QUANTITATIVE ASSESSMENT OF SEISMIC HAZARD IN THE AZERBAIJANI PART OF THE SOUTHERN SLOPE OF THE GREATER CAUCASUS

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The territory of Azerbaijan, which is part of the Alpine fold system, is characterized by quite high seismic activity. According to its geological structure and seismic features, the area can be divided into several large zones: the southern slope of the eastern part of the Greater Caucasus, the Kura basin, the northern slope of the Lesser Caucasus, the Gusar-Davachi basin, the Caspian Sea.

The map of epicenters of strong (M≥5,0) earthquakes [1; 2; 3; 4] from 427 year to the present, is an indicator of high seismic activity in the territory of Azerbaijan (Fig. 1).

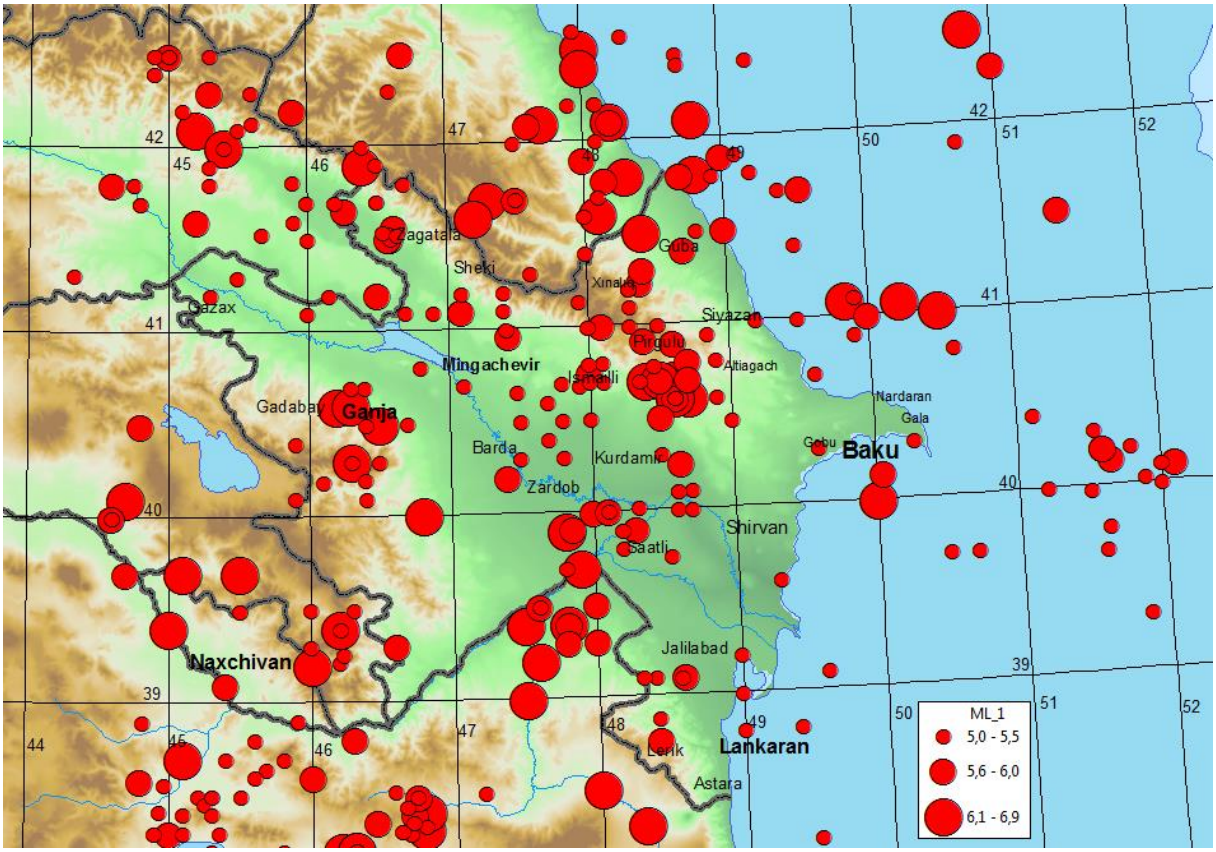

Fig. 1. The epicenters map of strong (M≥5,0) earthquakes occurred in Azerbaijan and adjacent areas during 427-2019 years

Analysis of the spatial distribution of thousands of weak and medium-magnitude earthquakes (an average of 600-800 shocks are recorded each year) registered in the country shows that the earthquakes are unevenly distributed (Fig.2). The vast majority of these earthquakes occur on the southern slope of the eastern part of the Greater Caucasus. Studies show that seismic shocks are unevenly distributed within this zone [5, 6].

They are concentrated in some places and in the remaining areas, few of them are noted. Analysis of the spatial distribution of strong earthquakes (M≥5) shows that they occur mainly in areas where weak earthquakes are concentrated. Strong earthquakes in this region (M≥5.0) occur at shallow depths (10-15 km) and this affects the effect of their manifestation on the Earth's surface, especially in the Pleystoseyst zone. The strongest earthquakes in the eastern part of the Greater Caucasus occurred in the Shamakhi region (Fig. 1). The magnitude of some of them varies between 6.0 ÷ 6.9 points. These earthquakes have been felt at the epicenter with an intensity of up to 9 point on the MSK-64

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scale [1]. The city of Shamakhi was repeatedly destroyed and there were numerous casualties. In other parts of the region, earthquakes with a magnitude of > 6.0 have not been recorded [2, 3, 4]. However, earthquakes with magnitude of 5.0-6.0 have been also quite strong at the epicenter, earthquake with magnitude of 7 according to the MSK-64 scale. The last time such a strong earthquake (M = 5.7) occurred in Zagatala in 2012, many houses were damaged, there have been a number of wrecks, fortunately there were no casualties.

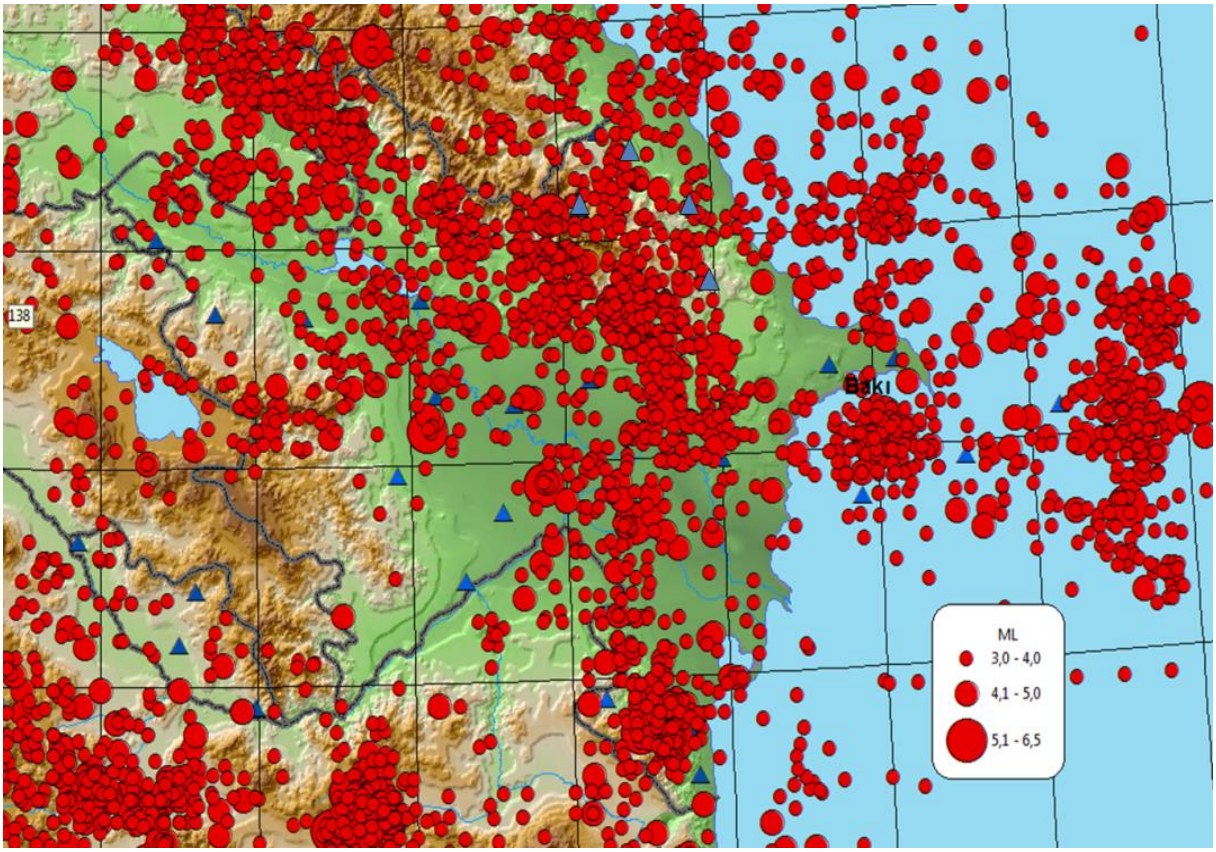

Fig.2. The epicenters map of earthquakes with magnitude of ≥3,0 occurred in Azerbaijan and adjacent areas during 1980-2019 years

One of the most important problems facing seismology is the seismic zoning of areas and the most important conditions for the correct compiling or specification of a seismic zoning map of great social, economic and ecological significance is a realistic assessment of the location and seismic potential of seismic zones, which can be the epicenter of a strong earthquake. For this purpose, extensive research is usually carried out, including a complex and detailed study of the depth structure of the Earth's crust, modern geodynamics, regional seismicity, seismotectonics. As a result of these studies, seismically active structures that are sources of seismic hazards, seismic effect caused by structures and extinction properties depending on the distance, parameters of seismic regime of these active structures are determined, the maximum possible level (point) of seismic impact is assessed in each part of the studied area. The seismic zoning map of the territory of Azerbaijan (mapping of the area according to the level of seismic hazard) has been repeatedly compiled by the method called “seismotectonic” or “genetic”. The last such map is the “Temporary seismic zoning map of the Republic of Azerbaijan” compiled in 1991 [7] (Fig. 3). As can be seen from this map, the southern slope of the Greater Caucasus - approximately from the meridian of the city of Gobustan (formerly Maraza) to the border with Georgia - is characterized by high intensity (8 and 9 points on the MSK-64 scale) seismic hazard.

In addition to the "seismotectonic" or "genetic" method mentioned above, the seismic hazard is also estimated by the probability method. In this case, the seismic hazard is expressed in terms of

peak ground acceleration (PGA) caused by the earthquake, and this method allows to quantify the probable seismic hazard. The calculation is carried out in the following stages:

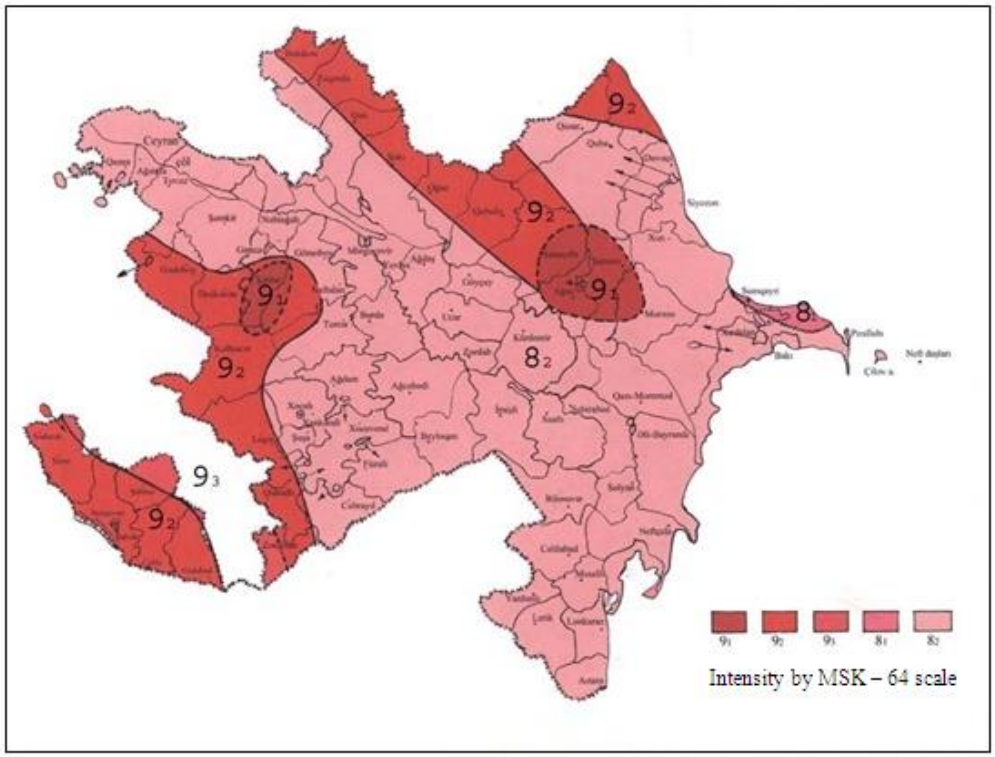

Fig.3. Map-scheme of temporary seismic zoning of the territory of Azerbaijan (1991)

1. The earthquake source and its characteristics are determined. Depending on the geological nature of the source, it can be considered as a field, line or point.
2. Seismic parameters (repetition) and probability models are evaluated for each seismic source. The model is usually based on the Gutenberg-Richter dependence.
3. The extinction model of ground vibrations is selected on the basis of the extinction coefficient, which reflects the change of ground vibrations depending on the magnitude of the earthquake and the distance from the source.
4. Seismic hazard is quantified taking into account the influence of the above three factors.
   Large depth faults determined by geological-geophysical methods in the study area were accepted as earthquake source zones. It is believed that earthquakes are evenly distributed in these fault zones, and there is a possibility of an earthquake at any point within the fault zones. Ground movement in the study area is modeled on the basis of earthquakes of known magnitude and extinction coefficients on known ground conditions. The formulas Boore and Atcinson [9], Campbell and Bozorgnia [10] were used in our studies. Calculations were made on rocks with transverse wave velocities of 760 m / s and the seismic effect of the ground equal to the value of acceleration. The research was performed in the following sequence:

1. Active depth faults in the territory of Azerbaijan were selected. It was found that the strong earthquakes that occurred in the Azerbaijani part of the southern slope of the Greater Caucasus and are likely to occur in the future are associated with the deep faults of Vandam and Adjichay-Alyat (Fig. 4).
2. The seismic source zones (SSZ) model have been compiled (Fig. 5).
3. The earthquakes with magnitude of ≥4.0 within zone 4 were selected.
4. The values of activity parameters *a* and *b* were calculated for source zones numbered 1 and 2, which able to create a seismic hazard in the study area. The seismic characteristics of zones (SSZ) are shown below:
5. The earthquakes with magnitude of ≥4.0 within zone 4 were selected

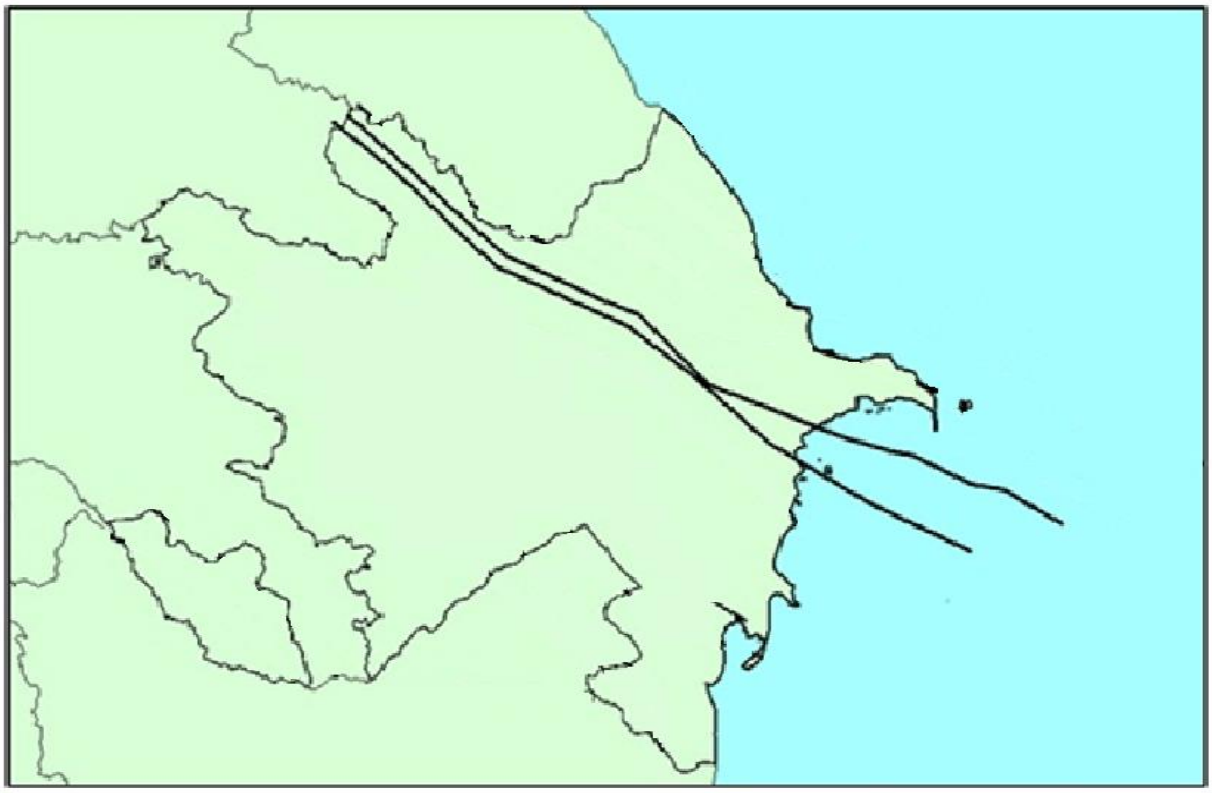

Fig.4. Layout scheme of the Vandam and Adjichay-Alyat deep faults passing through the Azerbaijani part of the southern slope of the Greater Caucasus

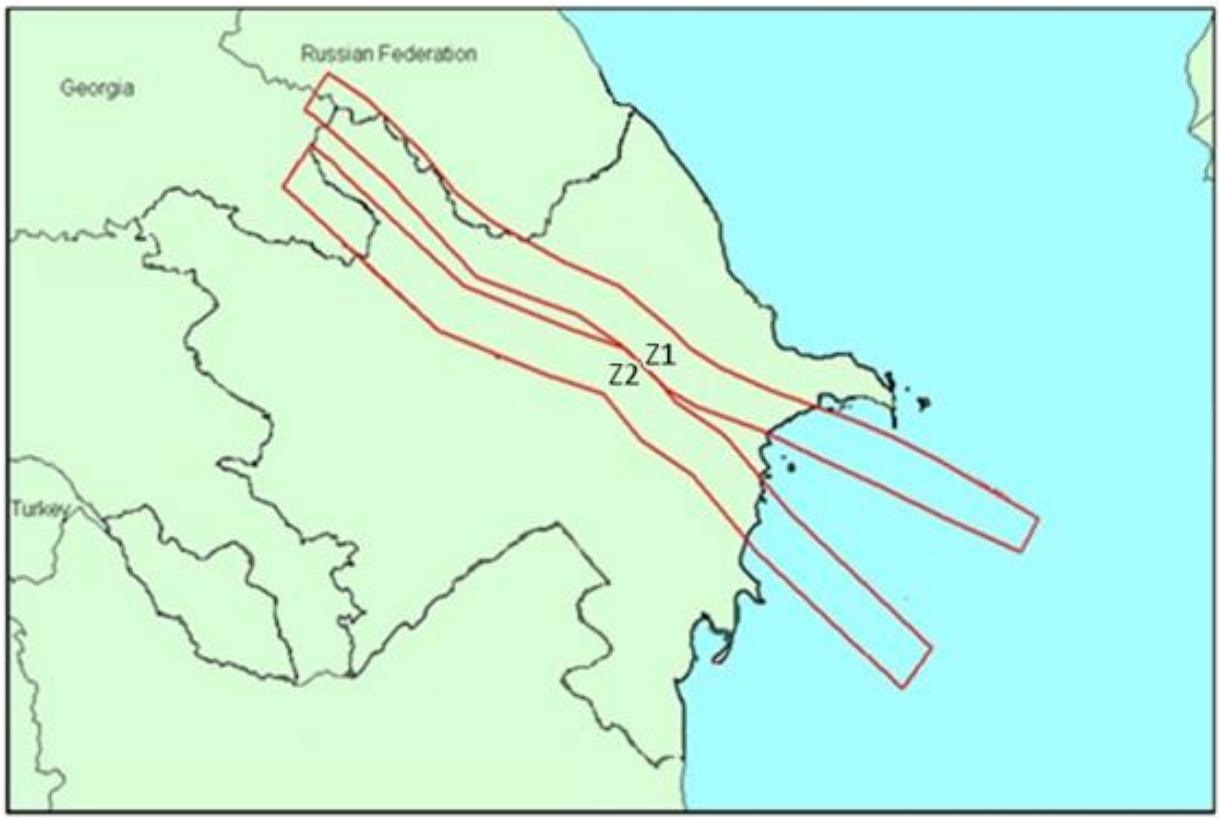

Fig.5. The model of the seismic source zones (SSZ) in the Azerbaijani part of the southern slope of the Greater Caucasus

SSZ	Mmax	Mmin	Depth		Coefficient b	Activity on Mmin
			Hmin	hmax		
Zone 1	7.0	4.0	2.5	70	-1.215	2.77
Zone 2	6.0	4.0	3	49	-1.449	2.22

The seismic hazard in the study area was assessed using the EZFRISK software package and maps were compiled using the MapInfo program. Hazard maps have been compiled based on the values of the peak ground 5% acceleration (PGA) of earthquakes at intervals of 475 and 2475 years (with a probability of more than 10% for 50 years and more than 2% for 50 years) (Fig. 6 and Fig. 7).

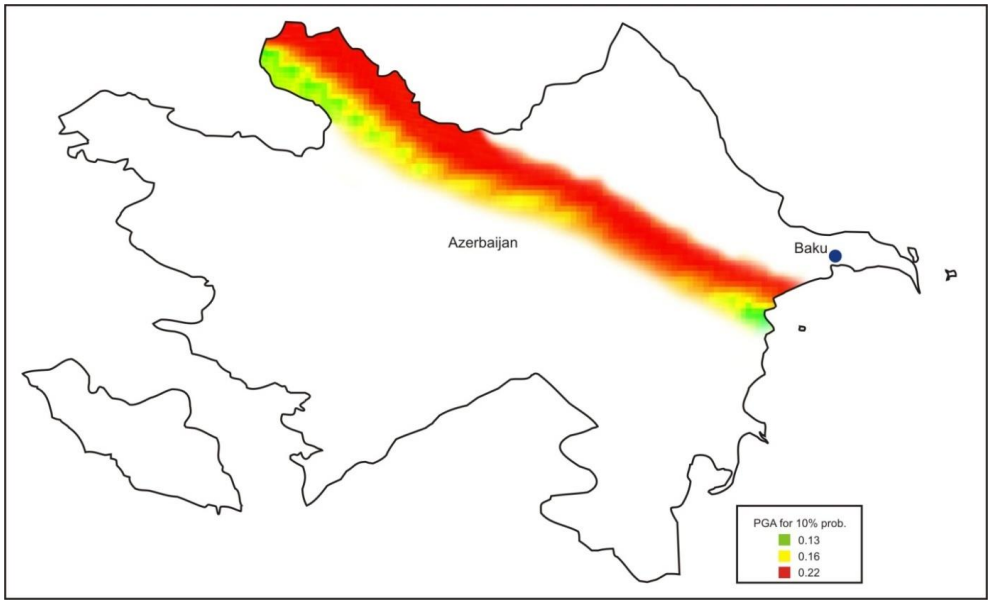

Fig.6. Peak Ground Acceleration (PGA) values over a 475-year recurrence interval (10% probability over 50 years)

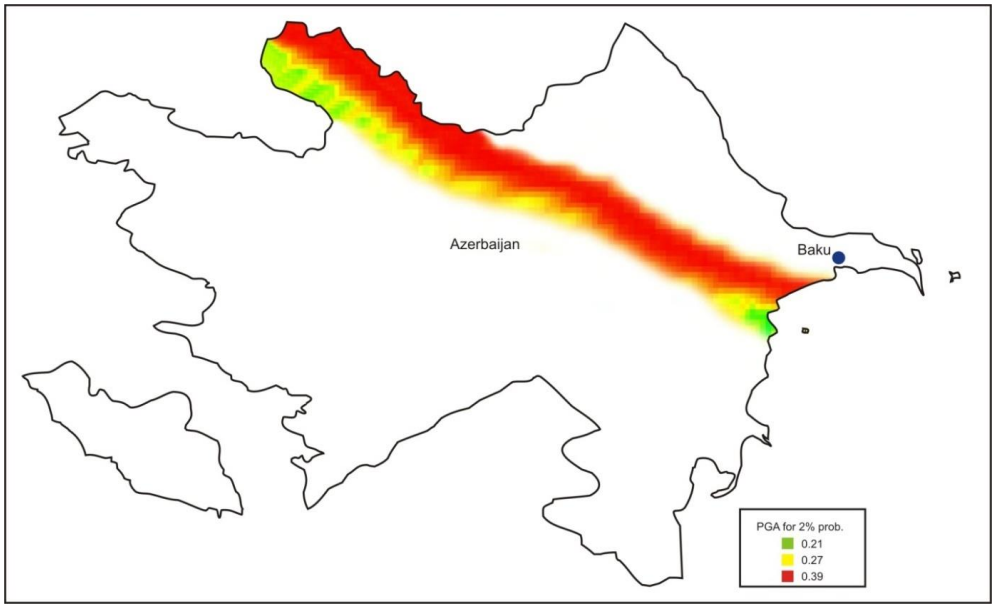

Fig.7. Peak Ground Acceleration (PGA) values for a 2475-year recurrence interval (2% probability over 50 years)

According to these maps, the value of the maximum soil acceleration in the study area varies between 0.13-0.22g according to the 475-year recurrence period and 0.21-0.39g according to the 2475-year recurrence period.

Conclusion

In the temporary seismic zoning map-scheme of the territory of Azerbaijan compiled by the method called "seismotectonic" or "genetic", the intensity of seismic hazard in the Azerbaijani part of the southern slope of the Greater Caucasus is estimated at 8 and 9 on the MSK-64 scale.

The value of the peak ground acceleration of the soil in this area varies between 0.13-0.22 g according to the recurrence period of 475 years, and 0.21-0.39 g according to the recurrence period of 2475 years.

Acknowledgments

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