DYNAMIC AND KINEMATIC CHARACTERISTICS OF EARTHQUAKES OF SHEKI-OGUZ REGION

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In the article the strong 7-point earthquake, occurred on September 4, 2015, at 4 h. 49 m. in the border of Sheki-Oghuz regions is analyzed. The historical earthquakes of the studied area, tectonic structure, peculiarities of epicentral field, focus distribution in depth were studied, the macroseismic investigations were held. The most earthquakes intensity was observed in the territories of Gozlubulag, Yagublu, Turan, Sarich, Chaykarakoyunlu and others, recognized on the basis of macroseismic investigations. Seismic focus mechanism was determined on the base of wideband digital record of seismic waves, registered by 35 telemetry stations. It has allowed to establish that the earthquakes, occurred in Oghuz region on September 4, at 4 h. 49 m. and on October 13, at 00h. 13 m., occurred due to similar compression and tention intensities. The type of main shock motion on both planes is left-lateral fault.

Introduction

The strong earthquake with the magnitude of 5.9 points occurred in the border of Sheki-Oghuz region of Azerbaijan in 04: 09 with Greenwich Time, on September 4. The earthquake was felt in all territory of the republic also in neighboring areas. The epicenter of earthquake was 29 km southeast of Sheki. Earthquake was felt 7 points in epicenter and 6.5 points in surrounding territory of the republic.

According to the archive Macro seismic data, earthquakes have been recorded in this area, since 1875. Based on data of N.V.Malinovskiy, (1940) up to 35 (not higher than 7 points) earthquakes with weak seismicity in "Vartashen zone" of local earthquakes epicenter had occurred until 1928. Starting from the 1950's tangible earthquakes have occurred in this area. In 1953, 4 earthquakes, magnitude of 7-6 points in Oghuz (ml=4.6-5.4), the earthquake with 5 points in Sheki in 1963 (ml = 4.7), earthquakes with 6-5 percentage points (ml = 4.0-4.6) have been recorded during the period of 1972-1980 in Sheki. Earthquake magnitude of 4.5, h=14 km occurred in the area of Oghuz on March 9, 2000. Earthquake was felt 5 points in Oghuz, 4-3 points in Sheki, 3 points in Gabala (Гасанов, Абдуллаева, 2009).

The earthquake with magnitude of 5.3, h=22 km had occurred on the territory of Sheki, Oghuz on June 1, 2003. The earthquake was felt at intensity 6-5 points in Oghuz- Sheki and it had caused destruction. Earthquakes were felt in Mingachevir (4 points), in Kurdemir and Axti (3 point) with weak intensity. The main parameters of historical earthquakes in Sheki-Oghuz and the map of epicenter are shown in the table 1 and the figure 1.

Tectonic structure

With the tectonic position the main shock occurred on the border of Lankaran-Govdag and Vandam zones (Figure 2).

Lankaran-Govdag zone originates in the west of the Azerbaijani part of the southern slope, and expanding the band can be traced to the Caspian Sea coast. The zone is a flysch trough formed in the western segment of clastic-carbonate-clay deposits of the Upper Jurassic-Neocomian, crumpled in a small, highly compressed, overturned to the south isoclinal folds. On the east section supplemented the Upper Cretaceous flysch, but in the coastal strip – Paleocene-Miocene sediments. Here dominate comb folds with a lot of faults (Хаин, Ализаде, 2005).

Its southern wing area covers real allochthonous complexes Kakheti, Vandam Gobustan megazone. As the strike east-west Megazone is divided into two structural zones. In the west it is represented by Vandam geoanticlinal uplift, in the roof which are exposed Bajocian volcanogenic formation of carbonates of the Upper Jurassic and Neocomian flyshoids, and the wings are folded volcanic-sedimentary and sedimentary chalk Upper Paleocene-Miocene, complicated comb-shaped folding.

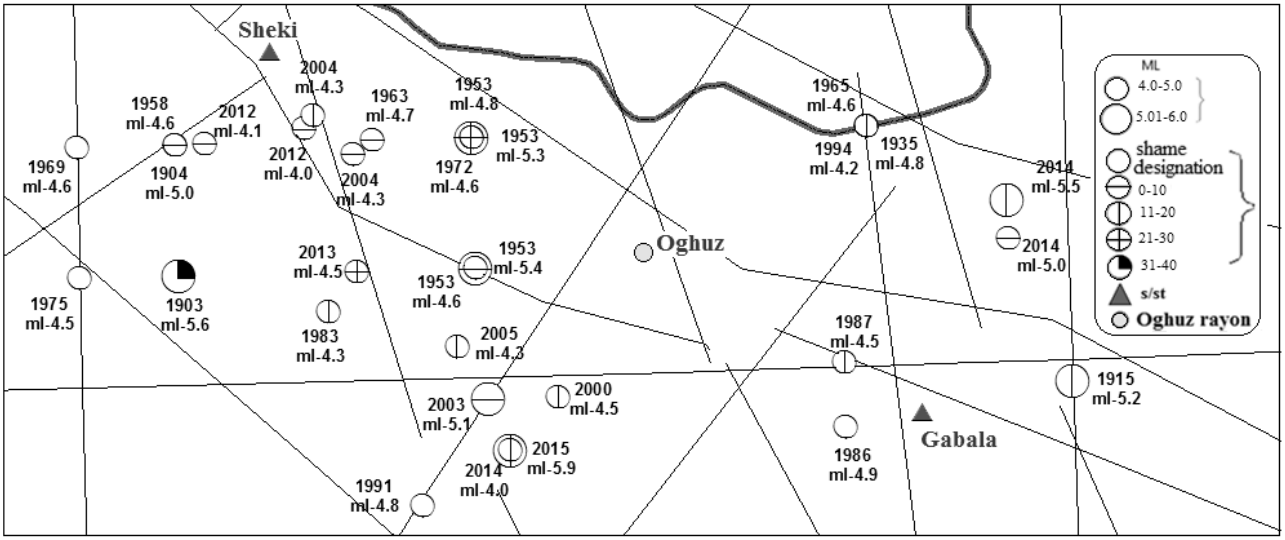

Fig. 1. The epicenters' map of historical earthquakes in the area of Sheki-Oghuz

Table 1

The main parameters of ml ≥ 4.0 earthquake in the Sheki-Oghuz-Gabala region during the 1903-2015 years

№	Date d.m.y	Time h.m.s.	Coordinates		H, km	ML	J_0	Note
			φ°.N	λ °.E				
1	02.11.1903	22-12±10м	41.10	47.10	36	5.6	6	Sheki
2	20.01.1904	02-00±1м	41.20	47.10	10	5.0	5	Sheki
3	06.10.1915	00-59 -27	41.00	48.00	15	5.2		Gabala
4	05.09.1935	22-38-28	41.20	47.80	15	4.8		Gabala
5	02.09.1953	00-36-01	41.10	47.40	5	5.4	7	Oghuz
6	02.09.1953	01-09-19.4	41.20	47.40	12	4.8	6	Oghuz
7	05.09.1953	05-29-32	41.10	47.40	8	4.6	6	Oghuz
8	16.09.1953	11-15-29	41.20	47.40	28	5.3	5	Oghuz
9	23.10.1958	12:05:20	41.20	47.10	7	4.6	6-5	Sheki
10	23.04.1963	06-39-19	41.20	47.30	5	4.7	7-6	Sheki
11	08.02.1965	11-43-51.0	41.20	47.80	9	4.6	6-5	Gabala
12	11.11.1969	15-08-49.0	41.20	47.00	17	4.6	5-4	Sheki
13	05.11.1972	13-06-41.1	41.20	47.40	5	4.6	6-5	Oghuz
14	20.10.1975	02-54-24.5	41.10	47.00		4.5	6-5	Sheki
15	23.07.1983	17-00-46.0	41.07	47.25	20	4.3		Sheki
16	02.06.1986	15-16-13.1	40.97	47.77		4.9		Gabala
17	14.08.1987	02-13-53.3	41.02	47.77	14	4.5		Gabala
18	21.10.1991	11-58-23.3	40.92	47.34		4.8		Sheki
19	19.12.1994	15-00-54.6	41.20	47.80		4.2		Gabala
20	09.03.2000	14-29-40.5	41.00	47.48	14	4.5	5	Oghuz
21	01.06.2003	6:09:44.1	41.00	47.41	9	5.1	6-5	Oghuz
22	08.02.2004	12-54-07.8	41.19	47.28	8	4.3	4	Sheki
23	08.02.2004	21-44-22.0	41.22	47.24	11	4.3	4	Sheki
24	08.11.2005	06-27-07.0	41.04	47.38	15	4.3	4-3	Oghuz
25	14.05.2012	9-58-17.4	41.20	47.13	6	4.1	5	Sheki
26	25.06.2012	20-05-57.5	41.21	47.23	7	4.0	4	Sheki
27	18.04.2013	20:38:51.7	41.10	47.28	25	4.5	3	Sheki
28	29.09.2014	1:38:07.2	41.14	47.94	13	5.5	5	Gabala
29	04.10.2014	4:59:32.7	41.11	47.94	6	5.0	5	Gabala
30	04.09.2015	4:49:37.0	40.96	47.43	16	5.9	7	Oghuz
31	13.10.2015	0:13:31.6	40.96	47.43	16	4.0	3	Oghuz

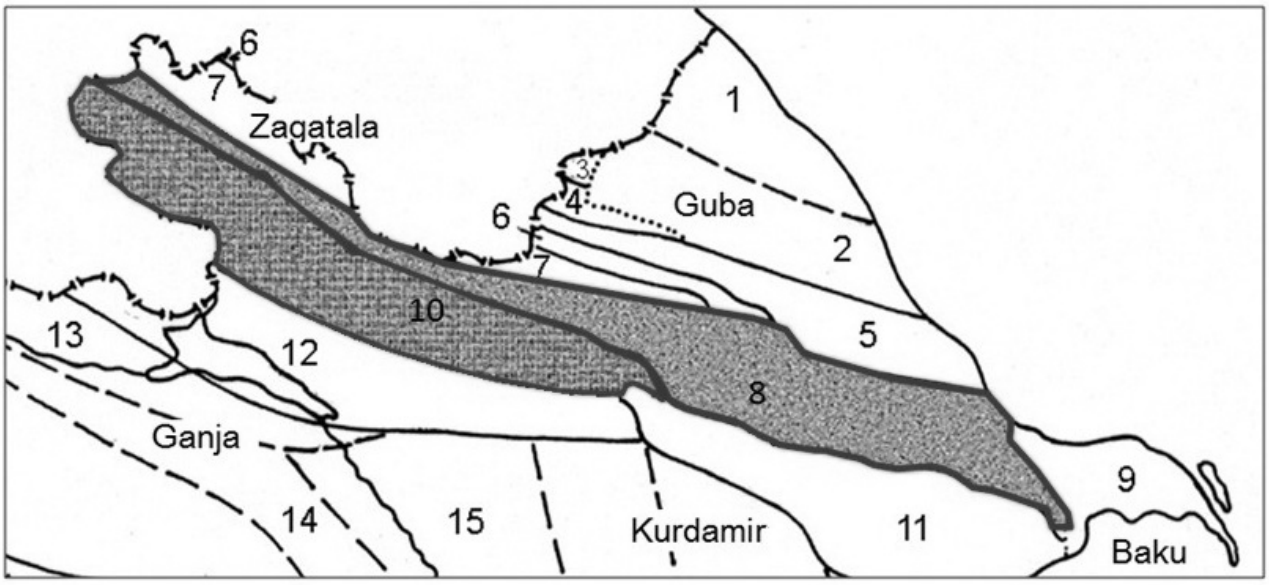

Fig. 2. Scheme of the tectonic zoning of the territory of Azerbaijan Republic. Compiled by T.N.Kengerli
Structural zone (figures in the diagram): 1-2 – Gusar-Davatchi megazone: 1 – Khachmaz; 2 – Guba; 3-6 – Megazone Side of the Great Caucasus Mountain Ridge: 3 – Tairjal; 4 – Sudur; 5 – Shakhdag-Khizy; 6 – Guton-Gonakhkend; 7-9 – Megazone of Southern slope of the Greater Caucasus: 7 – Sperozo-Tfansk; 8 – Zagatala-Govdag; 9 – Absheron; 10-11 – Khakhety-Vandam: 10 – Vandam; 11 – Shamakhy-Gobustan; 12-16 – Middle Kura megazone: 12 –Chatma-Ajinour; 13 – Jeyranchol; 14 – Lesser Caucasus; 15 – Yevlakh-Agjabedy

Most of the roof and the south wing uplift overlapped by continental molasses Pleistocene and modern alluvial proluvial formations (alluvial fan deposits of the southern slope of the rivers) Alazan-Ayrichay superimposed basin.

In the south the Vandam uplift on Ganikh-Ayrichay thrust borders with the northern wing of the Middle Kura depression. In the hanging wall of the thrust is Dashyuz-Amirvan strip uplifts composed of Pliocene-Quaternary sediments and presented by chain en echelon brachyanticline don't cut thrust of the southern wing (Хаин, Ализаде, 2005).

Seismicity

5 earthquakes with magnitude ≥ 3.2 had been recorded in Sheki-Oghuz zone in 2015. 2 tangible earthquakes had occurred in this zone. The strongest earthquake was registered with a magnitude of 5.9. Wave form of earthquake happened in Sheki-Oghuz in 04:09 on September 4 is shown in the figure 3.

After earthquake in Sheki-Oghuz which was occurred on September 4, 2015 the aftershock process have been sufficiently active. 35 aftershocks (fig. 4) had been recorded after the main shock during the first day. 86 aftershocks had occurred after strong earthquake.

Statistics of aftershocks in the source zones show that aftershocks had been continued until October 13. Tangible earthquake with ml=4 had been occurred in Oghuz on October 13.

The number of earthquakes occurred in the area of Sheki-Oghuz in 2015 and the distribution graphic (fig. 5) of seismic energy monthly shows that seismicity had been less than background level in the beginning of the year.

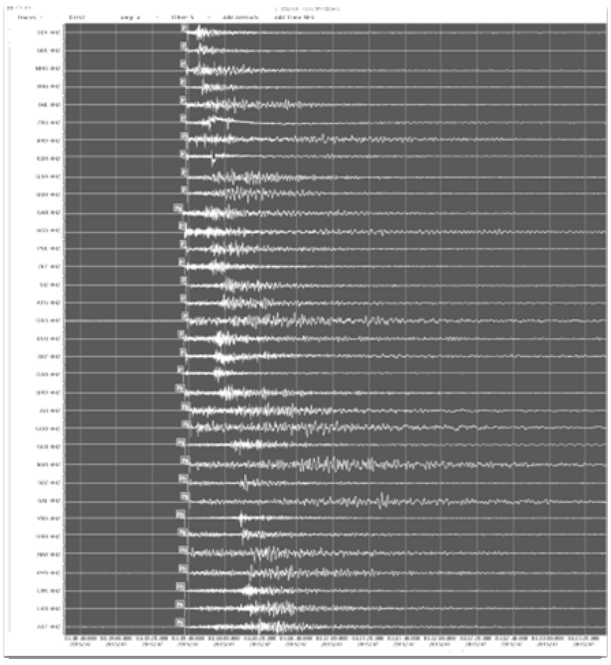

Fig. 3. The wave form of Sheki-Oghuz earthquake with magnitude 5.9 in 04:49 on September 4

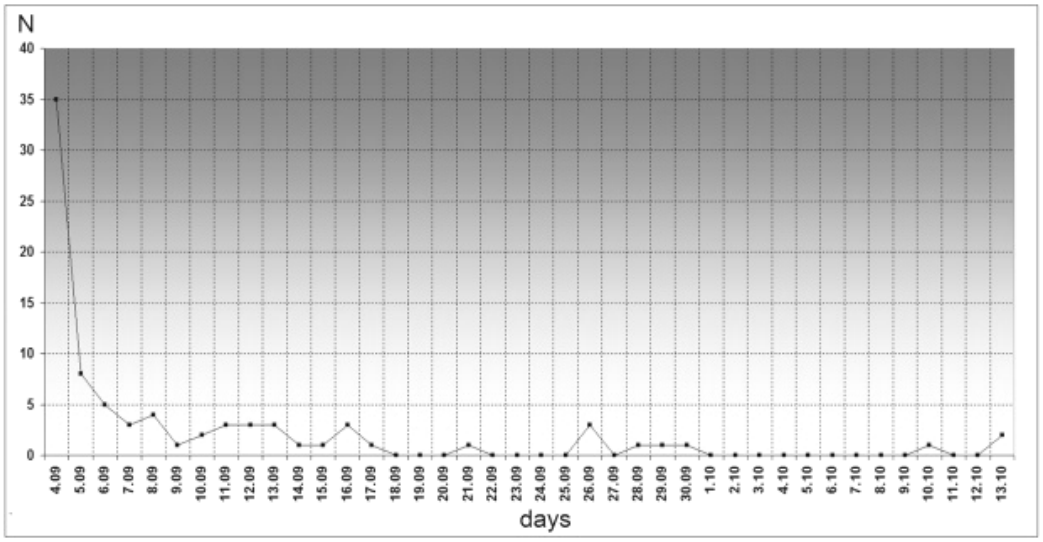

Fig. 4. Distribution histograms by days of earthquake's aftershocks which had occured on September 4, 2015

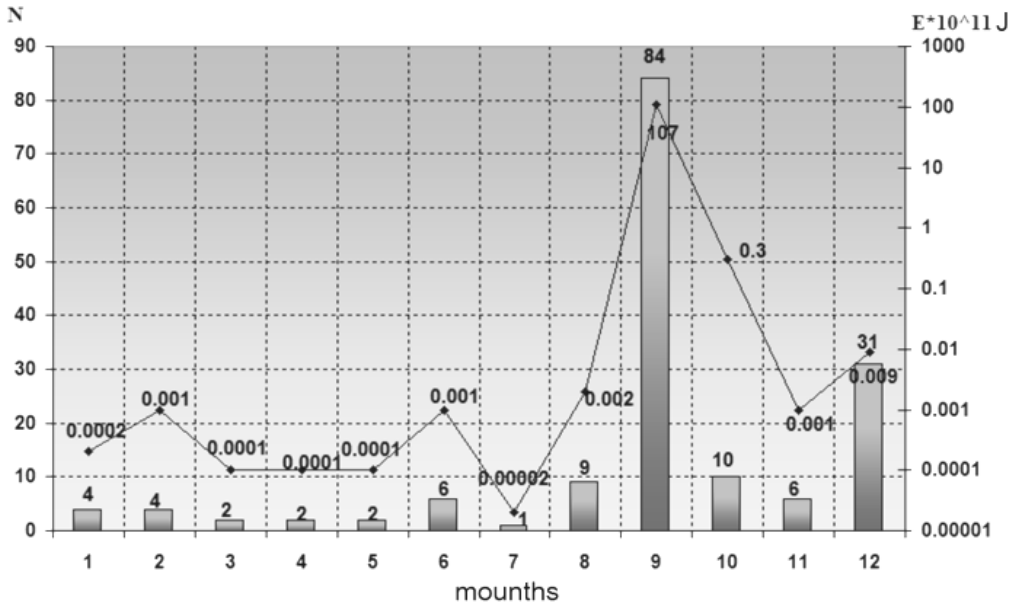

Fig. 5. Monthly distribution histogram of detachable energy and the number of earthquakes occurred in Sheki-Oghuz region in 2015

The sharp rise of number of earthquakes had been recorded from September. This higher quantity was connected with the strong earthquake. The high amount of seismic energy in September was connected with earthquakes and aftershocks. Since October, the number of earthquakes has been decreased, seismic energy with the exception of September was higher than in other months. This is due to the earthquake which occurred with ml = 4.0.

The epicenters map of earthquakes occurred in Sheki, Oghuz, Gabala zone is shown in figure 6. There are three source zones as seen on the map.

The distribution of source zones' earthquakes on the earth's crust was shown in seismic profile. The seismogeological profile direction from source zone earthquakes of Sheki, Oghuz, Gabala to the northwest and southeast (fig. 7). Active parts of Sheki, Oghuz, Gabala regions are clearly visible in seismogeological profil. Seismic activity in Sheki zone in 2015 was less than in 2014. The earthquakes of Sheki located in Vandam vertical and intersection zone of deep faults of Axway orthogonal.

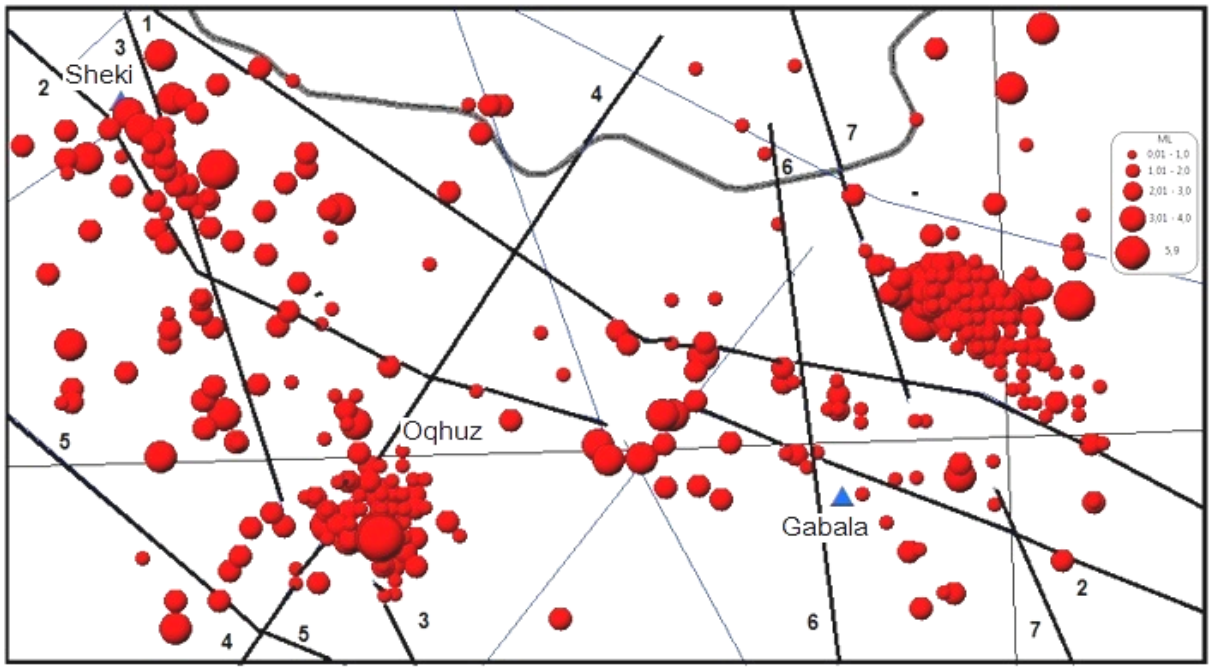

Fig. 6. The epicenter map of earthquakes occurred in Sheki, Oghuz, Gabala
Faults: 1. Dashgil-Mudrasa 2 Vandam (vertical) 3. Axway (orthogonal) 4. Barley-Samur (transverse) 5. Alazan-Ayrichay 6. Chaxirli Gabala (orthogonal) 7. Ismayilli-Sigirli (orthogonal)

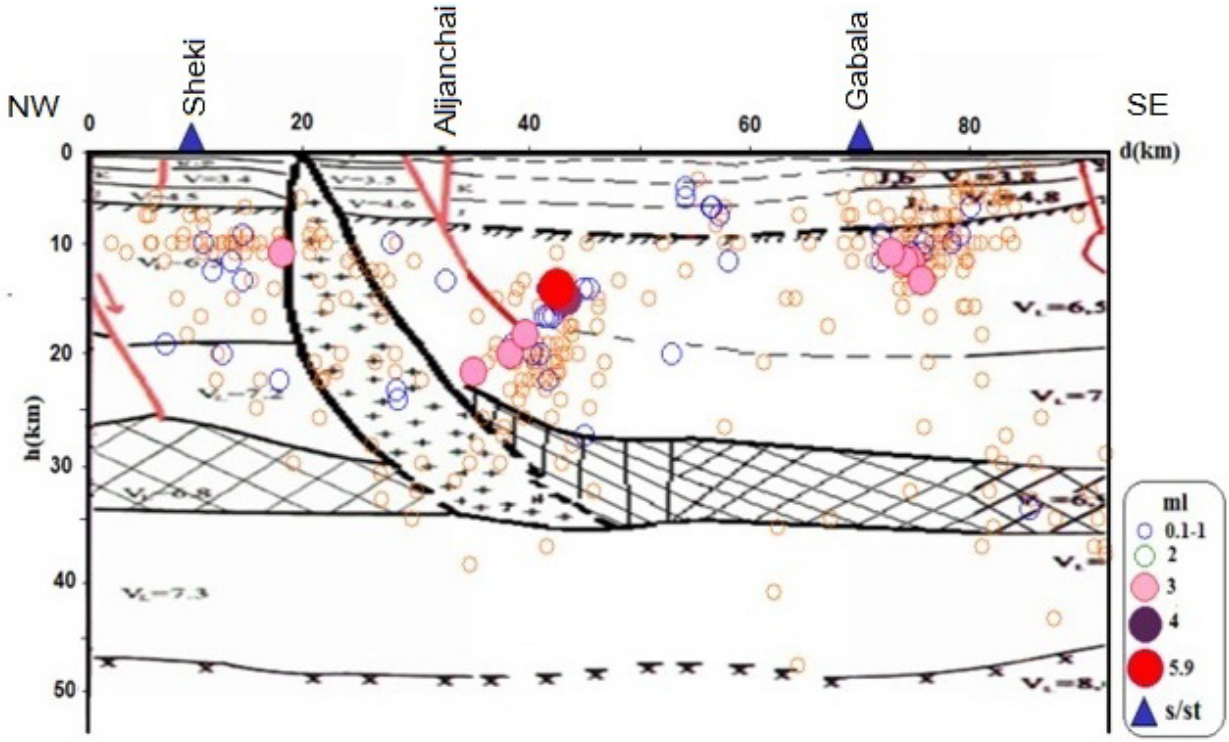

Fig. 7. I-I profile cutting seismogeological of Sheki, Oghuz, Gabala zones

Source earthquakes zones of Sheki distributed 7-25 km depth at earthquake with ml≥3.0, depth h=11 km. Oghuz earthquake epicenters spread in the deeper layers.

Oghuz earthquakes are located transverse deep fault of Arpa-Samur. Oghuz earthquake epicenters' depth is mainly 15-30 km. If ml≥3.0 depth distributed among the 16-22 km, depth of more strong source (ml=5.9) is 15 km. Earthquake epicenters are situated inside the consolidated layer.

The seismic activity in Gabala zone in 2015 was less than in 2014. It should be noted, in 2014, the earthquake occurred 5 times in the same area. The highest recorded earthquake magnitude was ml=5.5. The earthquake occurred 22 kilometers to the north-east of Gabala city at 06:38:07 on September 29. The earthquake was felt in the epicenter 6 points, in Gabala – 5 points, in most districts of the country – up to 3 or 4 points. In 2015, the earthquakes that occurred in Gabala, is located intersection zone of deep faults of Dashgil-Mudrasa and Ismayilli-Sigirli orthogonal. Earthquake epicenters' depth is mainly 2-16 km in Gabala. The sources are located both the inside of sedimentary layer and the upper part of the consolidated crust. Earthquake source zones with ml≥3.0 are spread between depths 11-14 km.

Microseismic field

While the survey, the people noted that there was buzzing sound on the surface, on the playstoseist territory of the earthquake in Gozlubulag, Yagublu, Turan, Sarija, Chaygaragoyunlu, Zarrab, Boyuksoyudlu, Padar settlements. At the same time, big clay soils were broken down from the precipice mountain slope of Chaygaragoyunlu rural, to the foot of the mountain (fig. 8-9) (Медведев, 1968).

It was determined on the basis of macroseismic research that the main shake was felt with the highest intensity in the territory of Gozlubulag, - Yagublu, Turan, Sarıja, Chaygaragoyunlu, Zarrab, Padar, Karimli, Boyuksoyudlu, Gayabashi, Jayirli, Shirinbulag, Aliyar, Boyuksoyudlu, Tapa and Garabaldir. The intensity of the earthquake in these territories, was assessed with 7 by 12 degree MSK-64 seismic table. The majority of the buildings in these regions affected more damage, were constructed with adobe and local riverbed stones. At the same time, there were cracks on the houses contructed with "kubik" stone (for example, there were 3 mm cracks on the house contructed with "kubik" stone, in Zarrab).

The isoseists map scheme of the earthquake was set up on the basis of gathered macroseismic data. The macroseismic area of earthquake has an extention in the direction of Great Caucasus Ridge. The playstoseist zone area was 23 km x 31 km=713 km^2. On the basis of macroseismic researchs have been defined coordinates of epicentre in φ =40.9^{0}N, λ =47.35^{0}E (fig.10).

The received macroseismic results were compared with the data of seismic stations network and the results of Eler v3 programme (ELER v3.0, 2010). The results calculated with each 3 methods, are almost the same till to the area of zones with intensity 4 (fig. 11).

Fig. 8. The slide of the fences in the village Yagublu

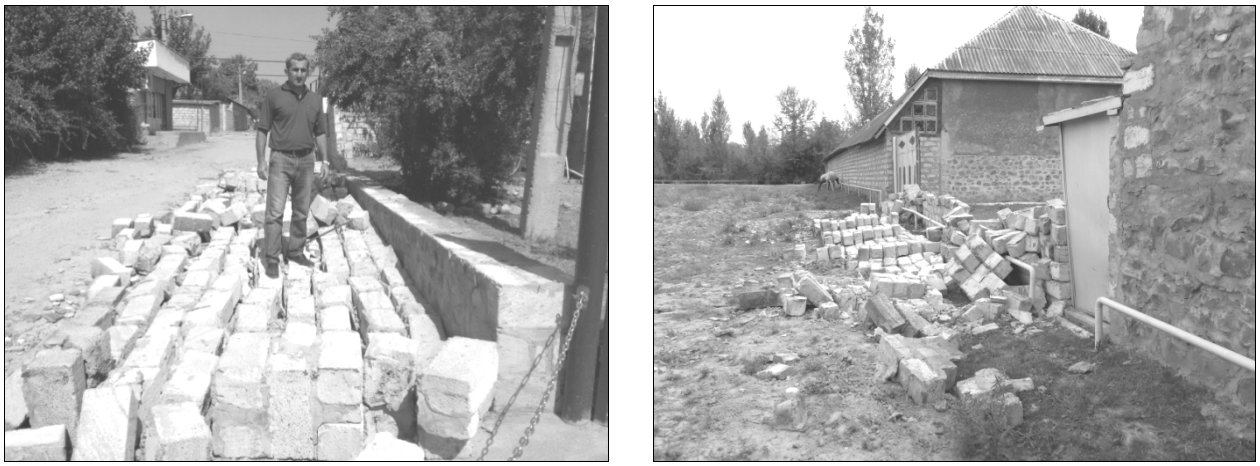

Fig. 9. The slide of the fences in the villages of Karimli and Padar

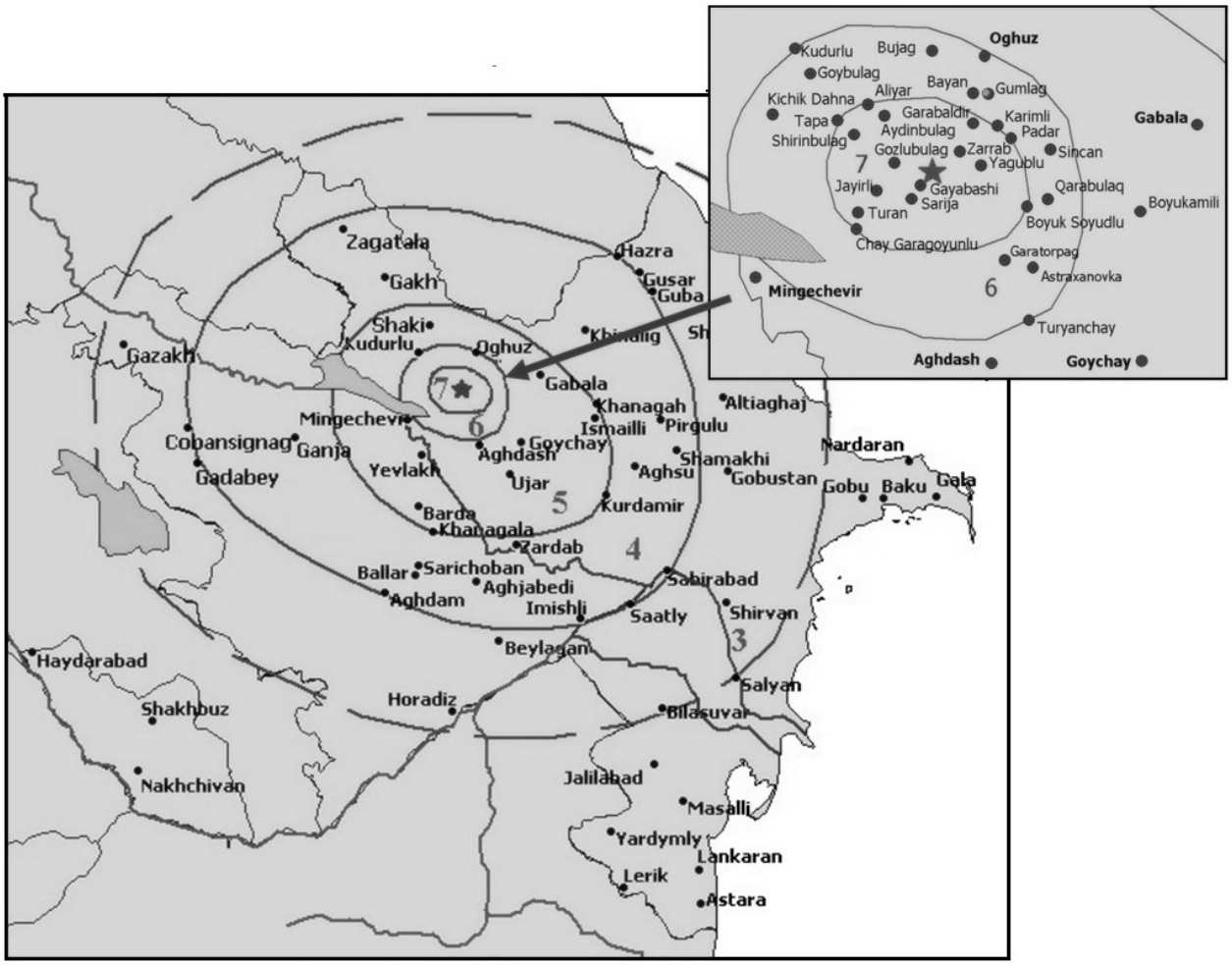

Fig. 10. The map scheme of the macroseismic playstoseist area of the earthquake happened on the border of Sheki-Oghuz on September 04, 2015

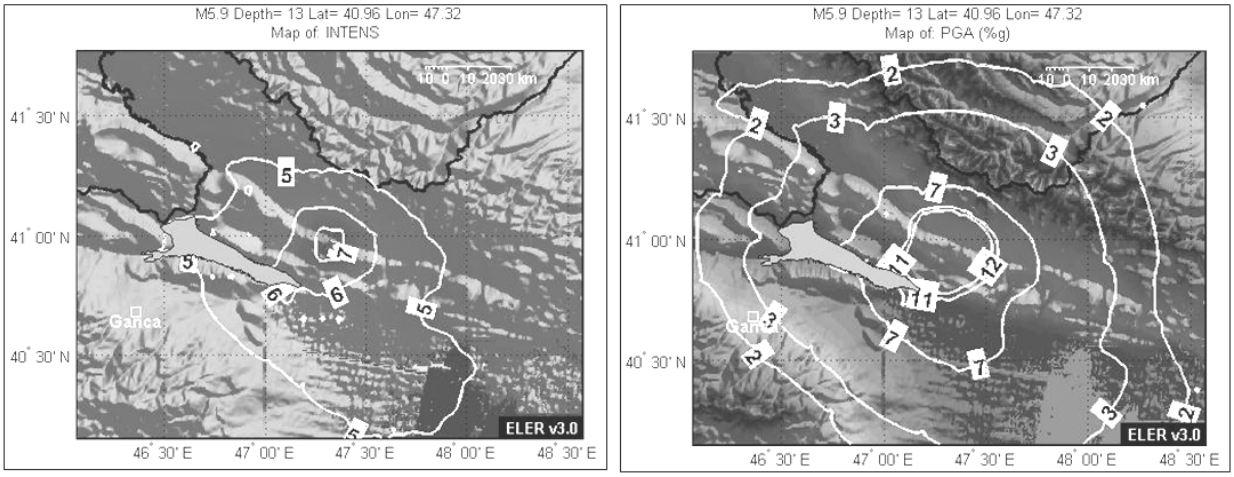

Fig. 11. The calculation of earthquake intensity and acceleration parameter manifestation in the surface with Eler v3.0 programme of the earthquake happened on the border of Sheki-Oghuz, on September 04 , 2015.

Focal mechanism solutions

In constructing the mechanisms were noted a well-established algorithm using the method of waveforms inversion – Time-Domain Moment Tensor INVerseCode (TDMT INVC), developed by Doug Dreger from the University of California, Berkeley (Dreger, 2002). This pack is used to calculate both the seismic moment tensor, as well as Mw.

Thus, were constructed and analyzed mechanisms of six earthquakes occurred within the study area in 2015 y.: 12.06.2015 with ml=3.1, 04.09.2015 with ml=5.9 (mail focus), 04.09.2015 with ml=3.2, 04.09.2015 with ml=3.3, 29.09.2015 with ml=3.3 and 13.10.2015 with ml=4.0 (fig. 12). Earthquakes are plotted on the scheme of the fault structure and features of geodynamic regime of the southern slope and the south-east dipping of the Greater Caucasus (Rzayev et al., 2013).

Analysis of the mechanisms of earthquakes foci data showed the prevalence of the two types of shifts. Earthquake in Sheki region on June 12 at 19:26:57 on September 04 4:55:41 and on September 04 9:38:44 occurred under the influence of near-horizontal compressive and near-vertical tensile stresses. Type reversed fault shifts with elements of right-shift that are associated with the influence of the longitudinal Vandam and transverse Arpa-Samur faults.

Earthquake in Oghuz region on 4 September 4:49:36, 3:06:39 29 September and October 13 at 00:13:31 occurred under the influence of almost equal tensile and compressive stresses. Table 2 shows that the first nodal gap plane extends in the southeast direction (153-318°) with a fall in the south-west at an angle of 86-90°, the second nodal plane has a NE trending (63-222°) with a fall in the south-east at an angle 83-90°. Type shifts of these earthquakes – a shift from the left-side horizontal component.

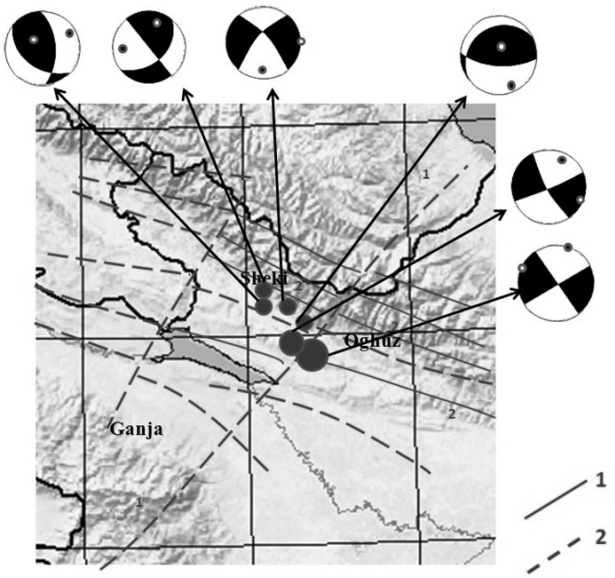

Fig. 12. The focal mechanisms of earthquake of Sheki and Oghuz regions occurred in 2016

The Oghuz epicenters of earthquakes are confined to the Arpa-Samur fault and can be interpreted as a left-lateral strike-slip deformation in the zone of influence of geodynamic left-lateral Arpa-Samur fault. It should be noted that Arpa-Samur ancient deep fault inception at all times from the Paleozoic by now is a zone of active tectonic movements, conductor of magmatic melts, ore-bearing fluids and seismicity.

Table 2

Focal mechanisms parameters of Sheki-Oghuz Earthquake 2015

№	Data *y m d*	t_0. *h min s*	*h*. *km*	Magnitude *ml*	Main axes of stresses						Nodal plane					
					T		*N*		*P*		*NP1*			*NP2*		
					PL	*AZM*	*PL*	*AZM*	*PL*	*AZM*	*STK*	*DP*	*SLIP*	*STK*	*DP*	*SLIP*
1	20150612	19:26:57	11	3.1	28	16	49	143	28	270	143	90	41	53	49	180
2	20150904	04:49:36	16	5.9	0	288	90	171	0	18	153	90	-180	63	90	0
3	20150904	04:55:41	21	3.2	63	40	20	263	17	166	93	65	113	228	33	50
4	20150904	09:38:44	20	3.3	64	316	25	157	8	63	354	58	120	127	43	52
5	20150929	03:06:39	24	3.3	0	90	65	0	24	180	318	73	-162	222	73	-18
6	20151013	00:13:31	16	4.0	2	287	82	180	7	18	153	86	-172	63	83	-4

Table 2 shows the stereogram of earthquakes focal mechanisms of the two earthquakes - the main shock and the strongest aftershocks, the displacement block diagram of NP2 plane corresponding to the specified fault. It must be noted, that analysis of the focal mechanism which occurred on September 29 in t=3:06:39 with ml = 3.3 showed the normal fault shifts, which is due to the influence of the North Adjinour normal fault longitudinal fault.

Results

Thus, the considered focal zone, located within the Lankaran-Govdag and Vandam zones has been characterized by high seismic activity since 1953 and continues to this day, periodically on average once every 9 years with an intensity of 6-7 points in the source.

It was determined on the basis of macroseismic research that the main shake was felt with the highest intensity in the territory of Gozlubulag, Yagublu, Turan, Sarıja, Chaygaragoyunlu, Zarrab, Padar, Karimli, Boyuksoyudlu, Gayabashi, Jayirli, Shirinbulag, Aliyar, Boyuksoyudlu, Tapa and Garabaldir. The intensity of the earthquake in these territories, was assessed with 7 by 12 degree MSK-64 seismic table.

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