

FOCAL PARAMETERS OF ISMAYILLI EARTHQUAKE OF OCTOBER 7, 2012

S.S.Ismayilova¹, S.E.Kazimova¹, G.I.Muradova¹, Sh.N.Khadidji¹, E.Kh.Muradova¹

Introduction

Analysis of the results of seismic studies of the Azerbaijan part of the southern slope of the Greater Caucasus in recent years has shown that there is a tendency of the distribution of seismogenic zones along the borders of all-Caucasian structures. That is, with a general activation along the junction zone of the Kura depression and the Greater Caucasus (or the zone of underthrust), longitudinal faults occur along the transverse faults. As the analysis shows, in most cases, the hypocenters of earthquakes are located in the upper part of the Earth's crust, which indicates elastic deformations of the stresses of the Earth's crust.

Seismic information obtained from 35 seismic stations allows us to investigate the seismic regime of the considered territory, identify areas of seismic activity, establish focal zones, as well as the mechanisms of earthquake sources. The sources of earthquakes, as a rule, are confined to the boundaries of the tectonic blocks of the Earth's crust, squeezed in a band of collisional interaction of the Arabian and Eurasian plates, and are associated with their movements. Beginning in 2012, an outbreak of seismicity was observed on the southern slope of the Greater Caucasus, which was accompanied by the occurrence of a number of strong earthquakes with a magnitude higher than 5.0, one of which was the Ismayilli earthquake.

Macroseismicity

The macroseismic field was studied using the ELER v3.0 program. The intensity at the epicenter of this earthquake on a 12-point scale was estimated at 6 points (Fig. 1), in the nearby settlements of Pirkulu, Shamakhi, Ismayilli, Akhsu, the earthquake was felt up to 4-2 points. According to instrumental observations, the coordinates of the earthquake are: $\varphi = 40.70^{\circ}\text{N}$, $\lambda = 48.35^{\circ}\text{E}$ and the depth is 41 km.

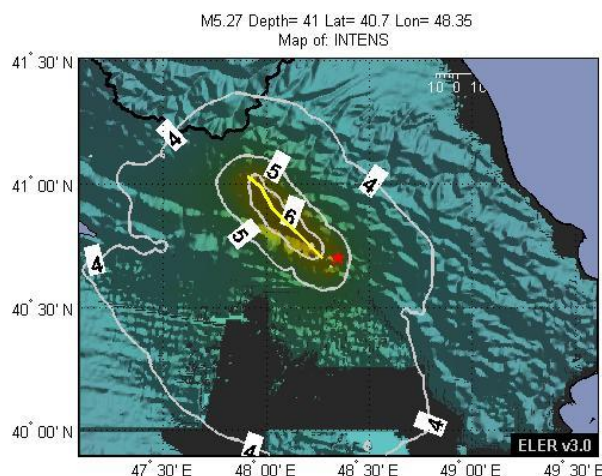


Figure 1. Isoseist map-scheme of the Ismayilli earthquake of 07.10.2012

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

According to the data obtained for the Ismayilli earthquake by RSSC ANAS were compiled schemes of distribution of accelerations (PGA) and velocities (PGV) of the soil (Fig.2). The PGA value was 0.25 g, and the PGV value was 10 cm/sec.

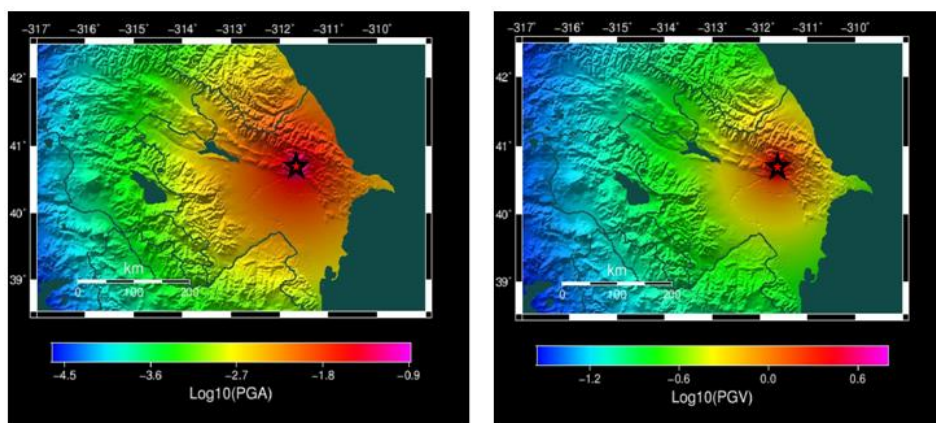


Figure 2. Schemes of the distribution of accelerations (PGA) and velocities (PGV) of the soil of the Ismayilli earthquake

Seismicity

The Shamakhi-Ismayilli focal zone is located within the south-eastern segment of the Greater Caucasus and is characterized by a complex step-block structure. It is supposed [Ahmedbeyli et al., 2010] that the tectonic steps in the pre-Alpine basement are complicated by a series of steeply dipping, forming lowered and elevated blocks of transverse and longitudinal faults, which in the Mesozoic-Cenozoic complex were transformed into gentle upthrusts and thrusts. Based on the works [Kerimov, Shikhalibeyli, 1992 and Kengerli, 2007], a diagram of the main elements was compiled, on which the epicenters of earthquakes within the study area with $m_l \geq 0.5$ for 2012 of the discontinuous tectonics of the Shamakhi-Ismayilli focal zone (Fig. 3) are applied. For the 2012 year, 298 shocks were recorded within the Ismayilli seismogenic zone. Of these, 7 earthquakes were with the magnitude $m_l \geq 3.0$, 2 of which were felt. Figure 5 shows the wave record of the Ismayilli earthquake on the HHZ component.

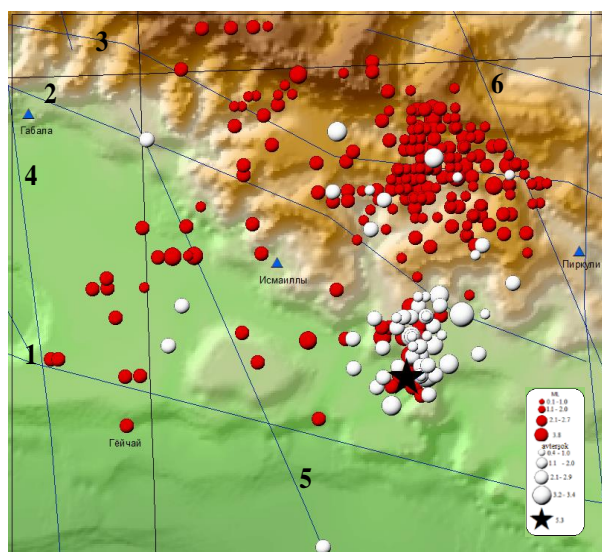


Figure 3. Map of the epicenters of the main shock and aftershocks of the 2012 Ismayilli earthquake.

Faults: The All-Caucasian Direction: 1 - Alazan-Agrichay-Alyat; 2 - Vandam; 3 - Dashgil-Mudrasa; Orthogonal faults: 4 - Chakhirli-Gabele; 5 - Ismayilli-Gabele; 6 - Tairaljachay-Salyan

On October 7, after a strong shock, 23 aftershocks were registered on the first day (Fig. 4).

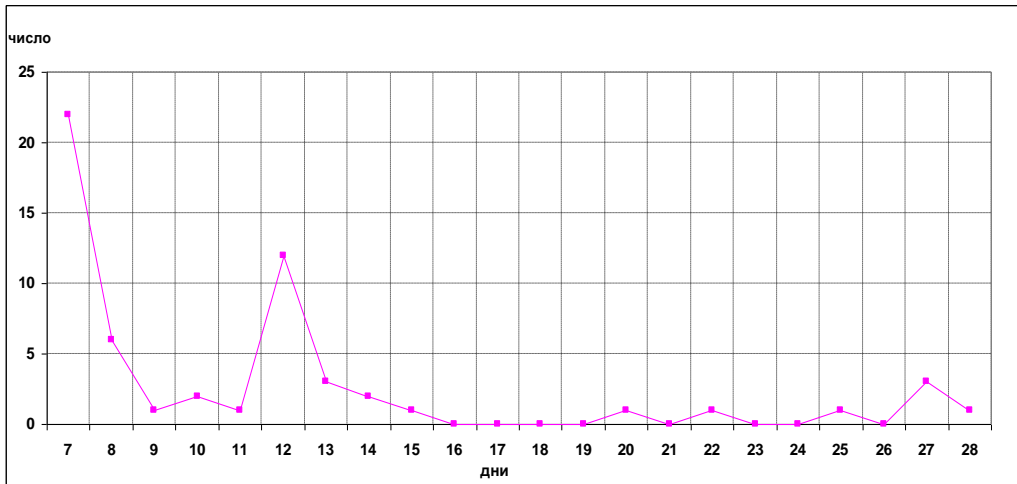


Figure 4. Histogram of the aftershocks of the Ismayilli earthquake of October 7, 2012

Analysis of aftershocks in the focal zones shows that, starting from October 28, a sharp decrease in the number of earthquakes is observed. Seismicity decreased to background level. Chart 5 shows that starting from April (except for July), seismic activity decreases, and already in September, seismic energy from $0.001 \cdot 10^{11} \text{J}$ increased to $0.065 \cdot 10^{11} \text{J}$ and reached its maximum in October equal to $14.8 \cdot 10^{11} \text{J}$.

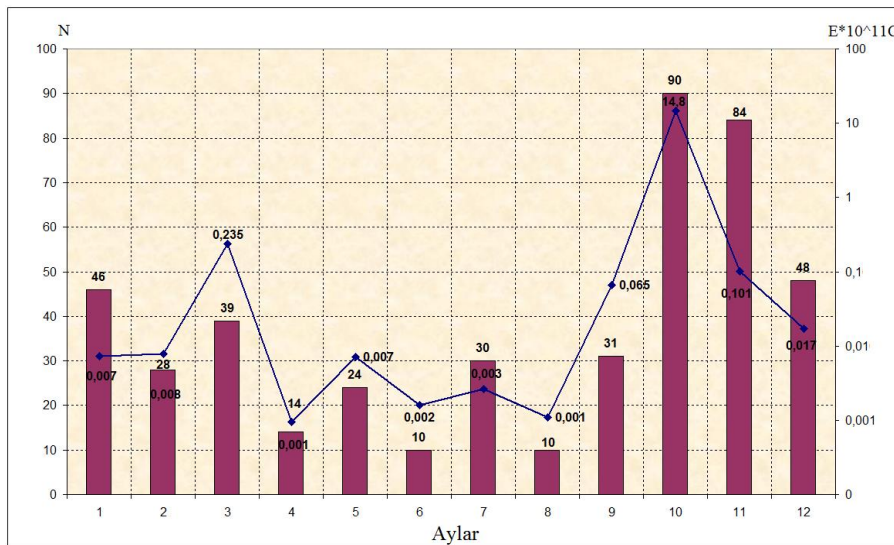


Figure 5. Histogram of the distribution of the number of earthquakes and seismic energy released in Ismayilli region

According to archive macroseismic data, in this zone since 1915, 34 (not more than 7 points) strong earthquakes (Fig.6) were recorded [2].

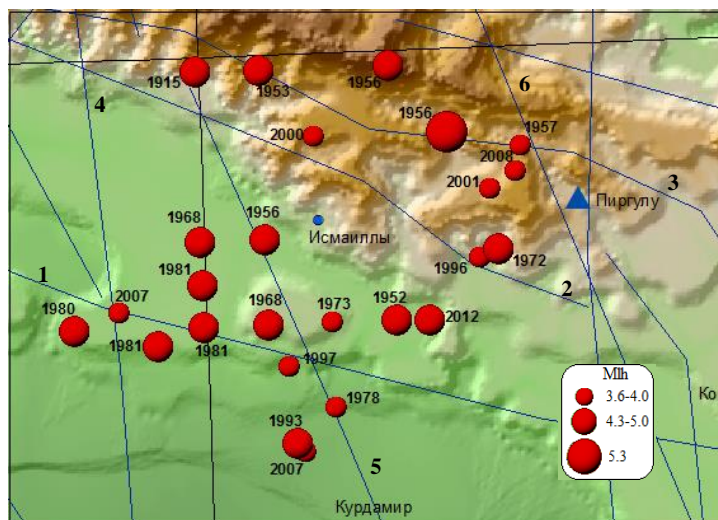


Figure 6. Map of epicenters of historical earthquakes in the Ismayilli seismogenic zone.

Faults: The All-Caucasian Direction: 1 - Alazan-Agrichay-Alyat; 2 - Vandam;
 3 - Dashgil-Mudrasa;
 Orthogonal faults: 4 - Chakhirli-Gabele; 5 - Ismayilli-Gabele;
 6 - Tairaljachay-Salyan

The strongest of these earthquakes was the earthquake of 1956 with a magnitude of $m_l = 5.8$ and an intensity of 7 points. Table 1 shows the parameters of historical earthquakes of the Ismayilli zone for 1915-2012.

Table 1. Parameters of epicenters of historical earthquakes occurred within the region under study.

№	Date д м год	t_0 Ч мин с	Epicenter		h, км	ML h	ML h*	ML	K_p	I_0 , балл	Notes	Source
			φ^0, N $\pm \delta \varphi^0$	λ^0, E $\pm \delta \lambda^0$								
1	06.10.1915	00-59 -27 $\pm 10c$	41.00 ± 0.5	48.00 ± 0.5	15 5-50	4.6 ± 0.5			12.3			[11]
2	11.07.1952	05-35-08 $\pm 5c$	40.70 ± 0.1	48.30 ± 0.1	4 2-5	4.3 ± 0.5			11.7	7 ± 0.5	Shamakha-7	---
3	11.07.1952	06-18-59 $\pm 5c$	40.70 ± 0.1	48.30 ± 0.1	3 2-5	4.3 ± 0.5			11.7	7 ± 0.5	Shamakha -7	---
4	30.04.1953	15-45-24 $\pm 5c$	41.00 ± 0.1	48.10 ± 0.1	20 14-30	5.0 ± 0.2			13.0	6 ± 0.5	Gabala- 5	---

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5	18.03.1956	03-55-39 ±2c	40.80 ±0.1	48.10 ±0.1	11 5-22	4.5 ±0.5			12.1	5-6 ±0.5		--
6	20.03.1956	16-19-20 ±2c	41.00 ±0.2	48.30 ±0.2	11 5-22	4.5 ±0.5			12.1	5-6 ±0.5		--
7	21.03.1956	04-54-48 ±1c	40.92 ±0.1	48.39 ±0.1	8 5-12	5.3 ±0.3			13.5	7-8 ±0.5	Shamakha-7	--
8	08.06.1957	16-45-42 ±2	40.90 ±0.1	48.50 ±0.1	10 7-15	4.0 ±0.5			11.2	5 ±1		--
9	05.02.1968	13-34-10.0 ±1c	40.80 ±0.2	48.00 ±0.2	7 3-14	4.4 ±0.5			11.9	5-6 ±1	foreshock	--
10	17.06.1968	04-59-02.0 ±1c	40.70 ±0.2	48.10 ±0.2	7 5-10	4.6 ±0.2			12.3	6-7 ±0.5	Ismayilli-6	--
11	03.02.1972	02-29-19.0 ±1c	40.78 ±0.1	48.46 ±0.1	5 ±5	4.9 ±0.2			12.8	6 ±1		--
12	26.10.1973	13-11-49.0	40.70	48.20			3.9	4.5	11.0			--
13	09.06.1978	00-13-38.0	40.60	48.20			3.9	4.5	11.0	3-4	Shamakha – 3. J ₀ = 4	[22]
14	01.04.1980	07-33-41.0	40.70	47.80			4.3	5.0	11.8	4-4.5	Gabala- 3-4.5	--
15	29.11.1981	23-37-30.0	40.75	48.00	10		4.8	5.6	12.6			--
16	02.12.1981	00-51-36.0	40.68	47.93	15		4.7	5.5	12.4			--
17	04.12.1981	02-35-36.0	40.70	48.00	10		4.3	5.0	11.8			--
18	09.12.1981	18-54-38.0	40.80	48.00	10		3.9	4.5	11.0			--
19	14.12.1981	05-01-52.0	40.80	48.10			3.9	4.5	11.0	3-5	Ismayilli-3-5	--
20	12.07.1982	05-04-35.0	40.70	48.30	10		3.9	4.5	11.0	3	Ismayilli-Lagich- 3-46. Shamakha – 3. Pirkulu – 46	--
21	13.11.1987	02-51-10.0	40.70	47.80	13		3.8	4.3	10.8	3	Ismayilli-36	--
22	15.10.1993	22-37-14.2	40.56	48.14	19		4.3	4.9	11.7	5.5	Ismayilli-56	--

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23	09.05.1996	10-58-37.8	40.77	48.43	14		3.9	4.4	11.0	3.5	Guba. Shamakha - 3-56	--
24	19.10.1997	07-51-06.8	40.65	48.13	49		3.7	4.2	10.7	3.5-4.5	Ismayilli -3.5-4.06	--
25	10.03.2000	14-20-35.6	40.92	48.18	19		3.9	4.4	11.0		Ismayilli-46	--
26	26.11.2001	05-24-19.8	40.85	48.45	19		4.0	4.6	11.3	4	Pirkulu -3-46. Shamakha -36	--
27	08.06.2007	05:54:35.1	40.72	47.87	32		3.6	4.1	10.5			--
28	12.12.2007	10-25-30.5	40.55	48.15	24		3.7	4.2	10.7	3.5	Shamakha-3.5. Pirkulu -36	--
29	19.12.2008	15:11:3.2	40.87	48.49	5		3.9	4.4	11.0	5	Pirkulu. Demirchi-4.5. Shamakha-46. Ismayilli-3.56	--
30	07.10.2012	11-42-50.6	40.70	48.35	41		4.5	5.3	12.2	4-5	Pirkulu. Shamakha. Ismayilli. Akhsu-56	--

Note. Information for the years 1980-2012 borrowed from the annual catalog of earthquakes in Azerbaijan; in parentheses are calculated by the formula $M = (Cr-4) / 1.8$ [2] values of M and Cr.

Considering that large thrusts have specific angles of incidence, as, incidentally, faults, it is difficult to draw conclusions about the connection between earthquake sources with certain discontinuous dislocations from the Fig.4 shown in the epicenter map. For this reason, a seismological section was made along the NW-SE profile of the strike through the study area (Fig. 7.).

As can be seen in the Figure, two groups of earthquake hypocenters are distinguished here — the Ismayilli ones characterized by deeper foci of 30–40 km and the Shamakhi foci [Kengerli., 1988]. The surface of the consolidated crust clearly stands out. From the north-west to the south-east there is a horizontal occurrence of the basement surface, and from the Shamakhi meridian there is a tendency of gradual immersion of the basement surface to 15 km in the Maraz region.

The main number of aftershocks of the Ismayilli earthquake is concentrated in the zone of intersection of multidirectional faults in the central part of the profile. Analyzing the distribution of hypocenters in depth, it can be noted that a large number of earthquakes are associated primarily with the North Ajinour strike-slip fault. The characteristic hypocenters to the plane of the North-Ajinour fault, traced in the interval of depths of 5-10 km and 30-45 km, suggest that the roots of this fault are in the Pre-Alpine basement.

As for the earthquake focal mechanisms of this zone, they first of all confirm the strike-slip fault and shift component of the movements along the West Caspian fault, further characterizing its high seismic activity and deep penetration to depth, noted in work of [Aslanov, 2005]. The source of the Ismayilli earthquake was characterized by horizontal ($PL_T=0^\circ$) tensile south-west orientation ($AZM = 212^\circ$) and near vertical compressive ($PL_R=83^\circ$) south-east orientation ($AZM=122^\circ$) stresses (Fig.8). The type of motion along both ($DP=45^\circ$) planes is a fault. The NP1 plane has a south-east strike ($STK_1=128^\circ$), and NP2 has a north-west strike ($STK_2=295^\circ$). Comparison of the strike of the nodal planes with the fault lines shows the agreement of both nodal planes with the strike of the North Ajinour strike-slip fault (Table 2).

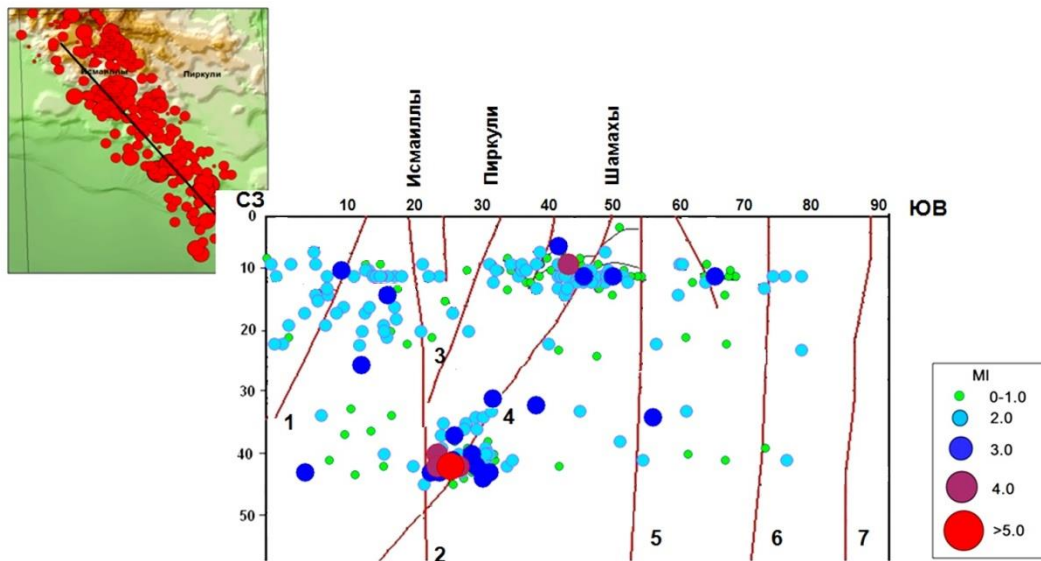


Figure 7. Seismological section along profile I - I of the Shamakhi-Ismayilli seismogenic zone
 Faults: 1- Dashgil-Mudrasa; 2-Girdmanchay; 3- Vandam; 4-North Ajinour; 5- Astara-Derbent; 6-Kelbajar-Jiloy; 7-Palmir-Absheron

Table 2. Parameters of the source mechanism of the Ismayilli earthquake 07.10.2012

№	Data, d m y	t_0 , h min s	h, km	ml	Mw	Coordinates of the sources		Nodal planes					
						latitude	longitude	NP1			NP2		
								STK	DP	SLIP	STK	DP	SLIP
4	20121007	11-42-50	41	5.3	5.1	40.70	48.35	128	45	-81	295	45	-98

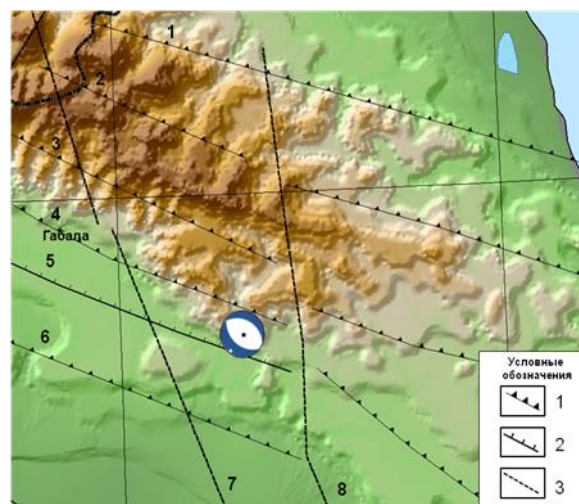


Figure 8. Focal mechanism of the Ismayilli earthquake on October 7, 2012

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