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CONTEMPORARY SEISMOGEODYNAMIC SITUATION OF AZERBAIJAN

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

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

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

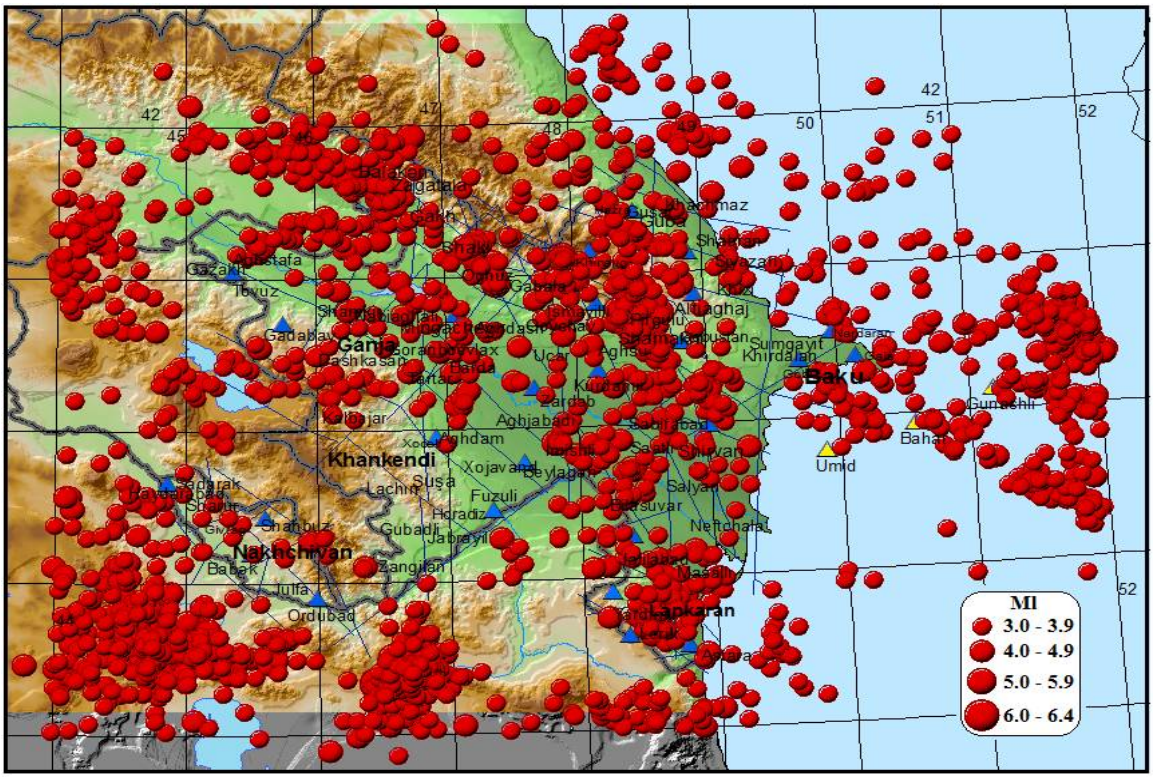

Figure 1. Map of earthquake epicenters of Azerbaijan for 2003-2017 with ml>3.0

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

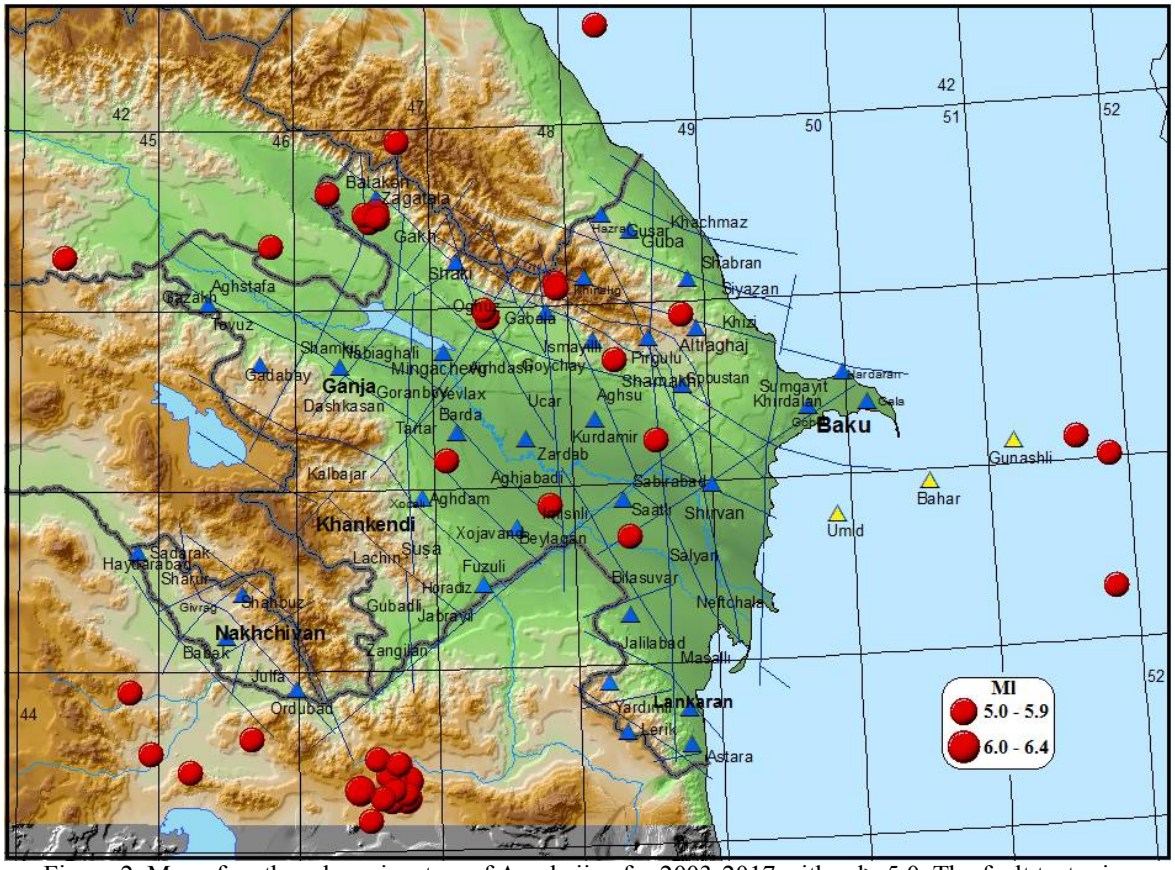

Figure 2. Map of earthquake epicenters of Azerbaijan for 2003-2017 with ml> 5.0. The fault tectonics [Kengerli TN, 2007]

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

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

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

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

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

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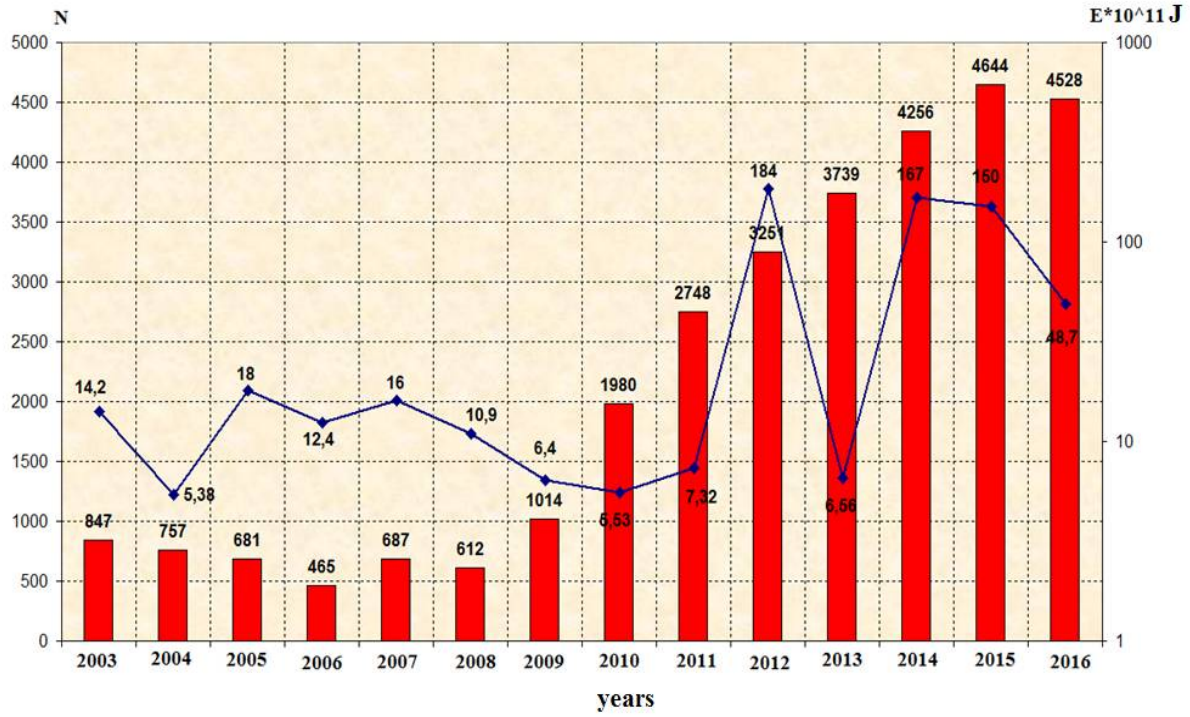

Figure 3. Graph of distribution of the number of earthquakes and released energy by years for the period of 2003-2016

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

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

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

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

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

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

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

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

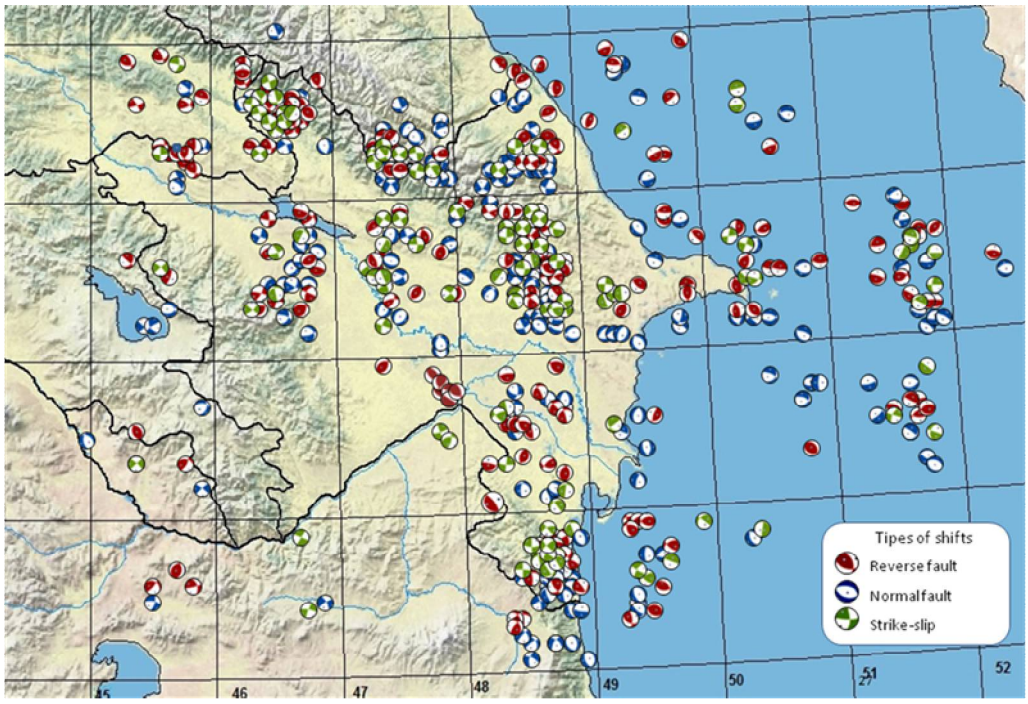

Figure 4. Map of distribution of earthquake source mechanisms for 2003-2017yy.

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

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earthquakes is interpreted as a fault-shear deformation in the zone of geodynamic influence of Ismayilli-Sygyrly orthogonal and shear deformation with elements of dumping in the zone of influence of the left-sided Arpa-Samur transverse fault.

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

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

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

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

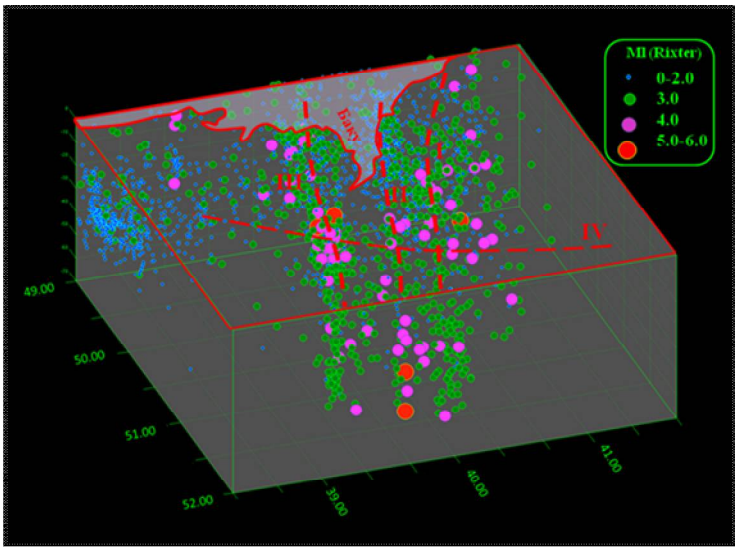

Figure 5. Volumetric model of distribution of hypocenters of earthquakes in the Caspian Sea
Faults: 1 - Central Caspian, 2 - Absheron-Nearbalkhan, 3 - Sangachal-Ogurchy, 4 - Central Caspian. The fracture tectonics of [Shihalibeyli E.S., 1996]

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

Conclusion

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

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

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

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