# PROBABILISTIC ASSESSMENT OF THE SEISMIC HAZARD LEVEL OF THE "TAKHTAKORPU" RESERVOIR LOCATION

*T.Y.Mammadli [1], R.B.Muradov [1]*

Takhtakorpu reservoir is located on the northern part of the eastern slope of the Greater Caucasus. Although this area is not characterized by high seismic activity, relatively weak seismic shocks are observed regularly in this area. A map of the earthquakes epicenters with magnitude ≥3.0 recorded in Azerbaijan and adjacent areas during 1980-2018 years [1] shows that although there are a small number of weak seismic shocks in the study area (Fig. 1). It should be noted that the registration of a large number of weak seismic shocks in Azerbaijan is mainly due to the activities of digital seismic stations produced by the US company Kinemetrics, which has a very wide frequency-dynamic range in the country since 2003.

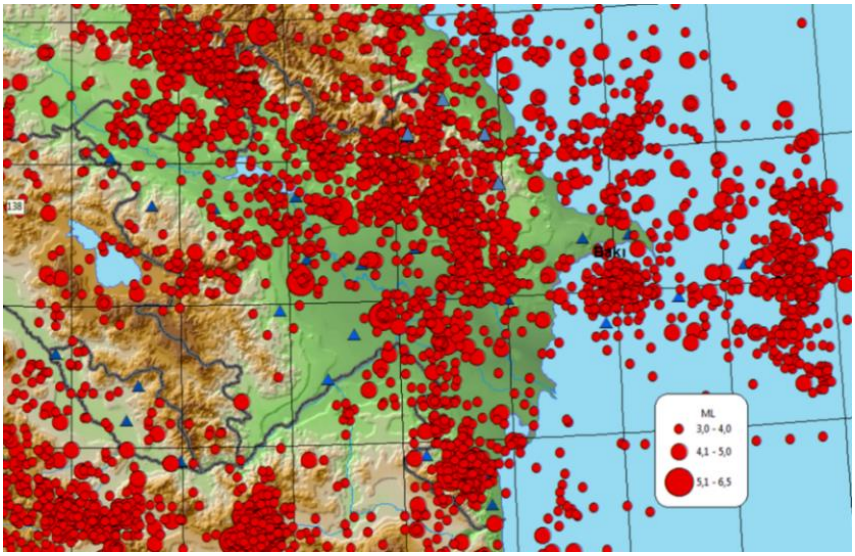


Figure 1. The map of earthquakes epicenters with magnitude >3 recorded in Azerbaijan and adjacent areas during 1980-2019 years.

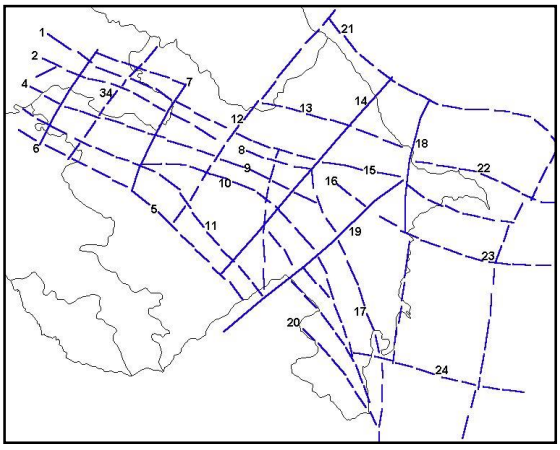


Figure 2. The map of the depth faults of the territory of Azerbaijan (K.M.Karimov and A.Sh.Shikhalibeyli, 1992).

*Symbols: Faults: 1 - Vandam; 2 - Gagro-Chava; 4 - South-Adjar-Trialet; 5 –Front Lesser Caucasus; 6 - Qazakh-Signakh; 7 - Gandja-Alazan; 8 - North-Adjinohur; 9 - Goychay; 10 - Mingachevir-Saatli; 11 - Kura; 12 - Arpa-Samur; 13 - Siyazan; 14 - Gizilbogaz-Davachi; 15 - Germian; 16 - Adjichay-Alyat; 17 - West Caspian; 18 - Yashma; 19 - Lower -Araz; 20 - Talish; 21 - Central Caspian; 22 - Absheron-Balakhayani; 23 - Sangachal-Ogurchu; 24 – Mil.*

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

At the same time, this area is affected by strong earthquakes shocks occurred in pan-Caucasian and anti-Caucasian active depth faults passing through the territory of Shamakhi-Ismayilli region near the reservoir and slightly to the north as well as in the Central-Caspian fault zones in the Caspian Sea (fig.2).

Directly no strong and destructive earthquakes have been recorded so far in the study area (Fig. 3). Strong earthquakes occurred mainly in the north, west and south of the Shabran district (reservoir) [3,4]. Undoubtedly, these earthquakes that are strong enough were felt with high intensity in the Shabran district.

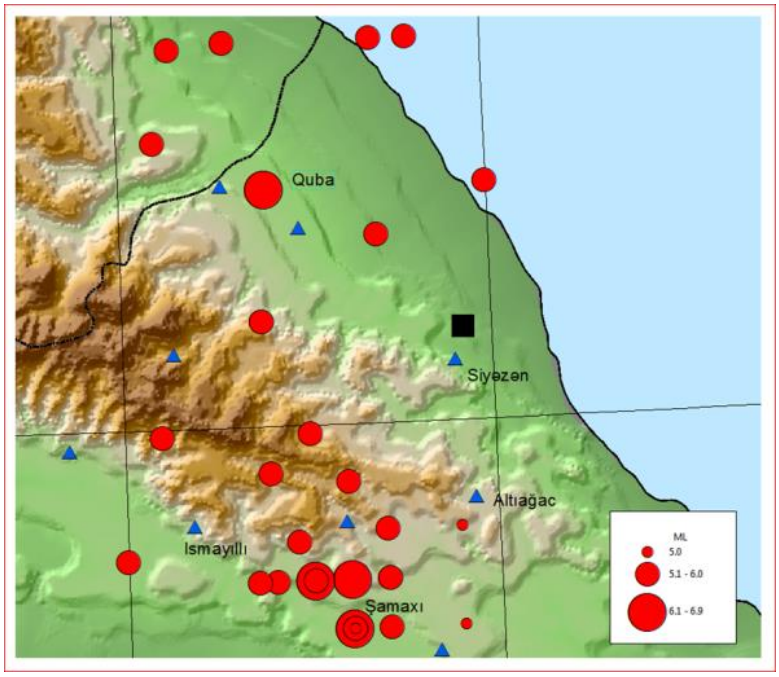


Figure 3. The map of the epicenters of strong earthquakes occurred in the north-east part of Azerbaijan during 427-2019 years.

Analysis of isoseist schemes of strong earthquakes in the territory of Azerbaijan shows that, so far, no earthquake with a magnitude higher than 6 on the MSK-64 scale has been recorded in the “Takhtakorpu” reservoir of Shabran district. Seismic shocks with this intensity were mainly spread by earthquakes in the Shamakhi district. It should be noted that only in 1963, a strong (M=6.2) earthquake in the Caspian Sea was felt in the narrow area along the coast of Shabran district with a magnitude of 7 points.

In order to determine the characteristics of the depth distribution of earthquakes in the study area,seismological sections were compiled on the I-I profile of the W-E direction and II-II profile of the SW-NE (Fig.4 and 5).

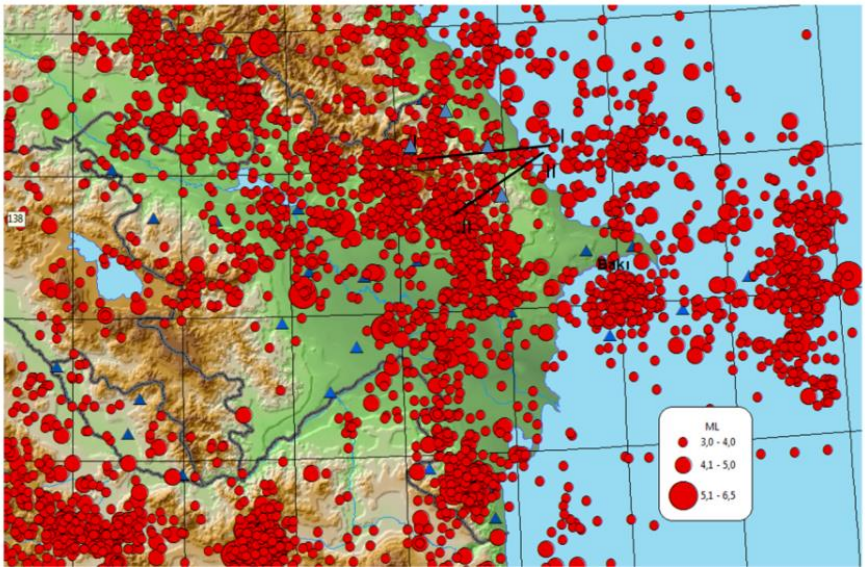


Figure 4. The location map of I-I and II-II profiles.

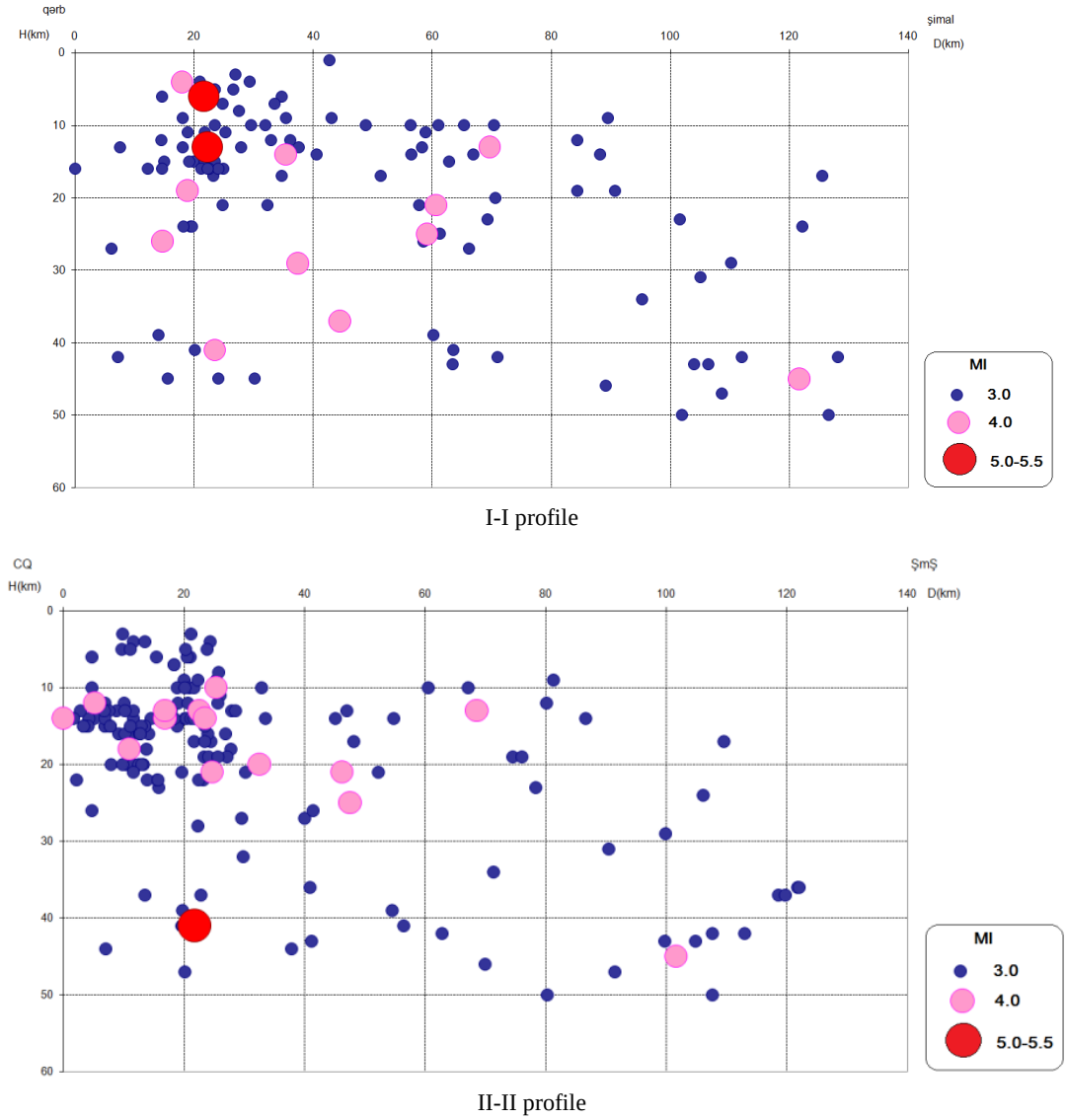


Figure 5. The seismological sections on profiles.

As can be seen from the seismological sections map, the seismic shocks are mainly concentrated in the western and south-western part of the sections corresponding to the Shamakhi-Ismayilli zone. Although these hypocenters extend from a depth of 3 km to 20-25 km, the depth of some shocks reaches 40-45 km. Strong (M≥5,0) earthquakes, as in other parts of the Greater Caucasus, occur at depths close to the surface of the crystalline base (10-15 km).

The area where the Takhtakorpu reservoir is located is characterized by 8-point seismic hazard on the MSK-64 scale on the seismic zoning map of Azerbaijan. Seismic zoning map of the territory of the republic (mapping of the area according to the level of seismic hazard) has been compiled several times. The last map is the "Temporary seismic zoning map of the Republic of Azerbaijan" compiled in 1991 (Fig. 6) [5].

Probable seismic hazards in this area are calculated by deterministic and probabilistic methods by determining the source zones in areas of high seismic activity.

Calculation of seismic hazard by probabilistic methods is carried out in the following stages:

1. The epicenter 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. The seismic hazard is assessed taking into account the influence of the above three factors.

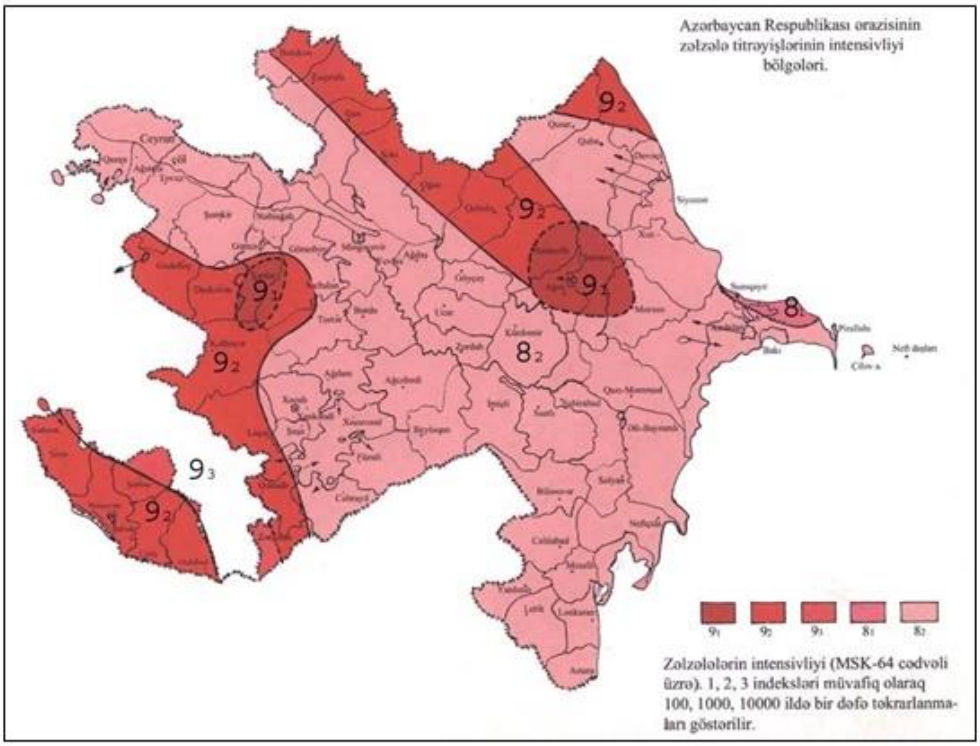


Figure 6. The temporary seismic zoning map-scheme of the territory of Azerbaijan (1991).

Earthquake sources are defined as fault zones that extend to the Earth's surface and have a certain depth. 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. Soil movement in the study area is modeled on the basis of earthquakes of known magnitude and extinction coefficients on known ground conditions. Our studies used the formulas Boore and Atkinson (Boore, Atkinson (2008)), Campell and Bozorgnia (Campell, Bozorgnia (2008)) [6,7]. 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.

Based on the above research sequence, initially the active depth faults in the territory of Azerbaijan were selected (Fig.7).

Then a model of seismic source zones (SSZ) was compiled (Fig.8).

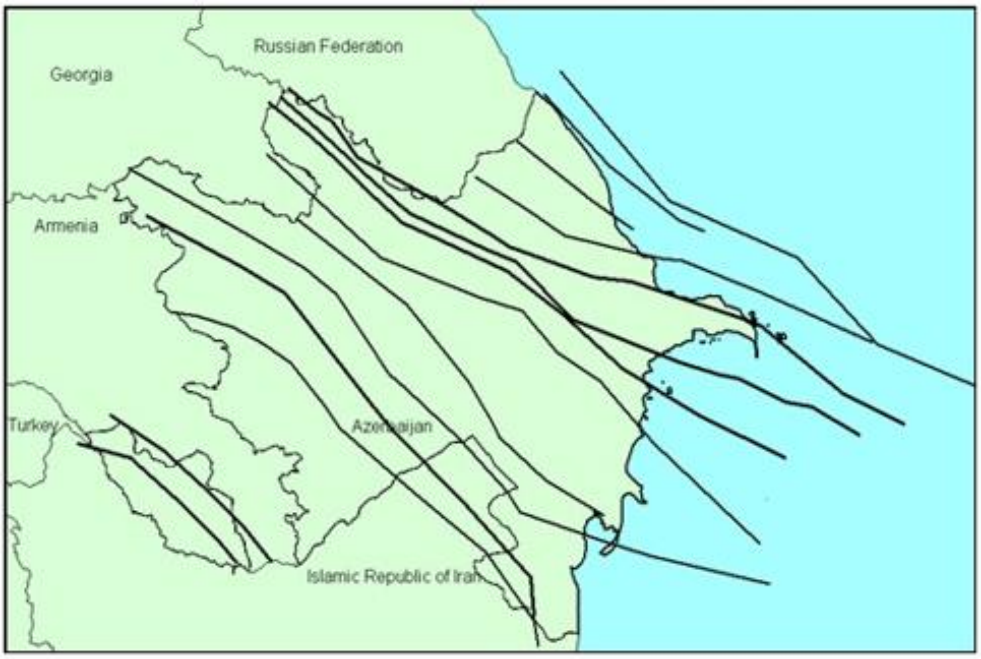


Figure 7. The map of the active tectonic faults in the territory of Azerbaijan.

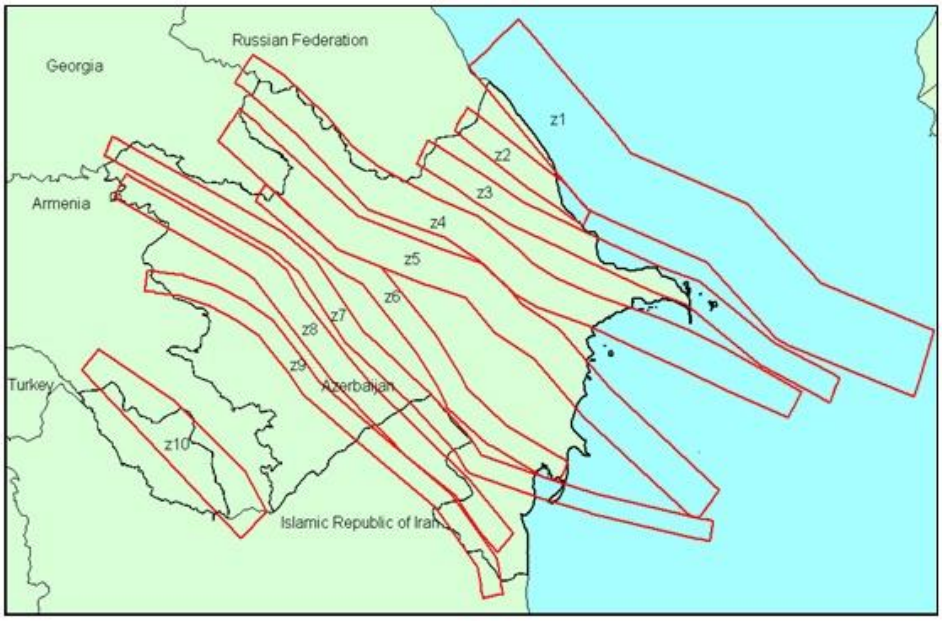


Figure 8. The model of seismic source zones (SSZ) in the territory of Azerbaijan

As can be seen from Figures 7 and 8, possible strong earthquakes in the Shabran district, where the study zone is located, may occur within zone 3. Therefore, in the next stage, earthquakes with magnitude of ≥4.0 in the area within zone 3 were selected and the values of activity parameters a and b were calculated for that source zone. The seismic characteristics of this zone (SSZ) are shown below:

| **SSZ** | **Mmax** | **Mmin** | **Depth** | | **coefficient b** | **Activity on Mmin** |
|---|---|---|---|---|---|---|
| | | | ***hmin*** | ***hmax*** | | |
| Zone 3 | 5,7 | 4.0 | 3 | 60 | -0.765 | 0.709 |

The seismic hazard in the study area was assessed using the EZ-FRISK software package and maps were compiled using the Mapinfo program.

Seismic hazard maps have been prepared as correspond to the intervals of 475 and 2475 years of peak ground acceleration (PGA) (with a probability of more than 10% for 50 years and with a probability of more than 2% for 50 years), pseudo-emergency (SA) for 0.2, 1.2, 2.0, 4.0 seconds. (Fig.9.- Fig.18.).

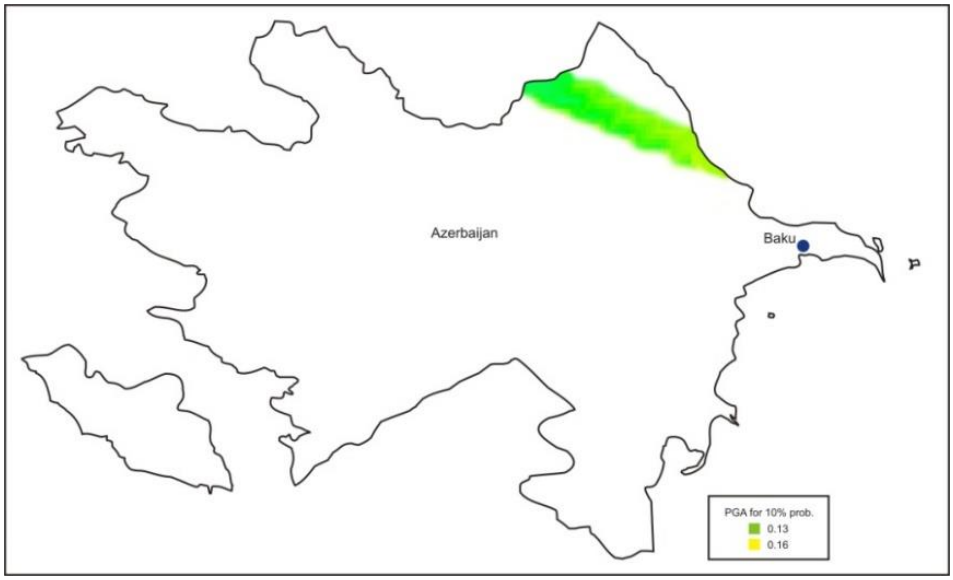


Figure 9. Peak Ground Acceleration (PGA) values over a 475-year recurrence interval (10% probability over 50 years).

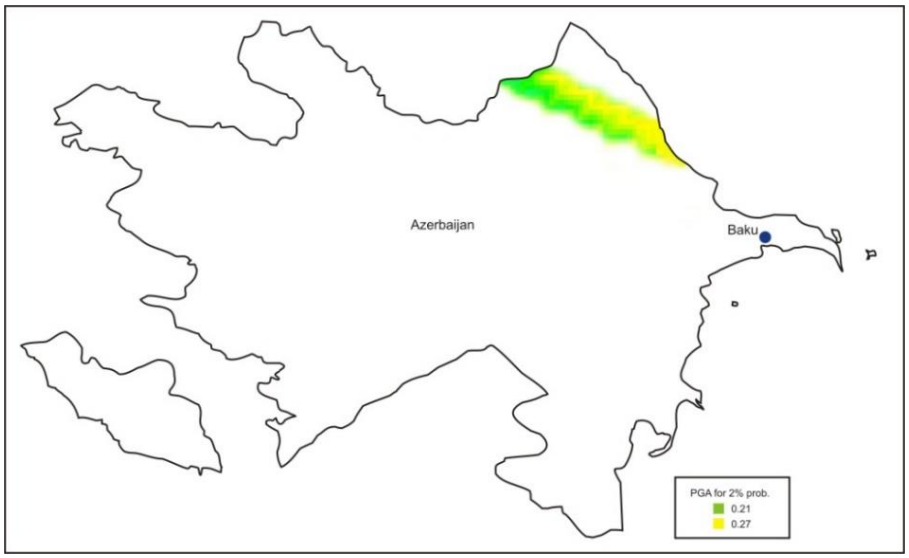


Figure 10. Peak Ground Acceleration (PGA) values for a 2475-year recurrence interval (with a probability of 2% over 50 years).

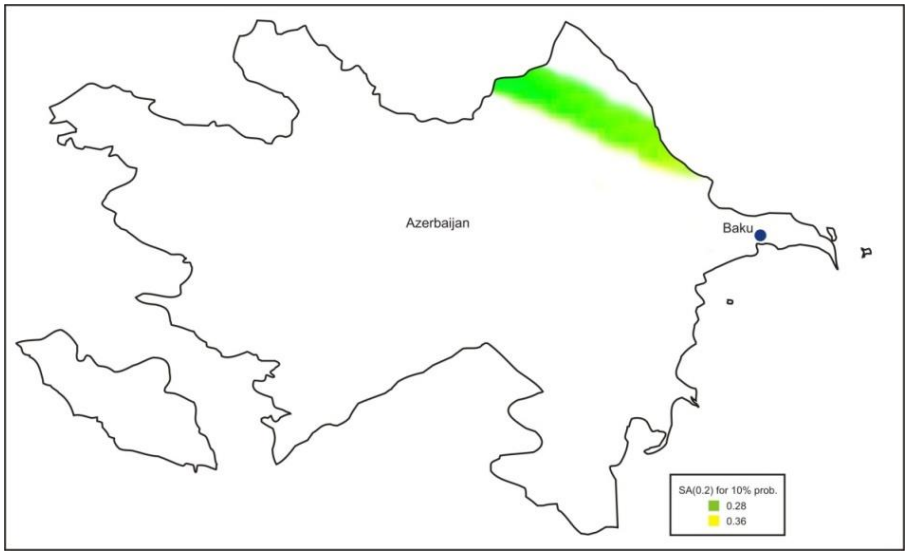


Figure 11. SA (0.2s) values of spectral acceleration over a period of 475 years (probability 10% over 50 years).

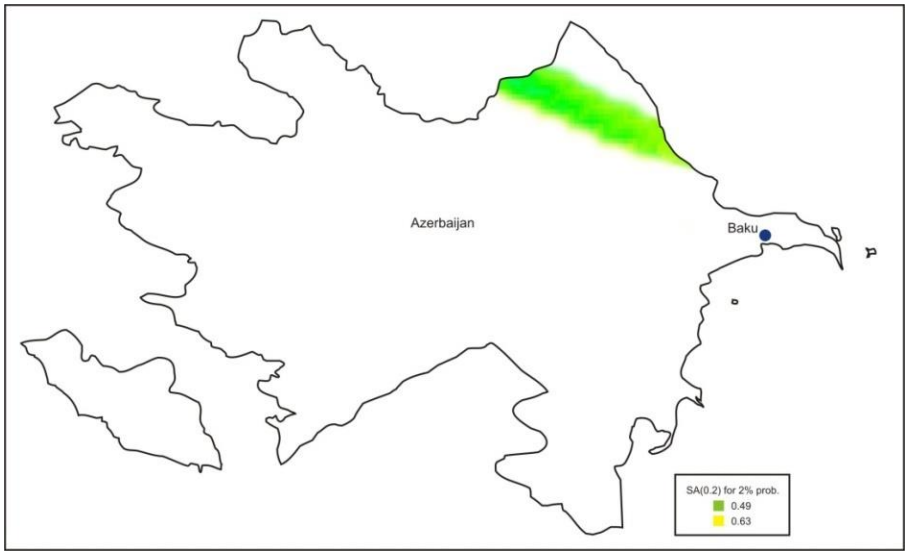


Figure 12. SA (0.2s) values of spectral acceleration at 2475 years interval (probability 2% over 50 years).

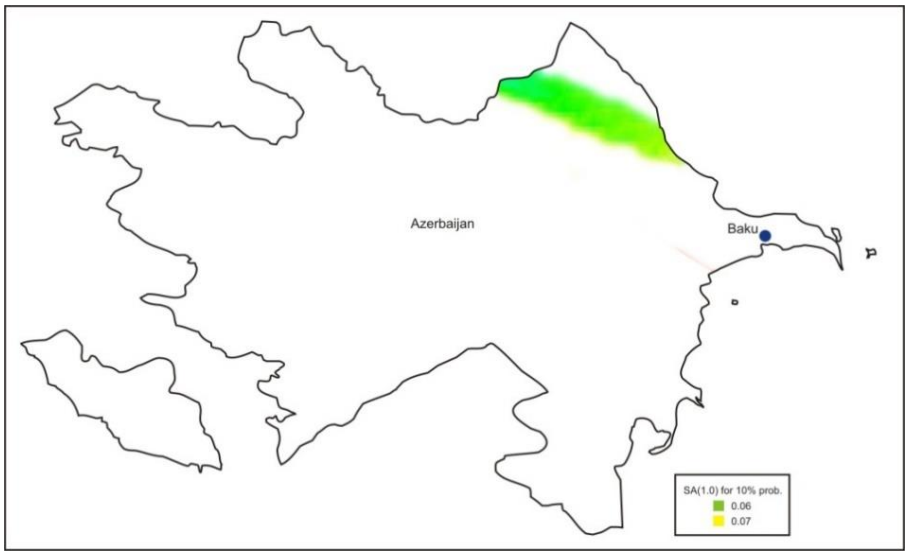


Figure 13. SA (1s) values of spectral acceleration over a period of 475 years (probability 10% over 50 years).

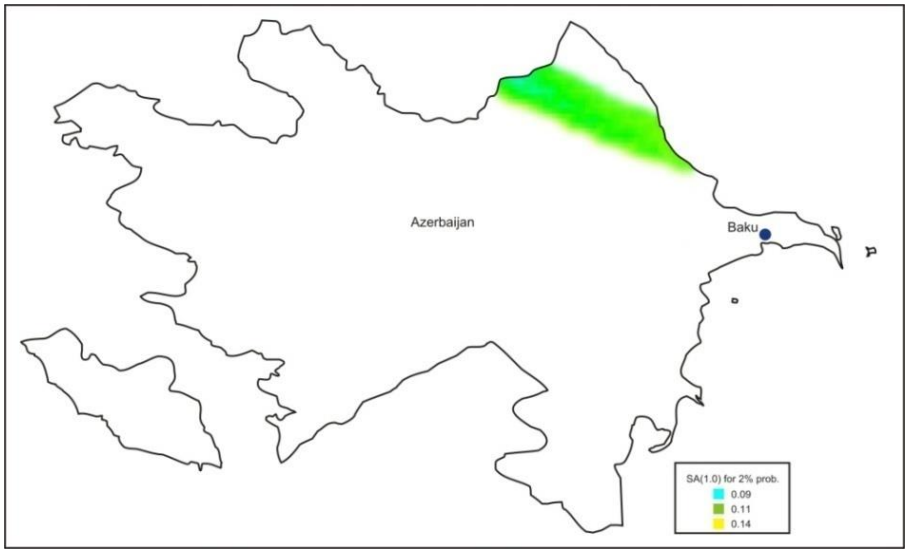


Figure 14. SA (1s) values of spectral acceleration at 2475 years interval (probability 2% over 50 years).

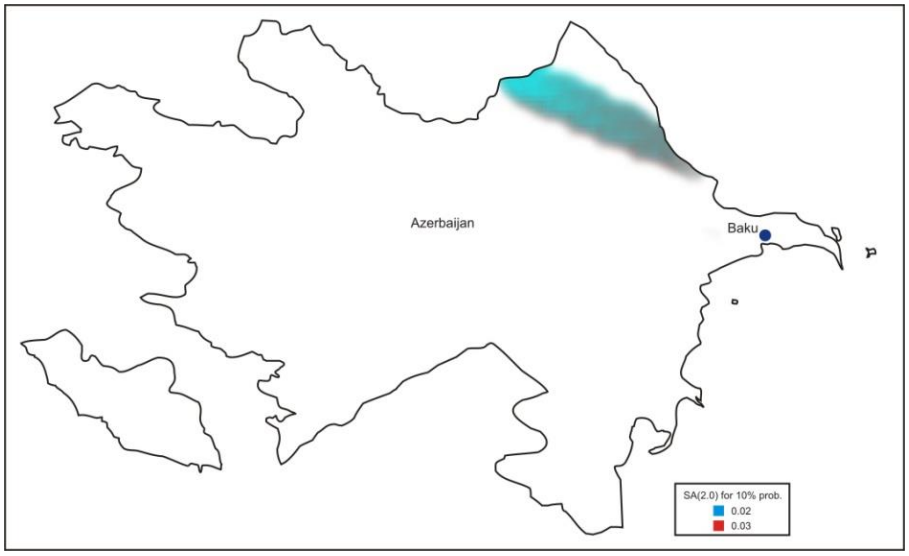


Figure 15. SA (2s) values of spectral acceleration over a period of 475 years (probability 10% over 50 years).

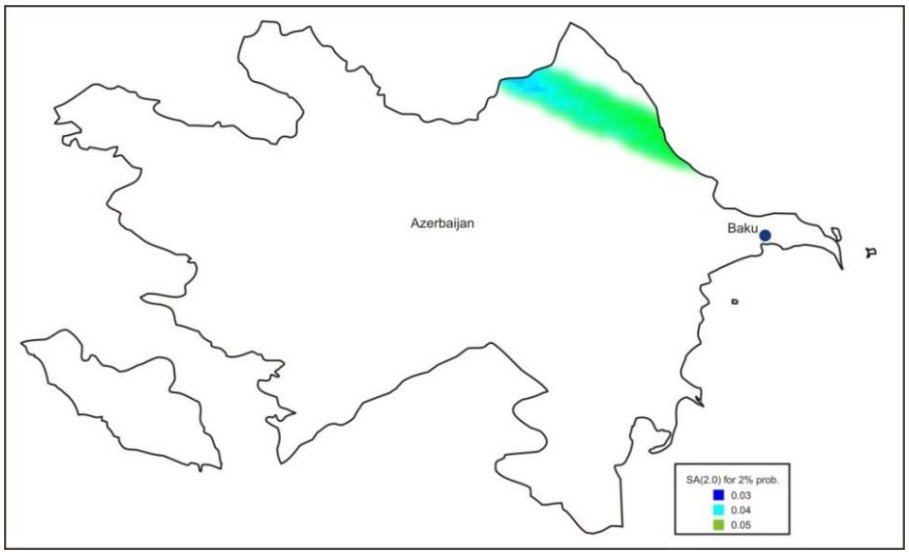


Figure 16. SA (2s) values of spectral acceleration at 2475 years interval (probability 2% over 50 years).

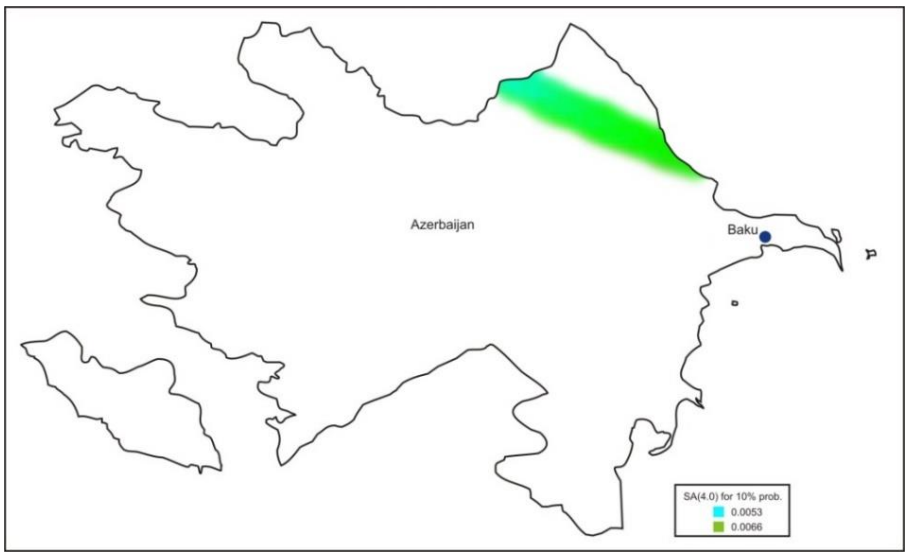


Figure 17. SA (4s) values of spectral acceleration over a period of 475 years (probability 10% over 50 years).

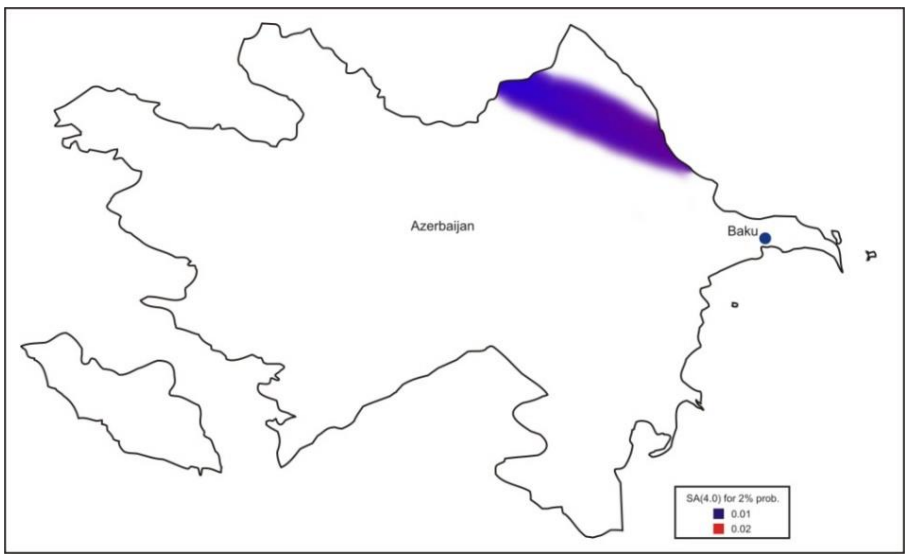


Figure 18. SA (4s) values of spectral acceleration at 2475 years interval (probability 2% over 50 years).

Thus, as a result of the research, the level of seismic hazard in the area where the reservoir is located is estimated by the probability method as follows: The value of the peak ground acceleration in the area for 10 years with a probability of 10% is 0.16g (I0 = VII points on the MSK-64 scale), the value of the peak ground acceleration with a probability of 2% for 50 years is 0.27g (I0 = VIII points on the MSK-64 scale)). The value of the peak ground acceleration corresponding to a period of 0.2 s of spectral acceleration with a probability of 10% for 50 years is 0.36 g, and the value of the peak ground acceleration corresponding to a period of 0.2s of spectral acceleration with a probability of 2% over 50 years is 0.63 g.

The value of the maximum acceleration for a period of 1s of the spectral acceleration with a probability of 10% for 50 years is 0.07 g, and the value of the maximum acceleration for a period of 2s with a probability of 2% for 50 years is 0.14g.

The value of the maximum acceleration corresponding to the 2s period of the spectral acceleration with a probability of 10% for 50 years is 0.03 g, and the value of the maximum acceleration corresponding to the 2s period of the spectral acceleration with a probability of 2% over 50 years is 0.05g.

The value of the maximum acceleration corresponding to the 4s period of the spectral acceleration with a probability of 10% for 50 years is 0.0066g, and the value of the maximum acceleration corresponding to the 4s period of the spectral acceleration with a probability of 2% over 50 years is 0.02 g.

The value of the maximum acceleration corresponding to the 4s period of the spectral acceleration for a recurrence period of 475 years is 0.0066g, and the value of the maximum acceleration corresponding to the 4s period of the spectral acceleration for the 2475-year recurrence period is 0.02 g.

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## REFERENCE

1. AMEA nəzdində Respublika Seysmoloji Xidmət Mərkəzinin fondu (1992-2019-cı illər üzrə zəlzələlər kataloqu).
2. Карта глубинного строения Черноморско-Южно-Каспийской области регионального прогибания М.1:1000000 / Гл. ред. К.М.Керимов, Э.Ш.Шихалибей-ли. Баку, 1992.
3. Новый каталог сильных землетрясений на территории СССР / Отв. редактор Н.В. Кондорская, Н.В.Шебалин. М.: Наука, 1977, 535 с.
4. Землетрясения в СССР (ежегодники 1976-1991гг.)
5. Ахмедбейли Ф.С., Гасанов А.Г., Кулиев Ф.Т., Панахи Б.М. Новые схемы областей возникновения очагов сильнейших землетрясений и сейсморайонирования территории Азербайджана/Каталог сейсмопрогностических наблюдений на территории Азербайджана 1987г. Баку: Элм, 1991, с.62-68.
6. BOORE D.M., and ATCINSON G. M. (2008), “Ground-Motion Prediction Equations for the Average Horizontal Component of PGA, PGV, and 5%-Damped PSA at Spectral Periods between 0.01 s and 10.0 s”, Earthquake Spectra, Volume 24, No. 1, pages 99–138, 2008, Earthquake Engineering Research Institute.
7. CAMPBELL K.W., BOZORGNIA Y., “NGA Ground Motion Model for the Geometric Mean Horizontal Component of PGA, PGV, PGD and 5% Damped Linear Elastic Response Spectra for Periods Ranging from 0.01 to 10 s”, Earthquake Spectra, Volume 24, No. 1, pages 139–171, 2008, Earthquake Engineering Research Institute.