methods for predicting seismic hazard. In this case, the main parameters of the study are seismic waves. At the present stage, a dense network of highly sensitive digital seismic stations, which allows recording all seismic events with a magnitude of ml> 0.1 within Azerbaijan, as well as extensive factual materials obtained from this network, have made it possible to develop many new methodological issues and outline new ways of predicting earthquakes. The purpose of this article was to determine the dynamic parameters of the source of a strong Oguz earthquake, as well as the solution of its mechanism.

On September 4, 2015, an earthquake with an observed intensity at the epicenter of I_0 = 7 points and I_0 = 7-3 points in nearby areas occurred near Oguz district. In accordance with the map of epicenters of seismic events for 1900-2003 in the region of the earthquake that occurred, a number of strong earthquakes were noted, with intensity at the epicenter of 6 or more points (Fig.1). The most significant of them are the earthquakes of 1953, 1968 with I_0 = 6-7 points, 1980, 1986, 1991 with I_0 = 5-6 points, March 5, 2000 I_0 = 5 points. The last tangible seismic event in this area was an earthquake on June 1, 2003 with I_0 = 6 points in the epicenter and 3-4 points in the regions of Mingachevir and Kurdamir (table 1) [1, 2].

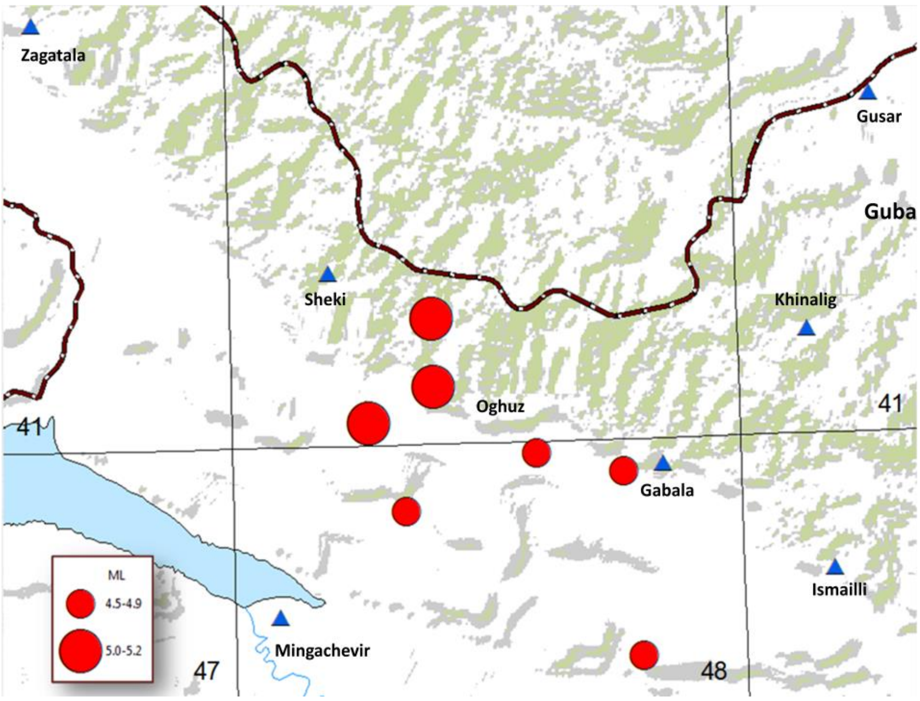

Figure 1. Map of the epicenters of strong earthquakes in the study area for the period 1900-2003.

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

Table 1. Strong earthquakes in Oguz and surrounding areas with an intensity at the epicenter of 5 or more points [1]

Date			Time			Coordinates		Depth	MI	Io points
year	month	day	hour	min	sec	northern latitude degrees	eastern longitude degrees	km		
1953	9	2	00	36	01	41.10	47.40	5	5.1	7
1953	9	16	11	15	29	41.20	47.40	28	5.0	6
1968	5	11	11	29	40	41.00	47.60	15	4.7	6
1980	4	1	07	33	41	40.70	47.80	20	4.7	6
1986	6	02	15	16	13	40.97	47.77	22	4.6	5
1991	10	21	11	58	23	40.92	47.34	16	4.5	5
2003	06	01	06	09	42	41.05	47.27	22	5.0	6

Instrumental data

Seismic vibrations from the September 4, 2015 earthquake were recorded by 18 world agencies and nearly 400 seismic stations in a wide azimuthal environment at distances from 300 to 13,407 km from the epicenter. The main parameters of the earthquake obtained by the Republican Seismic Survey Center of Azerbaijan are represented in Table 1. Based on macroseismic studies, it was revealed that the earthquake was felt most intensely in the Oguz and Sheki regions. Here, the intensity of the earthquake according to MSK-64 scale was estimated at 7 points. The earthquake was accompanied by more than 80 aftershocks with magnitudes from 0.5 to 4, 33 of which occurred on the first day [3,4]. The aftershock cloud spread up to 23 km in the direction of the south-west and 9 km in the direction of the west-east, however, the area of the main mass of the earthquake accumulation was 88 km^2. Despite the fact that the main source is located at a depth of 16 km in the granite layer, the depth of aftershocks varies between 11-34 km. As seen in Fig.2 the earthquake epicenter is confined to the zone of intersection of the longitudinal Dashgil-Mudrese and transverse Arpa-Samur faults [5]. It should be noted that the Arpa-Samur deep fault of the ancient formation at all times from the Paleozoic to the present day is a zone of active manifestation of tectonic movements, a conductor of magmatic melts, ore-bearing solutions and seismicity. According to Shikhalibeyli E.Sh. [6] the Arpa-Samur trans-Caucasian seismic-metal-bearing fault zone combines the Mrovdag-Zodsky, Terter and Khachinsky deep faults.

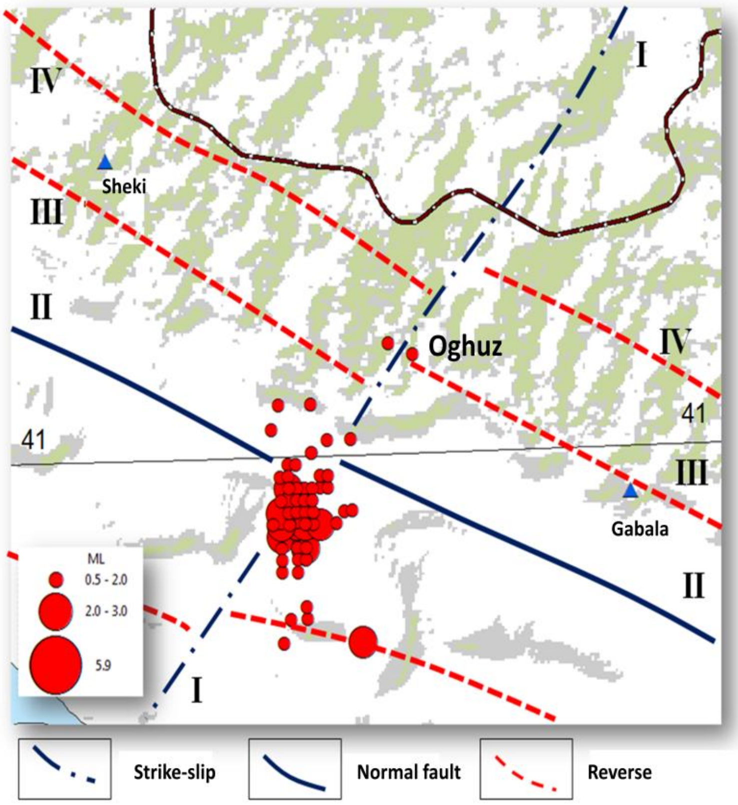

Figure 2. Aftershock field of the strong Oguz earthquake on September 4, 2015 with ml = 5.9
Faults: I - Arpa-Samur, II - North Adzhinour, III - Vandam, IV - Dashgil-Mudrese [4]

The solution of the source mechanism

The focal mechanism solution was obtained by the method of waveform inversion - Time-Domain Moment Tensor INVerseCode (TDMT INVC), developed by Doug Draeger from the University of California, Berkeley [7]. This package is used to calculate both the seismic moment tensor and Mw. In this method, the seismic moment tensor is determined on the basis of the inversion of the low-frequency part of the broadband 3-component waveform and then decomposed into the scalar seismic moment Mo and the orientation parameters of the strike, slip and rake forces. The moment magnitude Mw of interest to us is determined from the scalar seismic moment according to Kanamori [8]:

$$Mw = [\log 10 (Mo) - 16.1] / 1.5$$

The main source of RSSC ANAS seismograms. There is also information about the hypocenter and time at the source of the earthquake. Seismograms are downloaded in SEED format and converted to SAC format (Fig. 3). Broadband seismograms are selected subject to a distance limit (50-350 km). They should have a sufficient duration (the interval from P-waves to the initial part of S-waves is included) and quality (sufficiently high signal-to-noise ratio, lack of clipping). Preparation of seismograms for inversion includes: removal of the entry of the P-wave; deconvolution (restoration of true soil displacements); determination of epicenter distance, direct and reverse azimuths; calculation of radial and transverse components; filtering. Deconvolution takes place in the time domain [8]. For bandpass filtering, a 4-order Butterworth filter is used. If necessary, decimation is carried out in order to make the sampling frequency equal to 1 count per second. That is, lead to the same time step that the influence functions have: 1 second. In addition, the time interval that is used to solve the problem is determined.

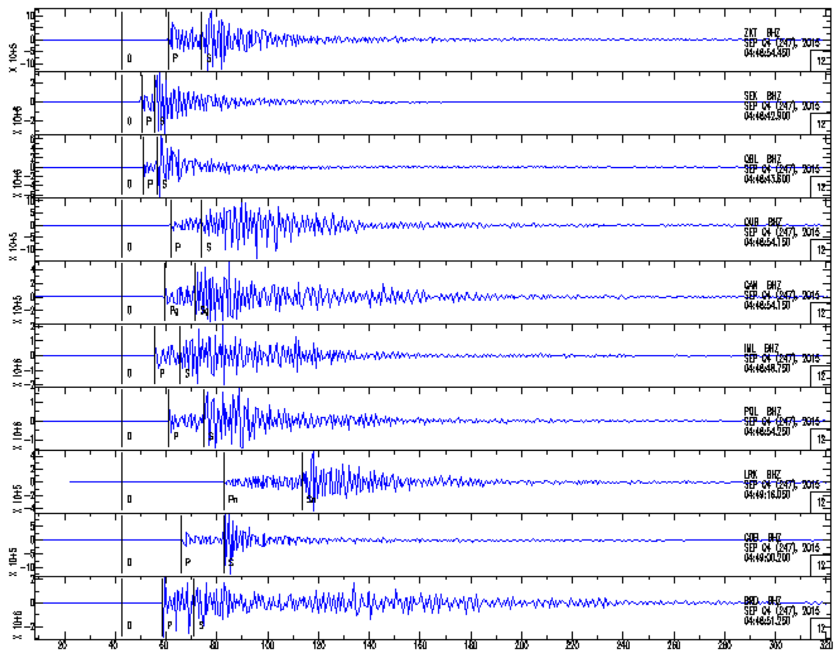

Figure 3. Wave recording of the Oguz earthquake in SAC format

Thus, the mechanisms of two earthquakes were constructed and analyzed: September 4, 2015 with ml = 5.9 (main shock) and October 13, 2015 with ml = 4.0. An analysis of the mechanisms of the sources of these earthquakes showed the predominance of two types of movements. The earthquakes that occurred in the Oguz region on September 4 at $04^h\ 49^m$ and October 13 at $00^h\ 13^m$ occurred under the action of tensile and compressive stresses of similar magnitude. Table 2 shows that the first nodal plane of the gap extends in the SE direction (153º) with a fall to the south-west at an angle of 86-90º, the second nodal plane has a NE strike (63º) with a fall to the south-east at an angle of 83-90º. In this case, the compressive stresses in the earthquake source were oriented in the north-east direction (azimuth 18) and acted near horizontally (angle with the horizon 0-7), and tensile forces were directed in the west-south-west direction (287-288) at an angle of 0-2 to the horizon. The type of movement of these earthquakes is a shift with a left-side horizontal component.

Table 2. Parameters of the mechanisms of the Oguz earthquake's sources in 2016 with ml = 5.9-4.0

№	Date, dmy	t_0, h min sec	h, km	Magnitudes			Axis of principal stress						Nodal planes					
							T		N		P		NP1			NP2		
				ml	mb	mw	PL	AZM	PL	AZM	PL	AZM	STK	DP	SLIP	STK	DP	SLIP
1	20150904	04:49:36	16	5.9	5.4	5.5	0	288	90	171	0	18	153	90	-180	63	90	0
2	20151013	00:13:31	16	4.0	-	-	2	287	82	180	7	18	153	86	-172	63	83	-4

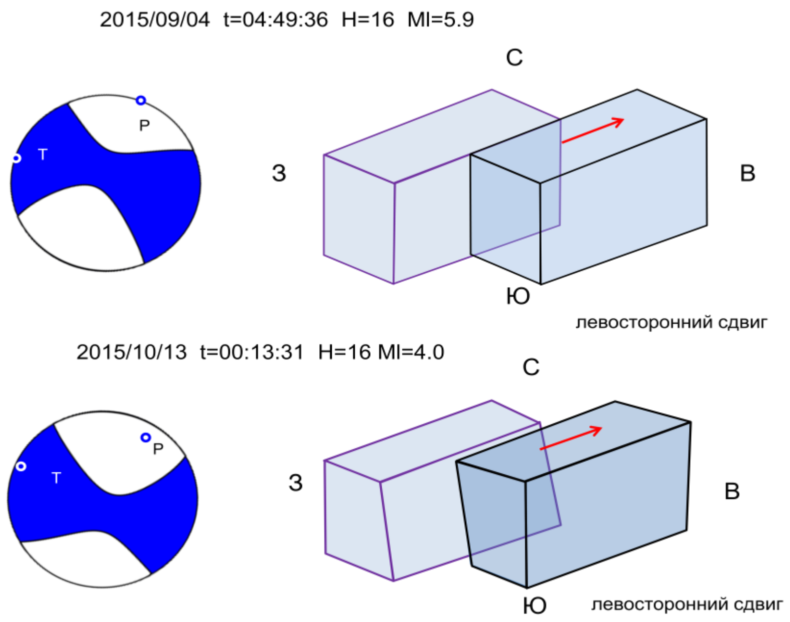

Figure 4. Earthquake source mechanisms, as well as block diagrams of displacement along the NP2 plane

The epicenters of the Oguz earthquakes are confined to the Arpa-Samur fault and can be interpreted as left-side shift deformation in the zone of geodynamic influence of the left-sided Arpa-Samur fault. Figure 4 shows the stereograms of the mechanisms of the sources of the two analyzed earthquakes, as well as the block diagram of the displacement along the NP2 plane corresponding to the specified fault. Figure 5 shows how aftershocks migrate north-eastward along the transverse fault, deepening to a depth of 35 km. It should be noted that the analysis of the mechanisms of the other two aftershocks (2015.09.04 with ml = 3.3 and 2015.09.29 with ml = 3.3) showed the fault type of underthrusts, which is associated with the influence of the North Adzhinour strike longitudinal fault.

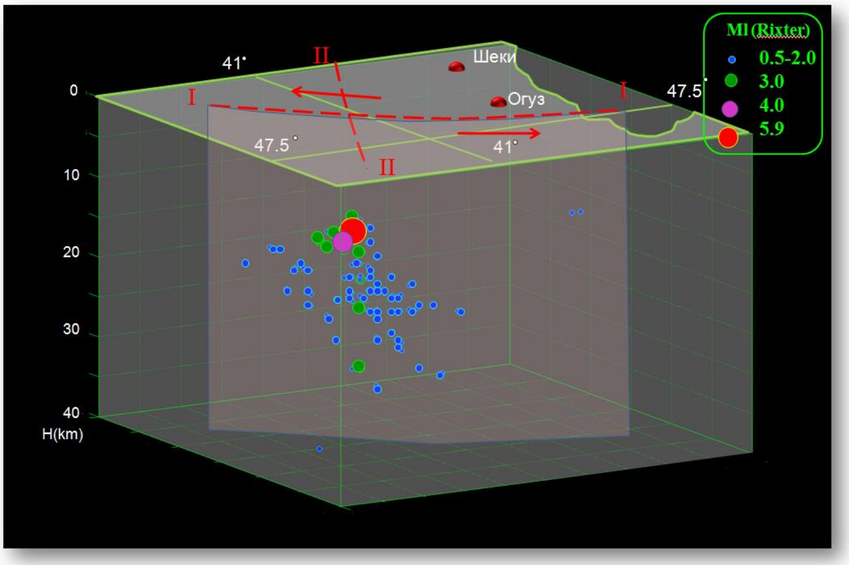

Figure 5. Three-dimensional model of the aftershock field of the Oguz earthquake on September 4, 2015 with ml = 5.9 Faults: I - Arpa-Samur, II - North-Adzhinour

It was said above that the earthquake data were recorded by 18 world agencies. A comparative analysis of the results of solutions of the focal mechanism in different regions was carried out. It was found that the solution of the seismic moment tensor of the centroid USGS and GFZ is close to the solution obtained from the RSSC seismic station network (Fig. 6).

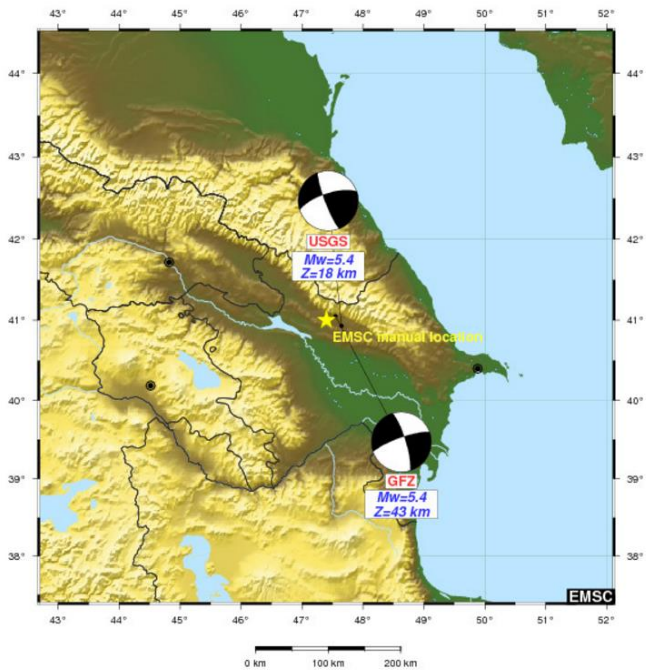

Figure 6. Focal mechanisms of Oguz earthquakes according to USGS and GFZ

Dynamic parameters.

Using the digital seismograms of the transverse waves of earthquakes, the Fourier amplitude spectra were constructed, which made it possible to determine the maximum level of the spectrum and the boundary upper frequency of the maximum level f_0. In the calculations, the classical model of D.Brun [9] was used. To determine the dynamic parameters of the earthquake sources, only S-wave recordings were used at 8 digital stations: Zagatala, Khinalig, Siyazan, Sheki, Saatly, Guba, Gusar and Pirkuli (Fig.7). To determine the parameters of the spectrum, it is approximated by two straight lines - a straight line parallel to the frequency axis (horizontal strike), in the low-frequency region and an inclined straight line in the high-frequency region. The interval of epicenter distances for the stations under consideration turned out to be Δ = 30-200 km.

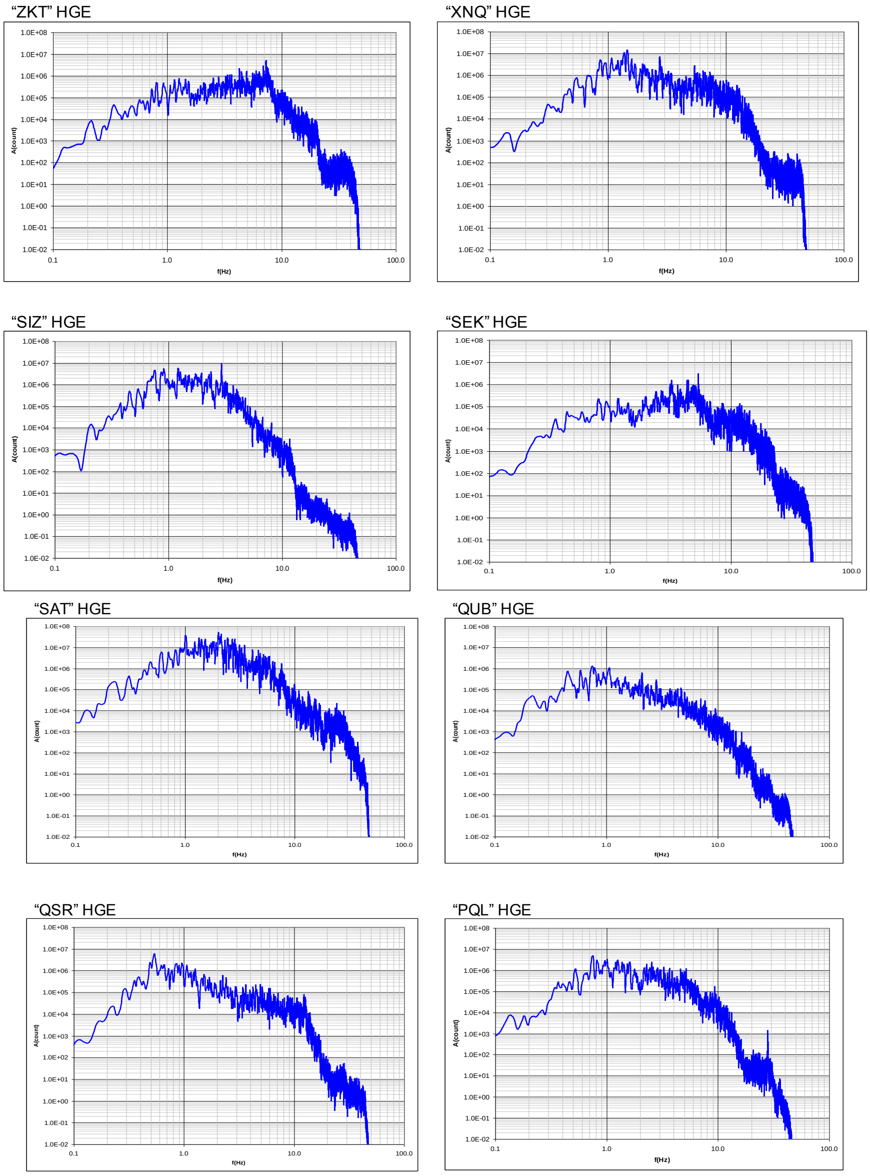

Figure 7. Amplitude spectra of the Oguz earthquake on September 4, 2015

The following spectral characteristics were determined: the angular frequency f_0, the radius of the circular dislocation r_0, the discharged tension $\Delta\sigma$, the source volume V, the average displacement along the discontinuity D. Table 3 also presents the values of the moment magnitude Mw and seismic moment M_0 calculated earlier using the tensor method seismic moment based on the inversion of the low-frequency part of the broadband 3-component waveform [7].

The values of the released tension appear to be underestimated. This is due to the fact that the radius of a circular dislocation can vary from station to station, depending on the position relative to the discontinuity plane and the direction of movement in the focus. This analysis showed the possibility of estimating dynamic parameters from observations of one station in a wide frequency range. Thus, the focal parameters of the Oguz earthquake are as follows: angular frequency f_0 = 1.0 Hz, seismic moment $M_0 = 2.6 * 10^{24}$, dyn · cm, circular dislocation radius r_0 = 1.4 km, released tension $\Delta\sigma$ = 44 dyn/cm^2, source volume V = 12 km^3, average displacement along the fault $D = 1.03 * 10^{-2}$ m.

Table 3. Dynamic parameters of the Oguz earthquake of September 4, 2016 with ml = 5.9

№	Ω_0, cm·c^2	F_0, Hz	M_0,10^{24}, dyn-cm	M_w	R_0, km	$\Delta\sigma$, dyn/cm^2	D,10^{-2}, m	V, km^3
1	2	3	4	5	6	7	8	9
1	ZKT	1.1	2.6	5.5	1.25	55.81	1.23	8.2
2	XNQ	1.0	2.6	5.5	1.38	41.93	1.02	11.0
3	SIZ	1.0	2.6	5.5	1.38	41.93	1.02	11.0
4	SEK	1.2	2.6	5.5	1.15	72.46	1.47	6.4
5	SAT	0.9	2.6	5.5	1.53	30.57	0.83	15.0
6	QUB	0.8	2.6	5.5	1.72	21.47	0.65	21.4
7	QSR	0.9	2.6	5.5	1.53	30.57	0.83	15.0
8	PQL	1.1	2.6	5.5	1.25	55.81	1.23	8.2
Average value		1.0	2.6	5.5	1.4	44	1.03	12

It is known that the nature of the movements recorded on the seismogram is determined both by the medium along the seismic wave propagation path and by the source, a comprehensive analysis of the record is required, which would allow obtaining additional information about the earthquake source, and better understand the source mechanism [10].

An important point in the calculation of dynamic parameters is the transition from the station spectrum to the focal spectrum. For such a transition, it is necessary to take into account the influence of the medium (“attenuation”) and the amplification factor on the path of the seismic beam. There are various methods for determining station corrections, which are described in works [11–13]. The purpose of the research is the calculation of station corrections (determination of the site effect of the station) based on the analysis of the seismic signal using the Nakamura method [14].

Calculation methodology

As is known, displacements of the earth's crust are measured in three directions: north-south (NS), east-west (EW) and vertically (Z). Nakamura's method is to find the ratio of the spectrum of the horizontal component (H) to the spectrum of the vertical (V). For this, it is necessary to use measurements of the 3 components of the E, N, Z seismogram [14]. The calculation of the component H occurs as the quadratic mean of the spectra of the E and N components, vertical V corresponds to the spectrum of the component Z. Next, the H / V ratio is directly calculated:

$$H(f) = \frac{\sqrt{N^2(f) + E^2(f)}}{2} \qquad (1)$$

$$H/V(f) = \frac{H(f)}{V(f)} \qquad (2)$$

Thus, we analyzed the data of digital records of the transverse wave for the three components HGE, HGN, HGZ of 21 stations of the main shock. In the study, the duration of the recording time window was 60 seconds.

A linear trend is eliminated from the selected recording section and, to prevent spectrum leakage, the signal is smoothed at the ends using a 5% cosine window. Corrections for the measurement error of the instrument are applied to the resulting series and the spectrum is calculated using the Fourier transform [12].

Thus, the spectral ratios were calculated and the amplification factor of 21 broadband digital earthquake stations that occurred on September 4, 2015 in the Oguz region with a magnitude of 5.9 was found (Fig. 8, 9, 10). We divided the result into three classes: stations for which the maximum values of the extension factor fluctuate in the frequency range 0.2-1.0 Hz (stations "ALI", "GBS", "GLB", "LKR", "PQL", "QBL", “QSR”, “XNQ”, “ZKT”,), stations for which the maximum values of the extension factor fluctuate in the frequency range 1.0-4.0 Hz (stations “ATG”, “HYR”, “IML” “MNG”, “QUB” , “SIZ”), and in the range 3.0–7.0 Hz (stations AST, GAN, LRK, ORB, SEK, BRD).

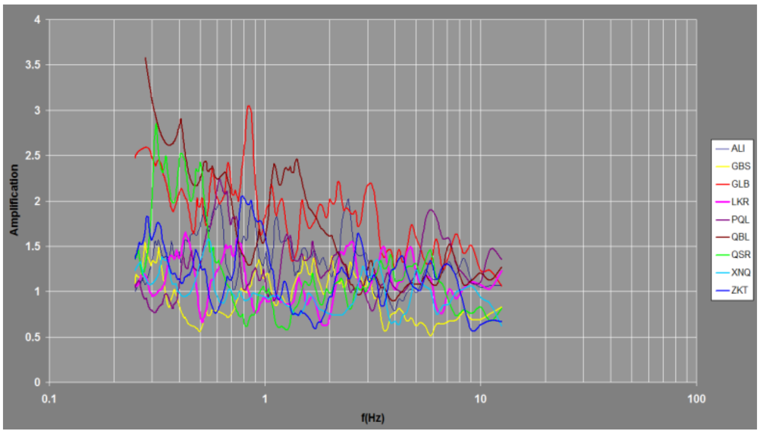

Figure 8. The seismic wave amplification factor at the stations “ALI”, “GBS”, “GLB”, “LKR”, “PQL”, “QBL”, “QSR”, “XNQ”, “ZKT”.

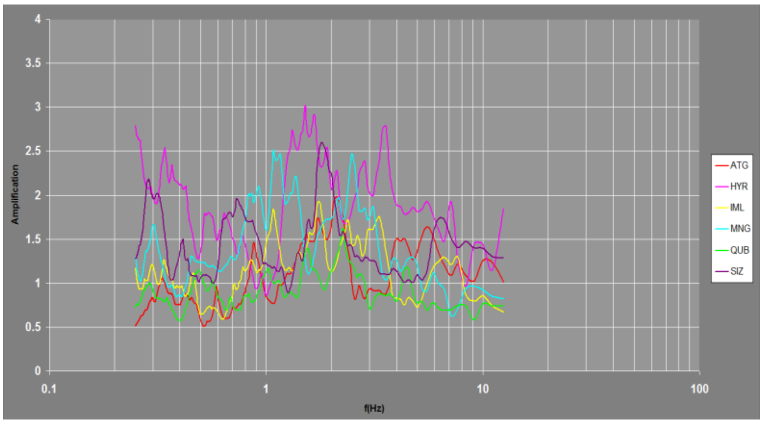

Figure 9. Seismic wave amplification factor at “ATG”, “HYR”, “IML”, “MNG”, “QUB”, “SIZ” stations

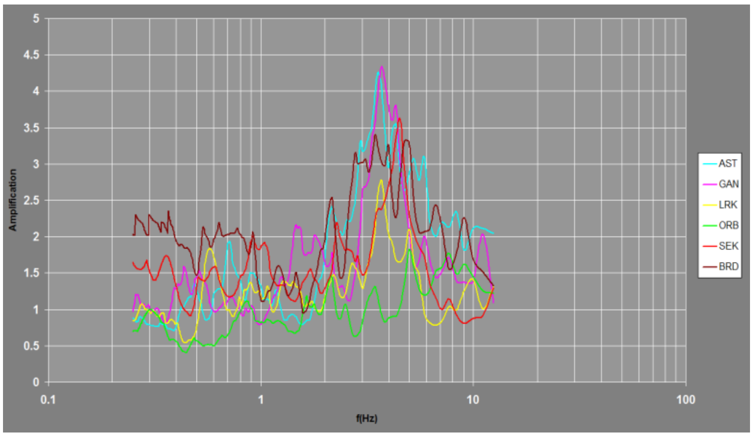

Figure 10. Seismic wave amplification factor at the stations “AST”, “GAN”, “LRK”, “ORB”, “SEK”, “BRD”

This method is based on the notion that the influence of a thin layer (a small layer of the earth’s crust immediately below the seismic station) of the object under study mainly refers to transverse waves (S-wave), which are amplified by this structure and practically do not change longitudinal waves (P -wave). Then the ratio of the spectral characteristics of two horizontal components to the spectrum of the vertical component will characterize the so-called transfer function, which strictly depends on the thin layer under the study object [12]. It was found that the maximum extension factor is characteristic for the stations “QBL” = 3.6, “AST” = 4.3, “GAN” = 4.3, “SEK” = 3.6, “BRD” = 3.4.

Conclusions

Thus, despite the fact that the main source of the Oguz earthquake that occurred on September 4, 2015, 04^h 49^m with ml = 5.9, was located at a depth of 16 km in the granite layer, the depth of aftershocks varies between 11-34 km. The aftershock cloud spread up to 23 km in the direction of the SW and 9 km in the direction of the WE, the area of the main earthquake accumulation was 88 km^2.

Based on the solution of the source mechanism, it was found by the method of inversion of wave forms that the earthquakes that occurred in the Oguz region on September 4 at 04^h 49^m and October 13 at 00^h 13^m occurred under the action of tensile and compressive stresses of similar magnitude. In this case, the compressive stresses in the earthquake source were oriented in the north-east direction (azimuth 18) and acted horizontally (angle with the horizon 0-7), and tensile forces were directed in the west-south-west direction (287-288) at an angle of 0-2 to the horizon. The type of movement of these earthquakes is a shift with a left-side horizontal component. An analysis of the mechanisms of the other two aftershocks (2015.09.04 with ml = 3.3 and 2015.09.29 with ml = 3.3) showed the fault type of movements. Earthquakes are confined to the zone of intersection of the longitudinal Dashgil-Mudrese and transverse Arpa-Samur faults, which are the zone of active manifestation of tectonic movements to this day.

Using the digital seismograms of the transverse waves of earthquakes, the Fourier amplitude spectra were constructed, which made it possible to determine the maximum level of the spectrum and the boundary upper frequency of the maximum level f_0. The focal parameters of the Oguz earthquake are as follows: angular frequency f_0 = 1.0 Hz, seismic moment M_0 = 2.6 * 1024, dyn ин cm, circular dislocation radius r_0 = 1.4 km, released tension $\Delta\sigma$ = 44 dyn / cm^2, source volume V = 12 km^3, average displacement shift D = 1.03 * 10^{-2} m. Based on the said above, the spectral ratios were calculated and the gain factor of 21 broadband digital stations was found. It was found that the maximum extension factor is characteristic for the stations “QBL” = 3.6, “AST” = 4.3, “GAN” = 4.3, “SEK” = 3.6, “BRD” = 3.4.

Summing up, it should be noted that further detailed and comprehensive study of the buried Arpa-Samur trans-Caucasian seismically active seismic-metal-bearing fault zone of deep faults, which has been active for a long time and sharply influenced the structure of the East Caucasus, can provide ample material for understanding geodynamic processes in this part of Mediterranean belt in the alpine cycle.

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COMPARATIVE ANALYSIS OF GRAVIMETRIC STUDIES IN BOZDAG-GOBU MUD VOLCANO AND SURROUNDING AREAS

E. M. Baghırov[1], A. T. İsmayılova[1]

Carrying out frequent measurements of non-tidal variations of relative gravity force according to relief in the area for construction of electric station in the Bozdagh-Gobu volcano and adjacent areas have been implemented by the use of the GC-5 Autograv device (Fig.1) according to 17 profiles, which include120 observation points. The geological structure of the site, the location of the tectonic faults, dimensions of the mass which may be dynamics of activity, depth of the faults and contours of probable potential hazard zones are determined based on the information obtained during the selection of gravimetric profiles. Additional frequent measurements have been carried out with gravimetry method absolutely in the10 profiles that length up to 3 km from the main construction site to volcanoes and in the volcano area in 3 and 5 profiles, in addition to covering the ES and the substation area which to be built. The distance between the project profiles and observation points are 100 meter and the researches have been done at each point taking 4 dimension value one in 60 seconds. The measurements are repeated with the condition of return to the back/support point after the accomplishment of the measurements for the each profile.

Figure 1. The view of the CG-5 AutoGrav gravimetry produced by Canada which the research works carrying out

Gravimetric researches have been conducted in the Bozdagh-Gobu volcano and adjacent areas on the designed profiles (Fig. 2.) and these researches have been implemented on the observation of the emergency differences in the gravitational acceleration between the two points. This method allows to improve the accuracy of the measurements and it is one of the leading methods for detecting depth fault, gradient zones, displacement, deformation of the gravity force in the inner structure of the earth. This enables us to evaluate the geological processes in the deeper layers of the crust in the research area and it provides to analyze complexly the direct relationship between geological processes and seismic activity.

The main purpose of the research is to study the fault-block structure of the Earth's crust due to non-tidal variations in the gravitational field for the construction works near the Bozdagh-Gobu volcano and is the assesment of geodynamic condition during the formation of structures involving a complex geophysical data in that area.

Observable values about the variation character according to time of the gravity force among the observation points have been processed considering all of the adjustments.The following results of the relative gravity force, the obtained results according to the all research field have been described visually in the form of A map, three-dimensional model and transects (Fig.3-7).

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Zones monitored with Δg, profiles, observation points and the risk areas for have been clearly covered by the isoanomal maps of the gravitational field construction (Fig. 3,8,9,10). Now, let's try to analyze the isoanomal maps of the gravitational field.

As shown in the isoanomal map (3. map) of the gravitational field, the anomalous zones have been observed with the variable characteristic of the relative gravity force values have been precisely covered. Composition of the rocks in the research field have been sharply differentiated by their density. This is due to the fact that it has been covered by sand, clay sand,volcanic breccia of mud volcano and etc.. The differentiation of such density take mosaic shaping of gravity force propagation forward. However, a regularity is recorded in the map. Thus, the relative gravity force (density of rocks) increases from the western part of the research areas to the eastern part from 11.5 mQal to 2.5 mQal.

Most porous rocks are in the western part of the field. It is clear that, the area which we are investigate is not stable from the point of geology.Basically, there are anomalous zones and sediment in the probable lower layer in the center of profiles III, IV, V.

Accordingly, 3D model of gravitational field (Fig. 4), transects on profiles according to isoanomal maps (Fig.5),diagram (Fig.6) and graphs (Fig.7) have been created. It is clear that form the transects on profiles, model diagram and graphs.

Gravimetric researches have been carried out in the area over the salt lake, up to the volcano in ≈ 3 km distance on 3 profiles (Fig.8) and on 5 profiles (Fig. 9) on the volcano crater considering the importance and expedient of studying the impact of the Bozdagh-Gobu volcano located in the north-eastern part of "Gobu" substation area with 330/220/110 kV and

Gobu Electric Station with 385 MVt will be built in "Gobu" area after studying the main research field.

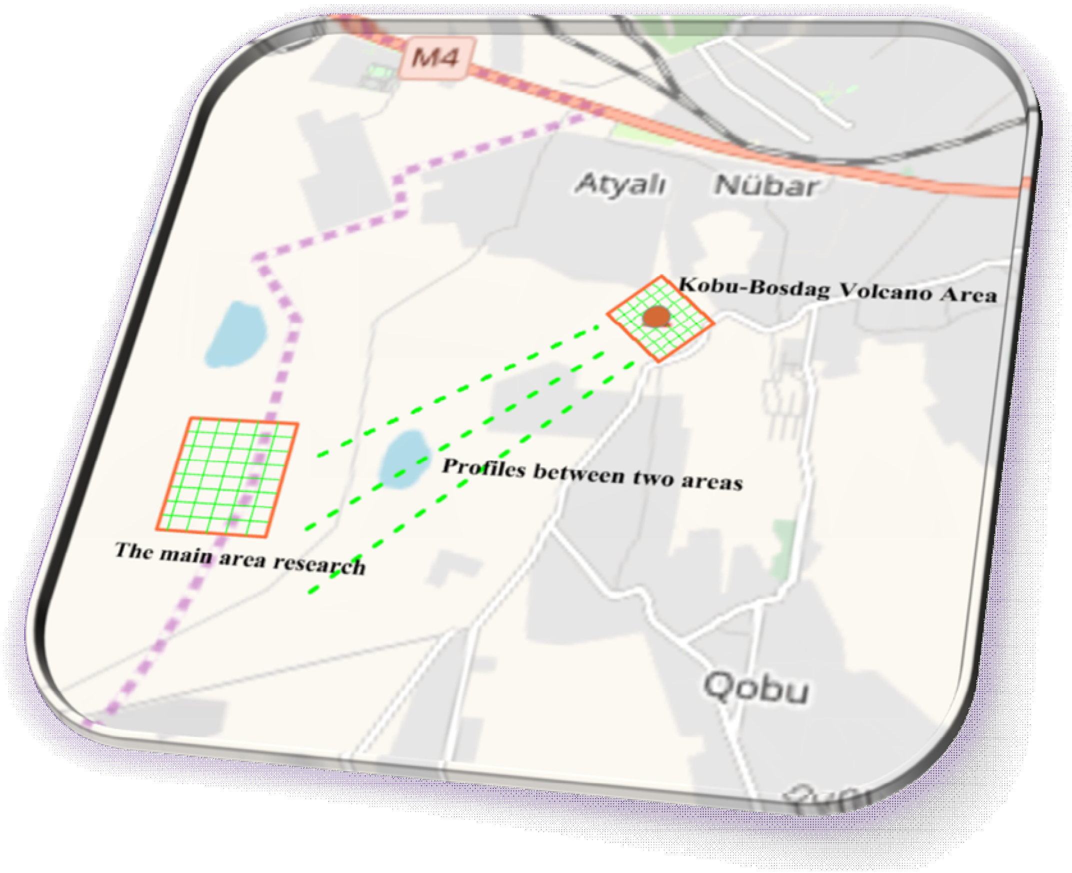

Figure 2. Scheme of the research field

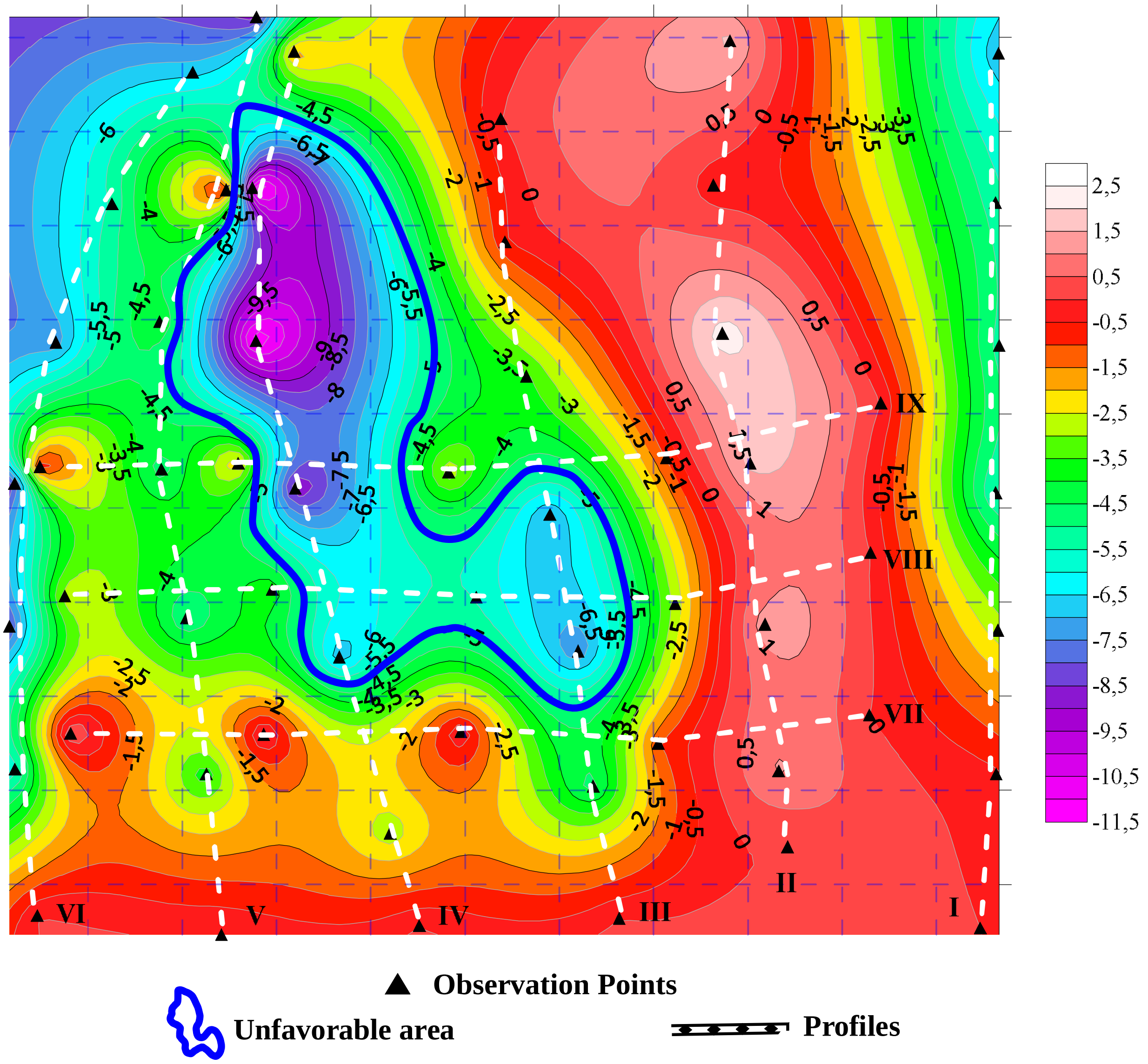

Figure 3. Isoanomal maps of the gravitational field.

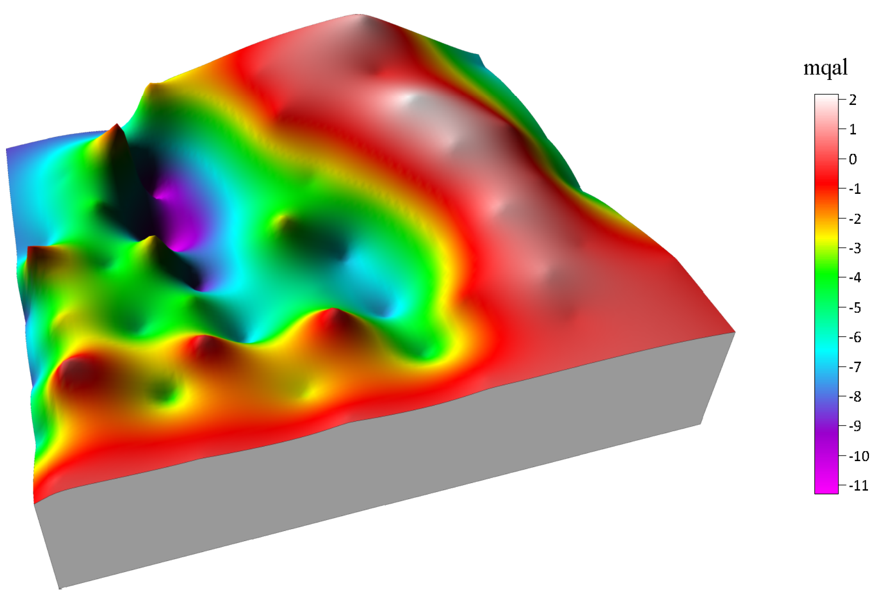

Figure 4. 3D model of the gravitational field corresponding to the isoanomal maps

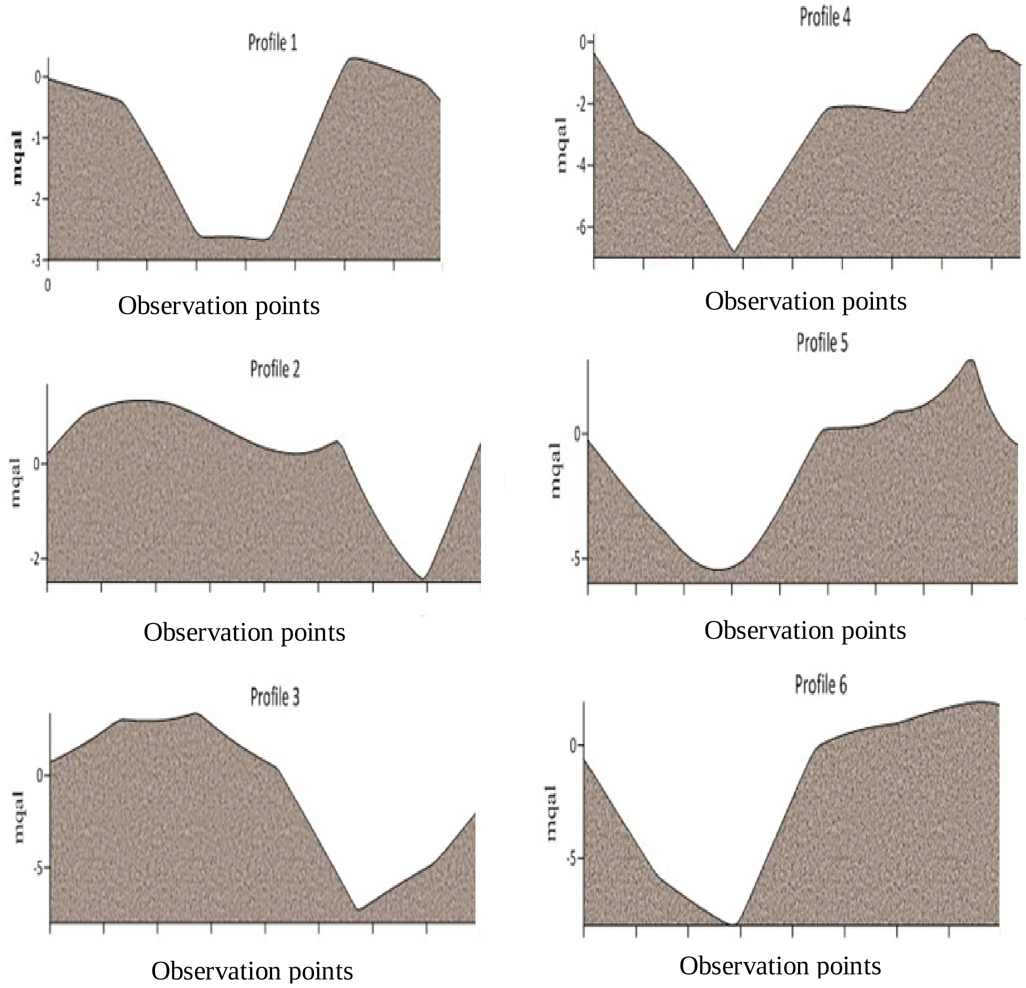

Figure 5. Transects on profiles according to the isoanomal maps of the gravitatioal field.

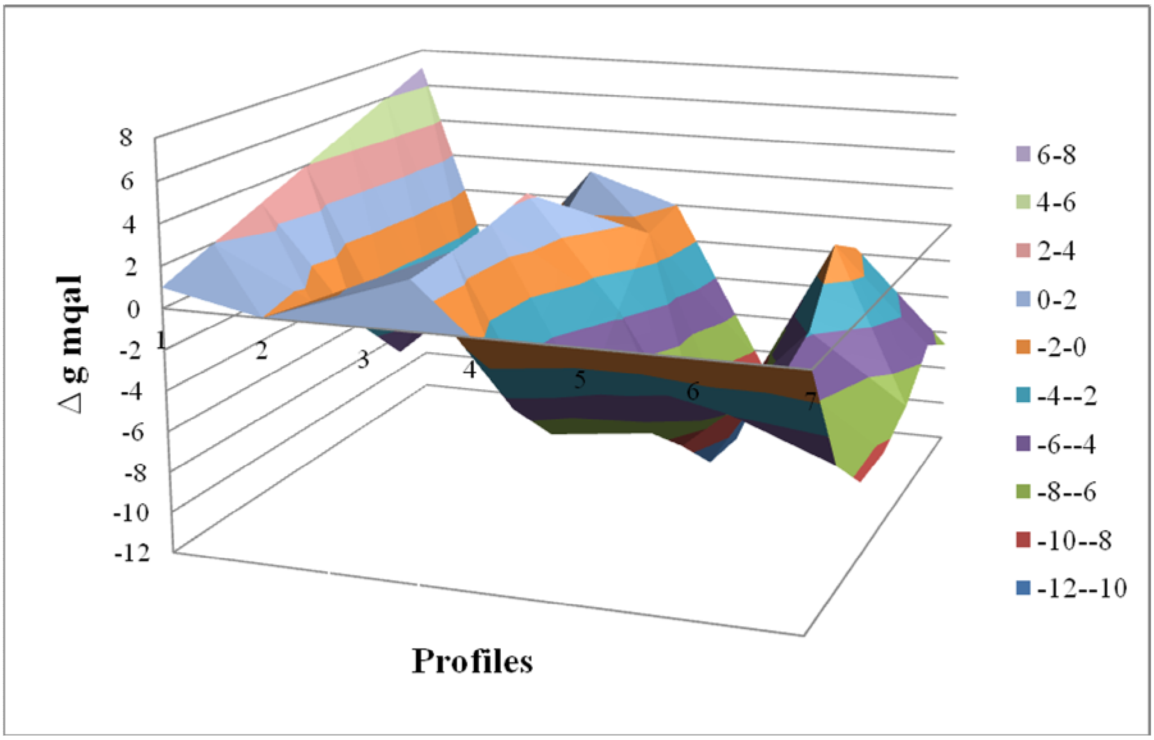

Figure 6. Model diagram on profiles according to the isoanomal maps of gravitational field

Figure 7. Comparative graphs on profiles according to the isoanomal maps of gravitational field

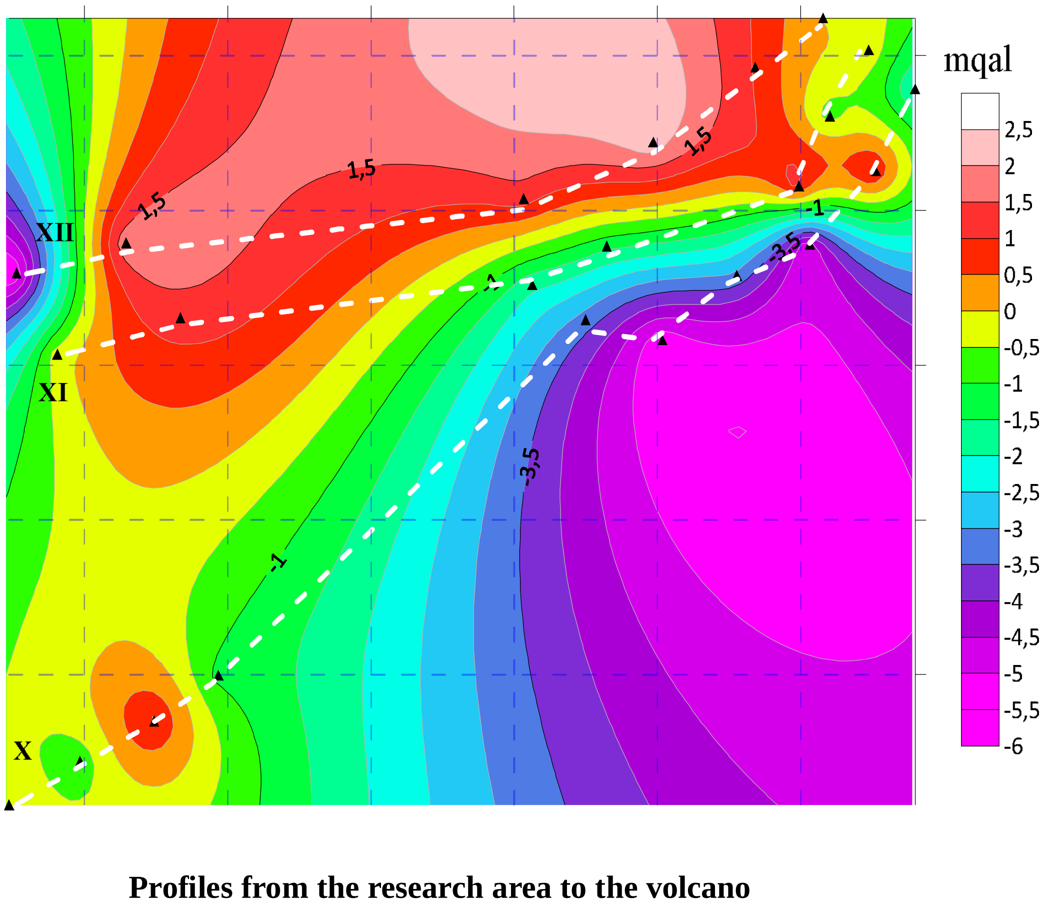

Figure 8. Isoanomal map of gravitational field in the area from the main research field to the Bozdagh-Gobu volcano.

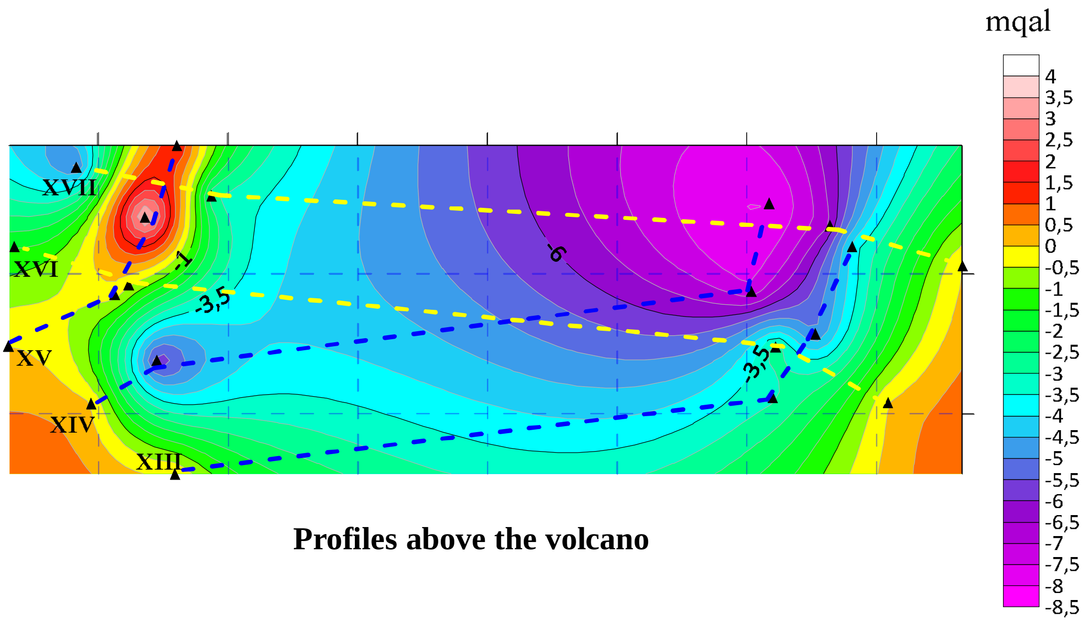

Figure 9. Isoanomal maps of the gravitational field in the Bozdagh-Gobu volcano

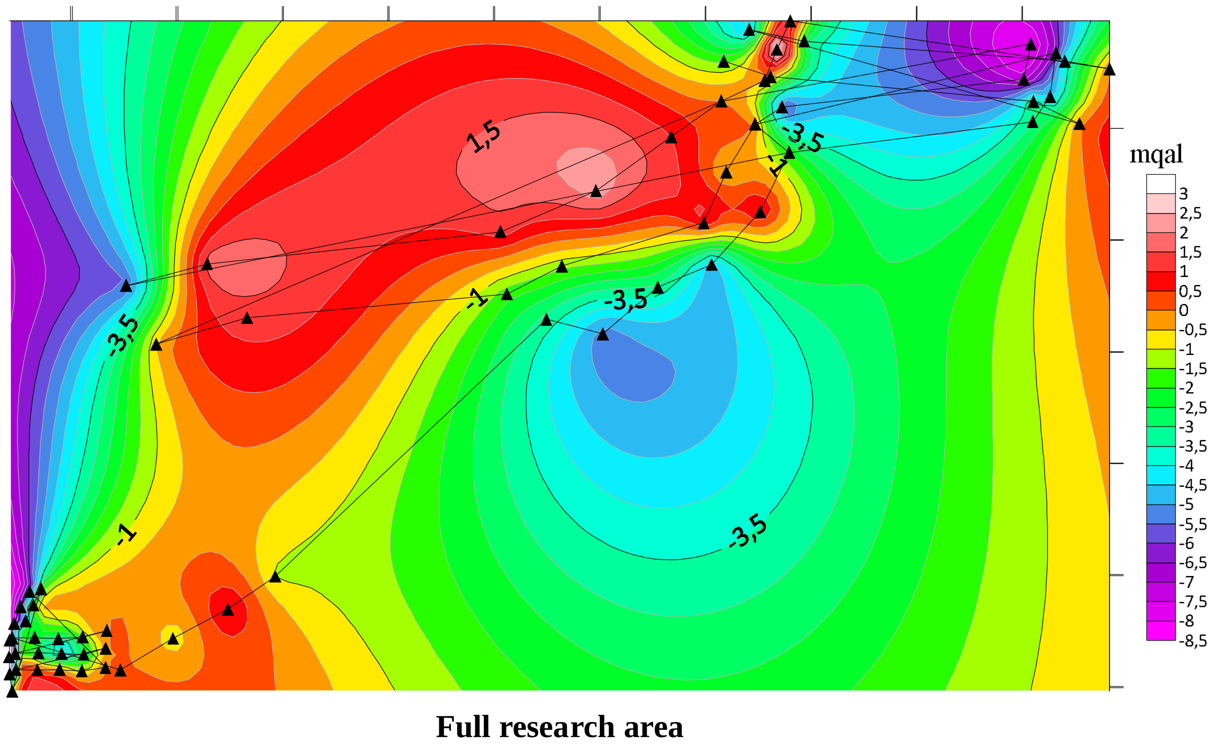

Figure 10. Isoanomal maps of gravitational field, fully covering the research area

Relative gravity force increases –6---2,5 mQal from south to north in the north direction in the area of Bozdagh-Gobu volcano,that is, concentrated in the north and porous rocks are spread in the north-east direction (Fig. 8). The relative gravity force increasing 8.5-----3.5 mQal is different in the Bozdagh-Gobu volcano (Fig. 9).Finally, the isoanomal maps of gravitational field over an area covered by 17 profiles are added to the article (Fig. 10).

Conclusions

- Anomal zones with variable characteristic value of Δg are highlighted in the isoanomal map of gravitatonal field
- The gravity force is not stable in this site and there are propably sediment, anomalous zones in the center of III, IV profiles
- 3D model of the gravitational field have been created on the basis of Transects on profiles, graphs and isoanomal map. Relative gravity force on total field varies between 11,5 ----- 2.5 mQal.
- The impact of Bozdagh-Gobu volcano to the construction site is minimum and the gravity force in this site varies between 8,5 --- 3,5 mQal.
- Unfavorable area is determined for construction in the main research area.

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STUDY OF THE LOW VELOCITY ZONES IN THE TERRITORY OF GOBU REGION (AN EXAMPLE OF THE GOBU POWER STATION)

E.S.Garaveliyev[1], A.V. Aghazade[1]

The territory of Gobu is located in the south-western part of the Western-Absheron anticlinorium and there are small mountain range in the east-west - north-south direction, here. There are numerous cones of the mud volcanoes in the hills of this area. The absolute height of the area varies between 120-160 meters and there is the tendency to gradual grounding in the south-west direction.

Territory of "Gobu" Electric Station located approximetly 2.5-3 km from Gobu-Bozdagh mud volcano and about 6 km from Guzdek-Bozdagh mud volcano is the research area. Although mud mass erupting out of the both volcanoes are less likely to reach to the living area, the Gobu-Bozdagh mud volcano generates the shakes always noticeable with dynamic activity and seismological signs and it caused serious damage in nearby houses.

The above-mentioned are the indications of complex seismological conditions of the "Gobu" Electric Station area and its dynamic activity.

This volcano erupted in 1827, then in 1974 and last time in 1999 year. When the volcano erupted, the flame height was 400 meters, and the temperature was more than 1,000 degrees. At the same time, 300,000 thousand cubic meters of volcanic mud have been erupted and spread around. The central part of the volcano's crater rose to 6-7 m height and many broken blocks have been formed there during the last eruption of this volcano in 1999 year. As the result of this, the large cracks that depth is 2 m up to Hokmeli region and approximetly 1200 m length have been formed.

In the area where the "Gobu" electric station considered to be built in Gobu region, part of the transect up to 10.0 m depth consists of the sediments of Paleogene Koun floor (P2k) based on the materials of previous geological and engineer-geological researches. These sediments involves to surface in the research area and consist of clays in terms of lithology. There are sandstones, schists and occasionally marl gasket in these sediments. The layer of soil-plant which thickness is 0.1-0.3 meters is observed above the sediment of the Koun floor.

As mentioned above, the Gobu area is an area characterized by complex geological features. Therefore, the research of small velocity zones during the construction-designing works in these areas is very important. For the purpose of research a small velocity zone of this area, the "Broken Microtremor" (Broken Microseisms) method of seismic exploration have been used (Loui, 2001). This method is considered to be a profitable seismic method to establish a wide wave profile in the research area in terms of substance and finance. Conducting such research will provide useful seismic data in the areas of noisy urbanization.The phase data of wave area mentioned in the "Broken Microtremor" (broken microseisms) is used.

The GEODE-24 engineering-seismic station, 24 seismic receiver for record the signals, seismic exploration wire with115meter and hammer with 11 kg have been used for the purpose of research of broken microseisms. Seismic source is the microshakes created by noise from the environment and shake method.

In the area where the substation to be built,18 seismic profiles have been established (preliminary materials of profile № 15 were unsatisfactory) and total amount of done works are 1955 linear meter.

Based on the obtained materials, there is a tectonic disturbance in the south of the "Gobu" Electric Station with 385 MVt to be built in Gobu district (I.A. Israfilbeyov and V.A.Listerengarten. Hydrological and Engineering Geology methods in the Absheron peninsula. Album of the Hydrogeological and Engineering Geological Map of the Absheron Peninsula M 1: 50000, General Directorate of Geodesy and Cartography of the Council of Ministers of the USSR, M .: 1983, s. 23-70).

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Figure 1. Relief changes in the western-Sonali residental area from the Gobu-Bozdagh volcano

Figure 2. The crater of the Gobu-Bozdagh volcano

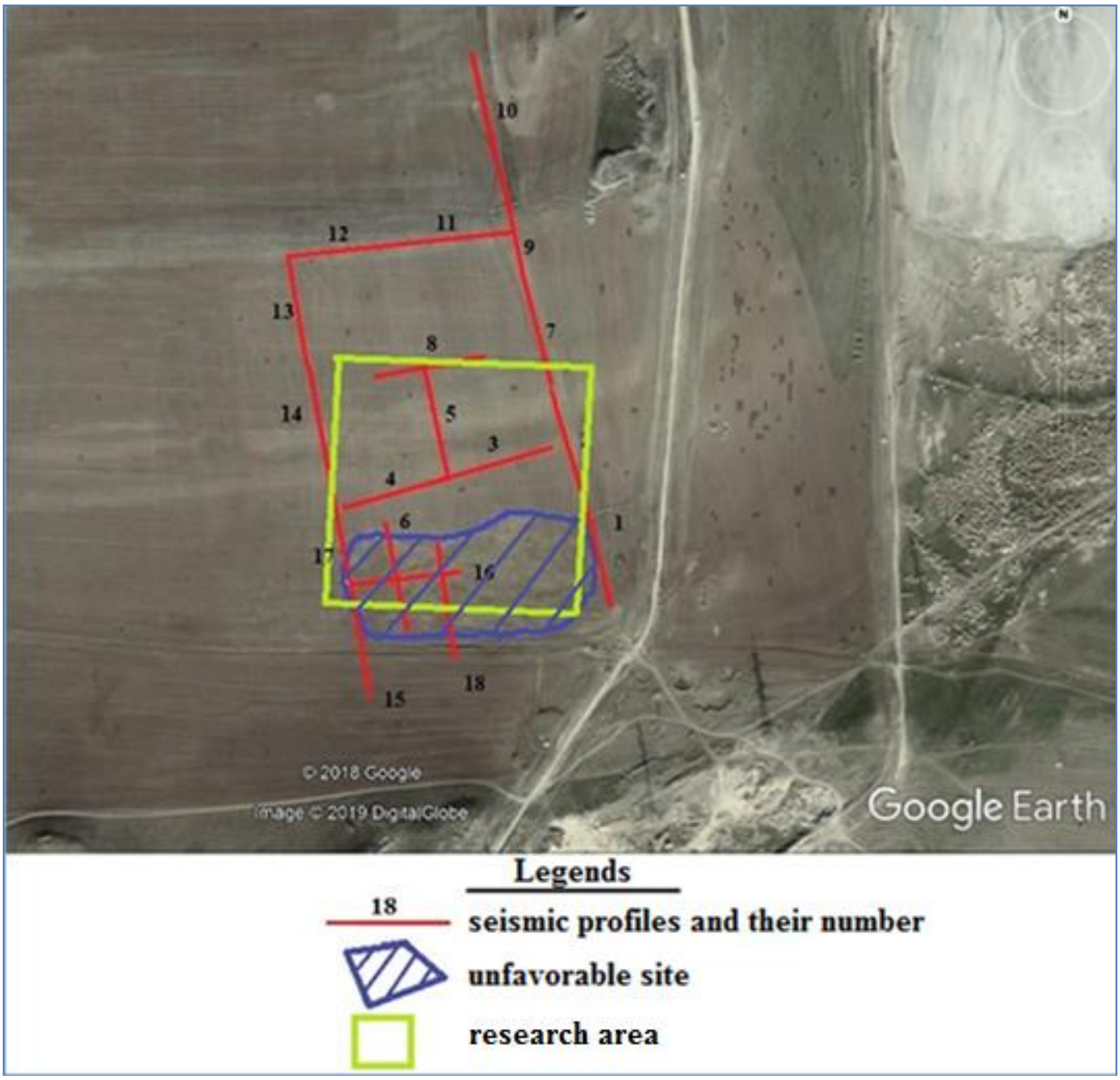

Figure 3. Geometric dimensions of the research area (250 x250 m) and the location scheme of the seismic profiles in the site

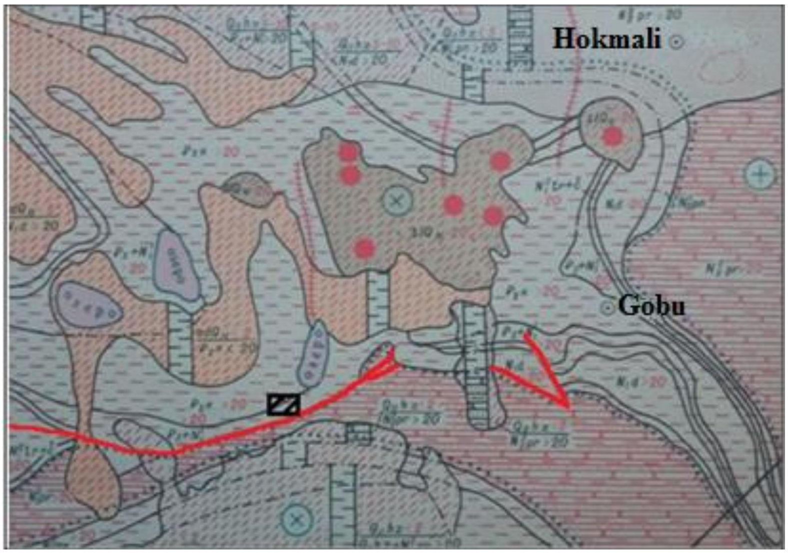

Figure 4. Engineering geology map of the area (authors: İ.A.İsraphilbeyov and V.A.Listengarten).

Figure 5. Geological transect and slope of the layers in the north-eastern, edge part of the field (shell, sandy clay rocks).

Figure 6. Damage caused by volcanic eruptions on a farm near the foot of the Gobu-Bozdagh volcano.

Figure 7. During the field work.

As a result of initial visual observation, it is determined that the one part of the research was inconvenient (sedimentary) from the point of view of construction (26000 m2 area).

Layers with the low wave speed (235-586 m/s) have been identified at a depth of about 6.5-12.0 m from the surface and respectively 28-78.5 m. at depths in the transect of the 1; 4-7; 9-11; 13; 17 and 18 numbered profiles (these values are lower than others in the 1-8, 13, 16 and 18 numbered profiles).

Layers with lower wave velocities are known to be unfavorable ground from a seismic point of view. In this regard, it is important to implement additional engineer researches in the area.

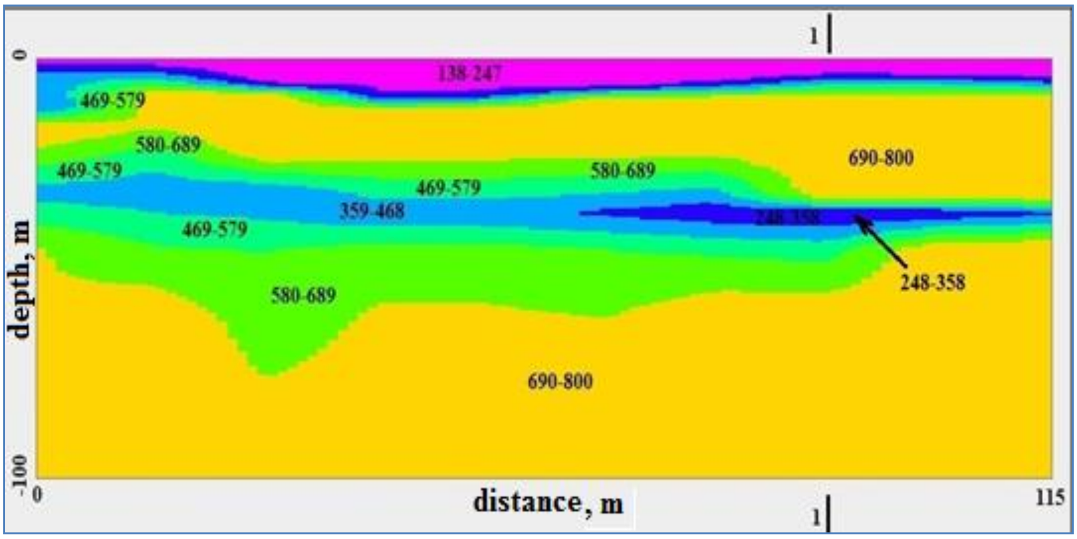

Figure 8. Two-dimensional velocity sectiont (m / s) of transverse waves on the seismic profile No. 1.

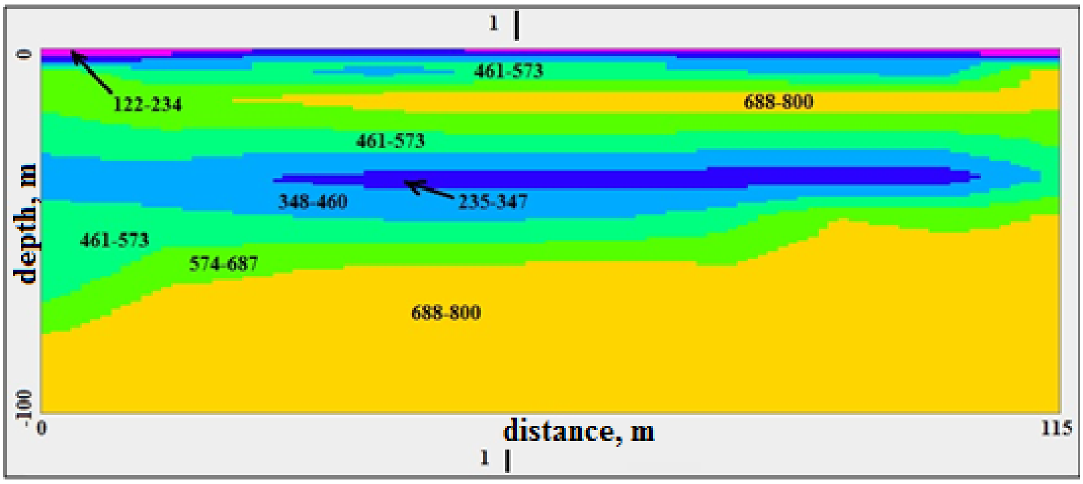

Figure 9. Two-dimensional velocity section (m / s) of transverse waves on the seismic profile No. 2.

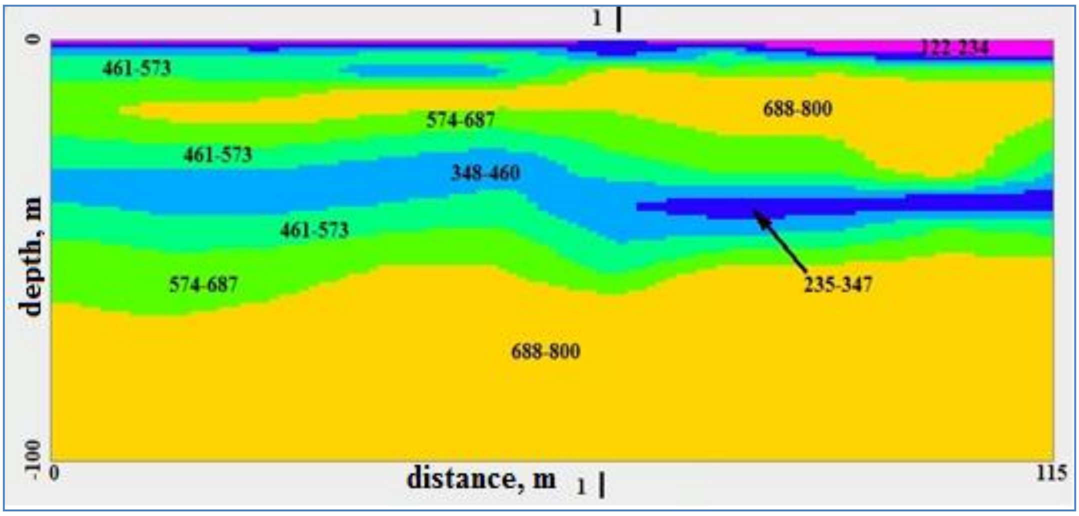

Figure 10. Two-dimensional velocity section (m / s) of transverse waves on the seismic profile No. 3.

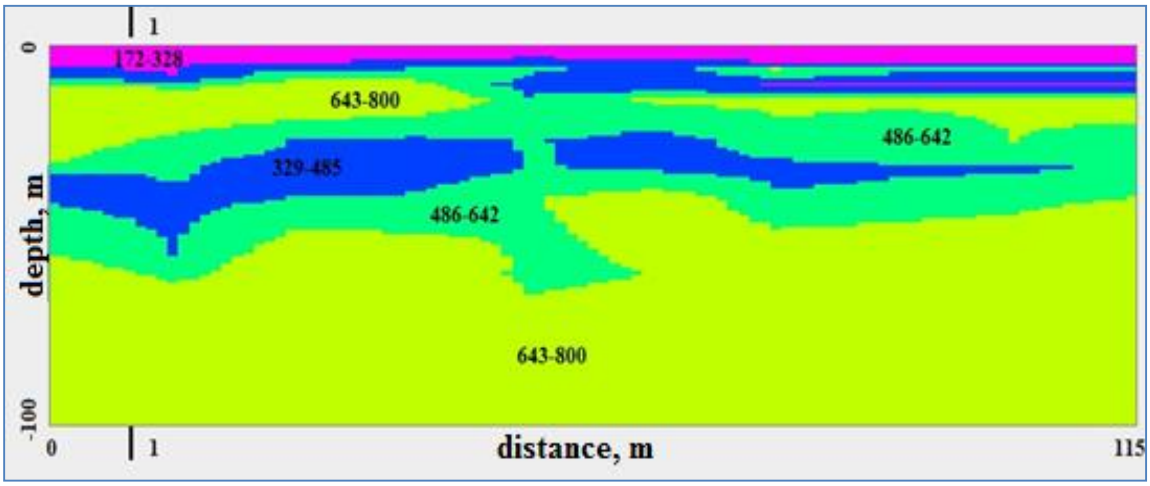

Figure 11. Two-dimensional velocity section (m / s) of transverse waves on the seismic profile No. 4.

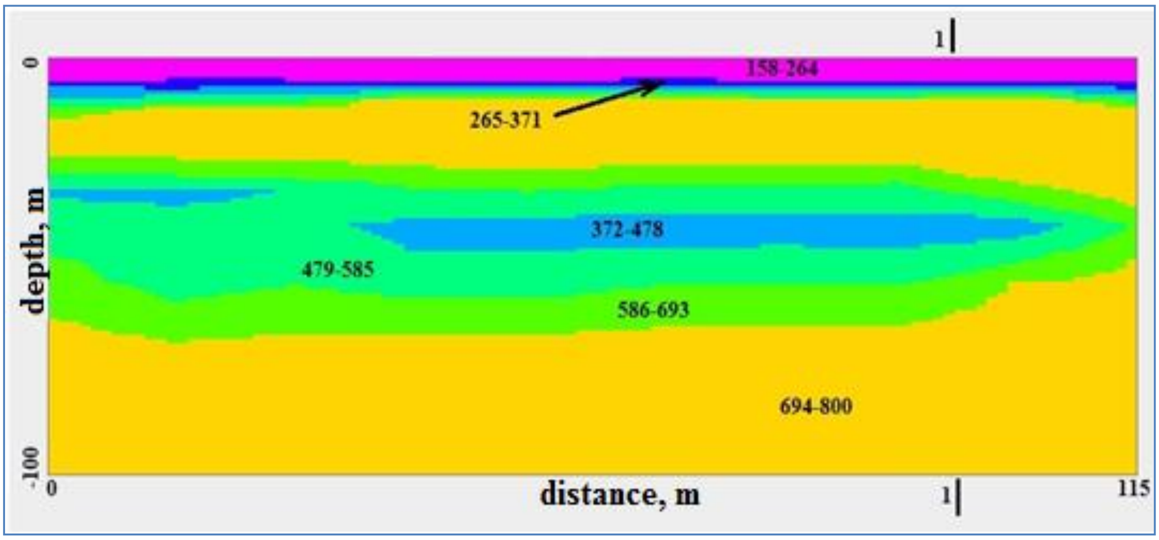

Figure 12. Two-dimensional velocity section (m / s) of transverse waves on the seismic profile No. 5.

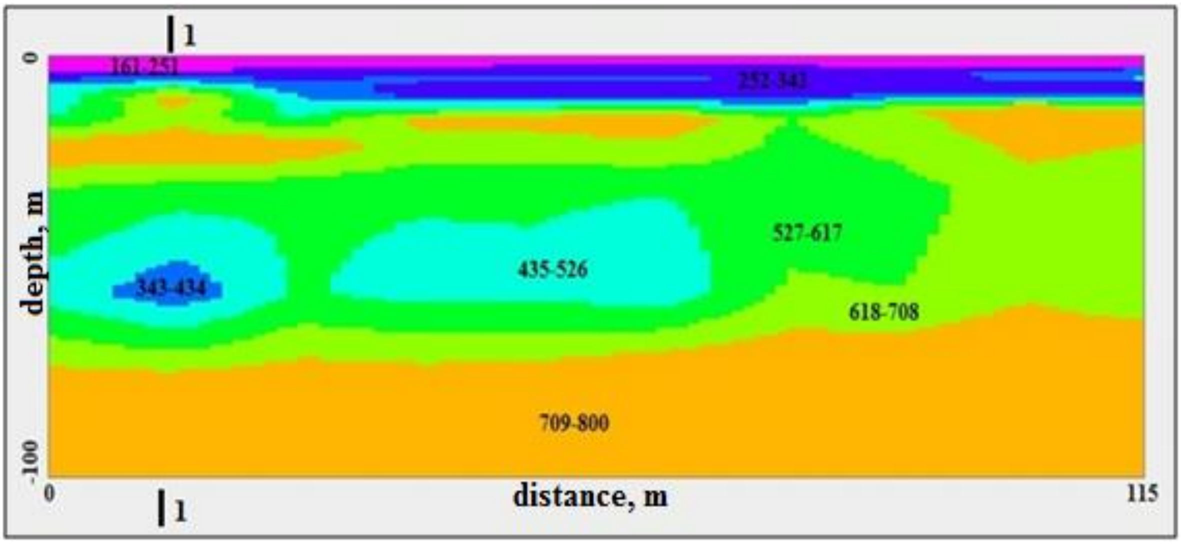

Figure 13. Two-dimensional velocity section (m / s) of transverse waves on the seismic profile No. 6.

Conclusions

- Fuzzy slope of the layers in the small velocities zones investigated to a depth of 100 m in the area, having the pinching out, the variation of the valuesof transverse seismic wave velocities between 120-800 m/sec in the layers.
- It is identified that the grounds in the approximetly 6.5-12.0 m depths are very weak (empty, soft or aqueous) and the unfavorable in terms of seismicity, starting from the surface on the seismic profiles No. 1; 4-7; 9-11; 13; 17 and18 and laying of the unfavorable grounds are to the depth of 3.0 m below the surface in the other 6 seismic profiles (with the exception of No. 15)
- Low seismic velocities in all seismic profiles have been determined (at depths of 28-78.5 m, with the wave velocities of 235-586 m / s). These values are lower than others on profile of 1-8, 13, 16 and 18 (235 -485 m/s).
- An unfavorable and sedimentary area for construction works has been identified in the relief, south of the research area (100 m x 260 m= 26000 m^2 in the area). There are unevennesses with the amplitude up to 1.0 m. within this unfavorable area and the same time, the color of the flora is completely different from the surrounding area.

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ANNOTATIONS

1. ASSESSMENT OF SEISMIC HAZARD IN THE TERRITORY OF "TAKHTAKORPU" RESERVOIR OF AZERBAIJAN

G.J. Yetirmishli, T.Y. Mammadli, R.B. Muradov, T.I. Jaferov

Seismological researches were conducted at the Takhtakorpu reservoir built in the territory of Shabran district. On the basis of earthquake data, active tectonic faults or potential source zones in Shabran district and adjacent areas have been identified and their seismic potential has been assessed. It was revealed that, the maximum magnitude of the probable earthquakes in the zone of two large-sized active faults or potential source in the area close to the research area is $M_{max} = 7.4$ and $M_{max} = 6.7$, respectively. Seismic hazards may occur in conducted researches of the maximum magnitude earthquakes in this source zones. The earthquakes with maximum magnitude in this source zones can cause seismic hazards with an intensity of 8-9 points on the MSK-64 scale in the territory of "Takhtakorpu" reservoir where researches were conducted.

Keywords: earthquake, active tectonic fault, source zones, seismic potential, magnitude, seismic section.

2. ANOMALOUS CHANGES OF MAGNETIC FIELD BEFORE THE ZAGATALA EARTHQUAKE ON 05.06.2018

A.G. Rzayev, L.A. Ibrahimova, N.B. Khanbabayev, M.K. Mammadova, V.R. Huseynova

Annotation: The formation character of the seismomagnetic effect have been studied before the Zagatala earthquake (ml = 5.5; 05.06.2018) which was felt in the zones with high geodynamic activity. About the non-homogeneous distribution of the local geomagnetic field tension in the Shamakhi-Sheki-Balakan geodynamic polygon is provided.

Keywords: RSSC- Republican Seismic Survey Center, SME- seismomagnetic effect, nTI-nano Tesla.

3. 1D VELOCITY MODEL BY LOCAL EARTHQUAKE DATA

S.E. Kazimova, Sh.N. Khadiji, S.E. Gummatli

The Caucasus-Caspian region is an area of complex tectonic structure accompanied by large variations in seismic wave velocities and attenuation. In such areas, accurate geophysical models are fundamentally important to seismic monitoring for two reasons: improved event location and path calibration (critical for accurate estimation of event size and mechanism). In particular, the great thickness and irregular geometry of the low velocity and low density sediments in the Kura and Caspian sea basins causes profound effects on seismic waveforms, especially on surface waves and regional phases. These effects are compounded by variation in crustal structure in the Caucasus and by high attenuation under the e. Anatolian plateau [3].

Keywords: wave velocity, velocity model, hypocenter, earthquake, Velest.

4. ASSESSMENT OF MODERN GEODYNAMICS OF AZERBAIJAN BY GPS MEASUREMENT DATA

G.J. Yetirmishli., I.E. Kazimov, A.F. Kazimova

The article presents the methodology for calculating the velocity fields of modern horizontal displacements of the tectonic blocks in Azerbaijan, obtained from observations at 24 stationary GPS RSSC stations, a characteristic aspect of which is a noticeable horizontal displacement in the north-

east direction at a speed of 5-18 mm / year. The velocities of joint seismic movement associated with earthquake events were investigated using the GAMIT kinematic positioning program for 2017 and 2018 years. Maps of horizontal velocities were built according to the data of the geodetic network of GPS stations of Azerbaijan for 2017 and 2018 years. An analysis of the data showed that the distribution of the velocities of horizontal displacements to the north and east is not constant, and the processes of shortening the surface of the Earth's crust in the study region are also not constant.

Keywords: GPS stations, geodynamics, velocity fields of horizontal displacements, plate tectonics.

5. FOCAL PARAMETERS OF THE OGUZ EARTHQUAKE SEPTEMBER 4, 2015 with ml = 5.9

S.E. Kazimova, S.S. Ismayilova

The article analyzes a strong 7-magnitude earthquake that occurred on September 4, 2015, at 04h 49m in the Oguz region. The epicentral field, as well as the distribution of sources in depth, was studied, and solutions to the mechanisms of the sources of the main shock and the most noticeable aftershock were constructed and analyzed. The epicenters of the Oguz earthquakes are confined to the Arpa-Samur fault and can be interpreted as left-side shift deformation in the zone of geodynamic influence of the left-sided Arpa-Samur fault. A three-dimensional model of the aftershock field is constructed. The Fourier amplitude spectra were constructed from digital seismograms of the transverse waves of earthquakes, which made it possible to determine such dynamic parameters as the angular frequency f_0, seismic moment M_0, the radius of the circular dislocation R, the discharged stress$\Delta\sigma$, and the average underthrust along the structure D. Based on the above said, The spectral ratios were calculated and an extension factor was found for 21 broadband digital stations.

Keywords: earthquake source, seismic moment, angular frequency, Fourier spectrum.

6. COMPARATIVE ANALYSIS OF GRAVIMETRIC STUDIES IN BOZDAG-GOBU MUD VOLCANO AND SURROUNDING AREAS

E. M. Baghırov, A.T. İsmayılova

Assessment of the geodynamic conditions and study of the fault-block structure of the consolidated crust due to insufficient variations in the gravitational field for the construction in the area adjacent to the Bozdagh-Gobu volcano.

Keywords: Bozdagh-Gobu volcano, gravity, non-tidal variations, gravimetric field

7. STUDY OF THE LOW VELOCITY ZONES IN THE TERRITORY OF GOBU REGION (AN EXAMPLE OF THE GOBU POWER STATION)

E.S. Garaveliyev, A.V. Aghazade

Study of the low velocity zones is especially important during the construction-designing works. As the result, the seismic features and parameters of the geological transect are determined in the research area. One of the researches has been carried out on the example of the Gobu Power Station to be built in the Gobu area. The upper transect of the surface to the depth of 100 m have been studied using the “Broken Microseisms” method of the seismic exploration during the research works.

Keywords: Seismic exploration, “Broken microseisms” methods, transverse wave velocity, GEODE -24 seismic stations.

ANNOTASIYALAR

1. AZƏRBAYCANIN "TAXTAKÖRPÜ" SU ANBARI ƏRAZISINDƏ SEYSMIK TƏHLÜKƏNIN QIYMƏTLƏNDIRILMƏSI

Q.C. Yetirmişli, T.Y. Məmmədli, R.B. Muradov, T.İ. Cəfərov

Şabran rayonunda inşa olunmuş Taxtakörpü su anbarı ərazisində seysmoloji tədqiqatlar aparılmışdır. Zəlzələ məlumatları əsasında Şabran rayonu və ona yaxın ərazilərdə aktiv tektonik qırılma və ya potensial ocaq zonaları müəyyənləşdirilmiş və onların seysmik potensialı qiymətləndirilmişdir. Məlum olmuşdur ki, tədqiqat sahəsinə yaxın ərazidə kifayət qədər böyük ölçülü iki aktiv qırılma və ya potensial ocaq zonalasında ehtimal olunan zəlzələlərin maksimum maqnitudu müvafiq olaraq M_{max} =7,4 və M_{max} =6,7 təşkil edir. Bu ocaq zonalarında maksimum maqnitudlu zəlzələlər tədqiqat aparılan "Taxtakörpü" su anbarı ərazisində MSK-64 şkalası üzrə 8-9 bal intensivlikli seysmik təhlükə yarana bilər.

Açar sözlər: zəlzələ, aktiv tektonik qırılma, ocaq zonaları, seysmik potensial, maqnituda, seysmoloji kəsiliş.

2. 05.06.2018-CI ILDƏ ZAQATALA ZƏLZƏSINDƏN ÖNCƏ MAQNIT SAHƏSININ ANOMAL DƏYIŞMƏLƏRI

A.Q. Rzayev, L.A. İbrahimova, N.B. Xanbabayev, M.K. Məmmədova, V.R. Hüseynova.

Yüksək geodinamik aktivliyi olan zonalarda hiss olunan Zaqatala zəlzələsindən əvvəl (ml = 5.5; 05.06.2018) seysmomaqnit effektinin yaranma xarakteri öyrənilmişdir.

Şamaxı-Şəki-Balakən geodinamik poliqonunda lokal geomaqnit sahə gərginliyinin qeyri-bircinsli paylanması haqqında məlumat verilir.

Açar sözlər: RSXM-Respublika Seysmoloji Xidmət Mərkəzi, SME-seysmomaqnit effekt, nTl-nano Tesla.

3. YERLI ZƏLZƏLƏLƏRIN MƏLUMATLARI ƏSASINDA BIR ÖLÇÜLÜ SÜRƏT MODELI

Kazımova S.E., Xədici Ş.N., Hümmətli S.E.

Qafqaz-Xəzər bölgəsi mürəkkəb tektonik quruluş zonası kimi xarakterizə olunan regiondur. Həmin ərazi seysmik sürətlərin böyük dalğalanması və seysmik dalğaların kəskin sönməsi ilə xarakterizə olunur. Belə ərazilərdə dəqiq geofiziki modellər iki səbəbə görə prinsipial əhəmiyyət daşıyır: zəlzələ ocaqlarının dəqiq koordinatların alınması və kolibrovkası üçün (mənbənin ölçüsünü və mexanizmini dəqiq qiymətləndirmək üçün vacibdir). Xüsusilə Kür və Xəzər hövzələrində çöküntü layın böyük qalınlığı və quruluşların nizamsız geometriyası aşağı sürətlər zonalar seysmik dalğalara, xüsusən səth dalğalarına və regional fazalara güclü təsir göstərir. Bu təsirlər Qafqazdakı yer qabığının quruluşunda dəyişiklik və Anadolu zonasında dalğaların yayılmasının tez sönməsi ilə mürəkkəbləşir .

Açar sözlər: dalğaların sürəti, sürət modeli, hiposentr, zəlzələ, Velest proqramı

4. GPS MƏLUMATLARI ƏSASINDA AZƏRBAYCANIN MÜASIR GEODINAMİKASININ GIYMƏTLƏNDIRILMƏSI

Q.C. Yetirmişli , İ. E. Kazımov , Kazımova A.F

Məqalədə 24 stasionar GPS_RSXM stansiyalarda aparılan müşahidələr nəticəsində əldə edilən Azərbaycanın tektonik bloklarının müasir horizontal yerdəyişmələrinin sürət sahələrinin hesablanması metodologiyası təqdim olunur. Xarakterik bir cəhət odur ki, şimal-şərq istiqamətində

5-18 mm sürətlə nəzərə çarpan horizontal yerdəyişməsidir. Tədqiqatlar 2017 və 2018-ci illər üçün GAMIT proqramı üzərində aparılmışdır. Məlumatların təhlili göstərdi ki, horizontal yerdəyişmə sürətlərinin şimal və şərqə paylanması daimi deyil və tədqiq olunan bölgədəki yer qabığının səthinin qısaldılması prosesləri də həmçin dəyişir.

Açar sözlər: GPS stansiyaları, geodinamika, horizontal yerdəyişmələrin sürət sahələri, plitələrin tektonikası

5. 4 SENTYABR 2015-CI IL TARIXINDƏ ML = 5.9 OLAN OGUZ ZƏLZƏLƏSININ FOKAL PARAMETRLƏRI

S.E. Kazımova, S.S. Ismayılova

Məqalədə 4 sentyabr 2015-ci il tarixində, saat 04: 49-da Oğuz bölgəsində baş verən 7 bal gücündə zəlzələ təhlil edilmişdir. Episentral sahə, habelə zəlzələlərin dərinliyə görə paylanması araşdırılmış və əsas təkanın və ən çox hiss olunan afterşokların ocaq mexanizmləri qurulmuş və təhlil edilmişdir. Oğuz zəlzələsinin episentrləri Arpa-Samur qırılması ilə uzlaşır və həmin qırılmanın təsiri altında sol tərəfli horizontal yerdəyişmə gərginlik deformasiyə kimi xarakterizə olunur. Aftershock sahəsinin üçölçülü modeli qurulmüşdur. Zəlzələlərin eninə dalğaların HG kanalların əsasında Furye spetktrları qurulmuş. Bu da bucaq tezlikl f_0 maksimal səviyyəsini, seysmik momenti M_o, dairəvi yer dəyişmənin radiusu R, boşalmış gərginlik $\Delta\sigma$ və qırılma üzrə yerdəyişmənin qiyməti D müəyyən etməyə imkan verdi. Yuxarıda göstərilənlərə əsasən 21 rəqamsal stansiyaların dalğaların spektrlərinin nisbətləri hesablanmış, gücləndirmə faktoru tapılmışdır.

Açar sözləri: zəlzələ ocağı, seysmik Moment, bucaq tezliyi, Furye spektri.

6. BOZDAĞ-QOBU PALÇIQ VULKANI VƏ ƏTRAF ƏRAZİLƏRDƏ APARILAN QRAVİMETRİK TƏDQİQATLARIN MÜQAYİSƏLİ TƏHLİLİ

E.M. Bağırov, A.T. İsmayılova

Bozdağ-Qobu vulkanına bitişik ərazidə tikinti işlərinin aparılması üçün qravitasiya sahəsinin qabarmayan variasiyalarına görə konsolidə olunmuş qabığın qırılma-blok quruluşunun öyrənilməsi və geodinamik şəraitin qiymətləndirilməsi.

Açar sözlər: Bozdağ-Qobu vulkanı, ağırlıq qüvvəsi, qabarmayan variasiyalar, qravimetrik sahə.

7. QOBU ƏRAZISINDƏ KIÇIK SÜRƏTLƏR ZONASININ TƏDQIQI ("QOBU" ELEKTRIK STANSIYASI ƏRAZISININ TIMSALINDA

E.S.Qaravəliyev, A.V. Ağazadə

Tikinti-layihələndirmə işləri zamanı ərazilərin kiçik sürətlər zonasının tədqiqi xüsusi əhəmiyyət daşıyır. Nəticə olaraq tədqiqat sahəsində geoloji kəsilişin seysmik xüsusiyyətləri və parametrləri müəyyən edilir. Bu cür tədqiqatlardan biri Qobu ərazisində inşa ediləcək "Qobu" Elektrik Stansiyası ərazisinin timsalında yerinə yetirilmişdir. Tədqiqat işləri zamanı Seysmik kəşfiyyatın "Sınan Mikroseysmlər" üsulundan istifadə edərək yerin 100 m dərinliyə qədər üst kəsilişi tədqiq edilmişdir.

Açar sözlər: Seysmik kəşfiyyat, "Sınan Mikroseysmlər" üsulu, eninə dalğa sürəti, GEODE-24 seysmik stansiyası

АННОТАЦИИ

1. ОЦЕНКА СЕЙСМИЧЕСКОЙ ОПАСНОСТИ ТЕРРИТОРИИ ВОДОХРАНИЛИЩА “ТАХТАКЕРПЮ”, ПОСТРОЕННОГО В ШАБРАНСКОМ РАЙОНЕ АЗЕРБАЙДЖАНА

Г.Дж. Етирмишли, Т.Я. Маммадли, Р.Б. Мурадов, Т.И. Джафаров

На территории резервуара Тахтакерпю, построенного в Шабранском районе, проведены сейсмологические исследования. На основе данных о землетрясениях установлены активные тектонические разломы или потенциальные очаговые зоны, определен их сейсмический потенциал. Было установлено, что максимальная магнитуда вблизи территории исследования, в достаточно крупных активных разломах или потенциальных очаговых зонах составляет M_{max} =7,4 и M_{max} =6,7. Такие землетрясения с максимальной магнитудой могут сотрясти территории резервуара Тахтакерпю с интенсивностью в 8-9 баллов по шкале MSK-64.

Ключевые слова: землетрясение, активный тектонический разрыв, очаговые зоны, сейсмический потенциал, магнитуда, сейсмологический разрыв.

2. АНОМАЛЬНЫЕ ИЗМЕНЕНИЯ В МАГНИТНОМ ПОЛЕ ДО ЗАКАТАЛЬСКОГО ЗЕМЛЕТРЯСЕНИЯ 05.06.2018

А.Г.Рзаев, Л.А. Ибрагимова, Н.Б. Ханбабаев, М.К. Маммадова, В.Р. Гусейнова

Изучен характер проявления сейсмомагнитного эффекта перед Загатальским ощутимым землетрясением (ml=5.5 05.06.2018) в зоне высокой геодинамической активности. Показана неоднородность распределения локальной напряженности геомагнитного поля по площади Шамахы-Шеки-Балакенского полигона.

Ключевые слова: РЦСС - Республиканский центр сейсмологической службы, сейсмомагнитный эффект, нТл - нано Тесла.

3. ОДНОМЕРНАЯ СКОРОСТНАЯ МОДЕЛЬ ПО ДАННЫМ МЕСТНЫХ ЗЕМЛЕТРЯСЕНИЙ

С.Э. Казымова, Ш.Н. Хадиджи , С.Э. Гумматли

Кавказско-Каспийский регион представляет собой зону сложной тектонической структуры, характеризующуюся большими колебаниями скоростей и резким затуханием сейсмических волн. В таких областях для сейсмического мониторинга принципиально важны точные геофизические модели по двум причинам: улучшение местоположения сейсмического события и калибровка пути (критически важны для точной оценки размера и механизма очага). В частности, большая толщина осадочного чехла и неправильная геометрия структур с низкой скоростью и низкой плотностью в бассейнах Куры и Каспийского моря оказывают сильное влияние на сейсмические волны, особенно на поверхностные волны и региональные фазы. Эти эффекты усугубляются изменением структуры земной коры на Кавказе и высоким затуханием в зоне Анатолийского плато.

Ключевые слова: скорость волны, скоростная модель, гипоцентр, землетрясение, программа «Велест».

4. ОЦЕНКА СОВРЕМЕННОЙ ГЕОДИНАМИКИ АЗЕРБАЙДЖАНА ПО ДАННЫМ GPS ИЗМЕРЕНИЙ

Г.Дж .Етирмишли, И.Э. Казымов, А.Ф. Казымова

В статье представлена методика расчета полей скоростей современных горизонтальных смещений тектонических блоков Азербайджана, полученная по результатам наблюдений на 24 стационарных GPS РЦСС станциях, характерным аспектом, которого является заметное горизонтальное смещение в северо-восточном направлении со скоростью 5–18 мм/год. Исследования проведены на программе GAMIT за 2017 и 2018 гг. Анализ данных показал, что распределение значений скоростей горизонтальных смещений на север и на восток не постоянны, не постоянны также и процессы укорачивания поверхности земной коры в регионе исследования.

Ключевые слова: GPS станции, геодинамика, поля скоростей горизонтальных смещений, тектоника плит

5. ПАРАМЕТРЫ ОЧАГА ОГУЗСКОГО ЗЕМЛЕТРЯСЕНИЯ 4 СЕНТЯБРЯ 2015 Г. С ML = 5.9

С.Э. Казымова, С.С. Исмайлова

В статье анализируется сильное 7-ми бальное землетрясение, произошедшее 4 сентября 2015 г., в 04^h 49^m в Огузском районе. Изучено эпицентральное поле, а также распределение очагов по глубине, построены и проанализированы решения механизмов очагов основного толчка и наиболее ощутимого афтершока. Эпицентры Огузских землетрясений приурочены к Арпа-Самурскому разлому и могут быть проинтерпретированы как левосторонняя сдвиговая деформация в зоне геодинамического влияния левостороннего Арпа-Самурского разлома. Построена трехмерная модель афтершокового поля. По цифровым сейсмограммам поперечных волн землетрясений были построены амплитудные спектры Фурье, которые дали возможность определения таких динамических параметров, как угловая частота f_0, сейсмический момент M_0, радиус круговой дислокации R, сброшенное напряжение $\Delta\sigma$, средняя подвижка по разрыву D. На основе выше сказанного были вычислены спектральные отношения и найден фактор усиления для 21 широкополосных цифровых станций.

Ключевые слова: очаг землетрясения, сейсмический момент, угловая частота, спектр Фурье.

6. ОСОБЕННОСТИ ГРАВИТАЦИОННОГО ПОЛЯ НА ВУЛКАНЕ ГОБУ-БОЗДАГ И ПРИЛЕГАЮЩИХ К НЕМУ ОБЛАСТЕЙ

Е.М. Багиров, А.Т.Исмайлова

Изучения свойства блок разломов консолидированного слоя с помощью неприливных вариаций гравитационного поля с целью введения строительных работ на прилагаемых районах Гобу-Боздагского вулкана.

Ключевые слова: Гобу-Боздагский вулкан, гравитационное поле, неприливные вариации.

7. ИССЛЕДОВАНИЯ ЗОН МАЛЫХ СКОРОСТЕЙ НА ТЕРРИТОРИИ ГОБУ («НА ПРИМЕРЕ ТЕРРИТОРИИ ЭЛЕКТРОСТАНЦИИ ГОБУ»).

Э.С.Гаравелиев, А.В.Агазаде

Исследования зон малых скоростей в районе проектно-строительных работ имеют особое значение. Как результат были определены сейсмические особенности и параметры геологического разреза в районе исследований. Одно из таких исследований было проведено на примере территории электростанции Гобу, которая будет построена на территории Гобу. Используя метод «Переломленные Микросейсмы» сейсморазведки был исследован разрез от поверхности участка до 100 м глубины.

Ключевые слова: сейсморазведка, метод «Переломленные Микросейсмы», скорость поперечных волн, сейсмостанция GEODE-24.

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