Estimation of local seismic activity by deterministic hazard assessment. A case study in north-eastern of Azerbaijan

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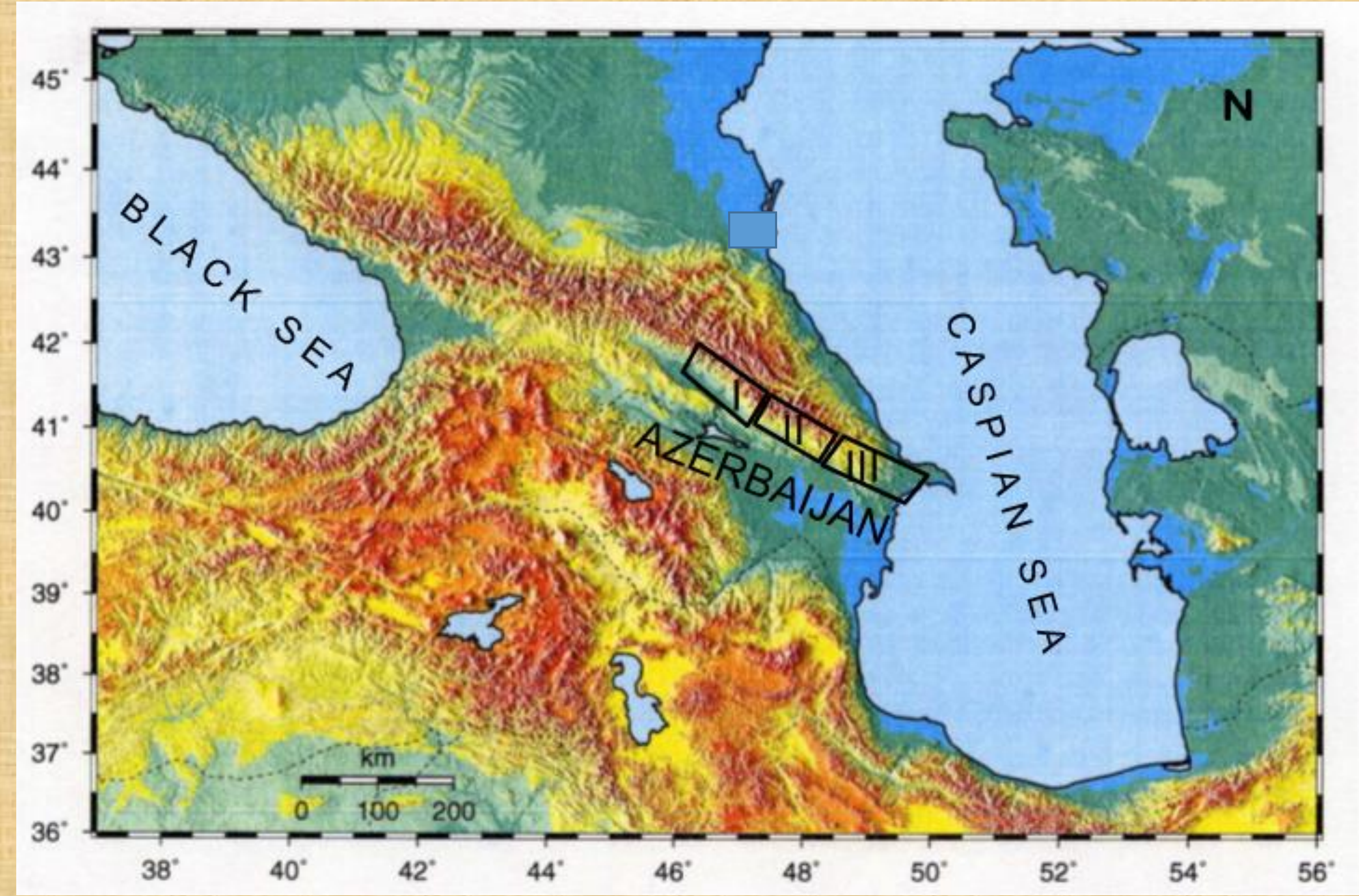
Objective:

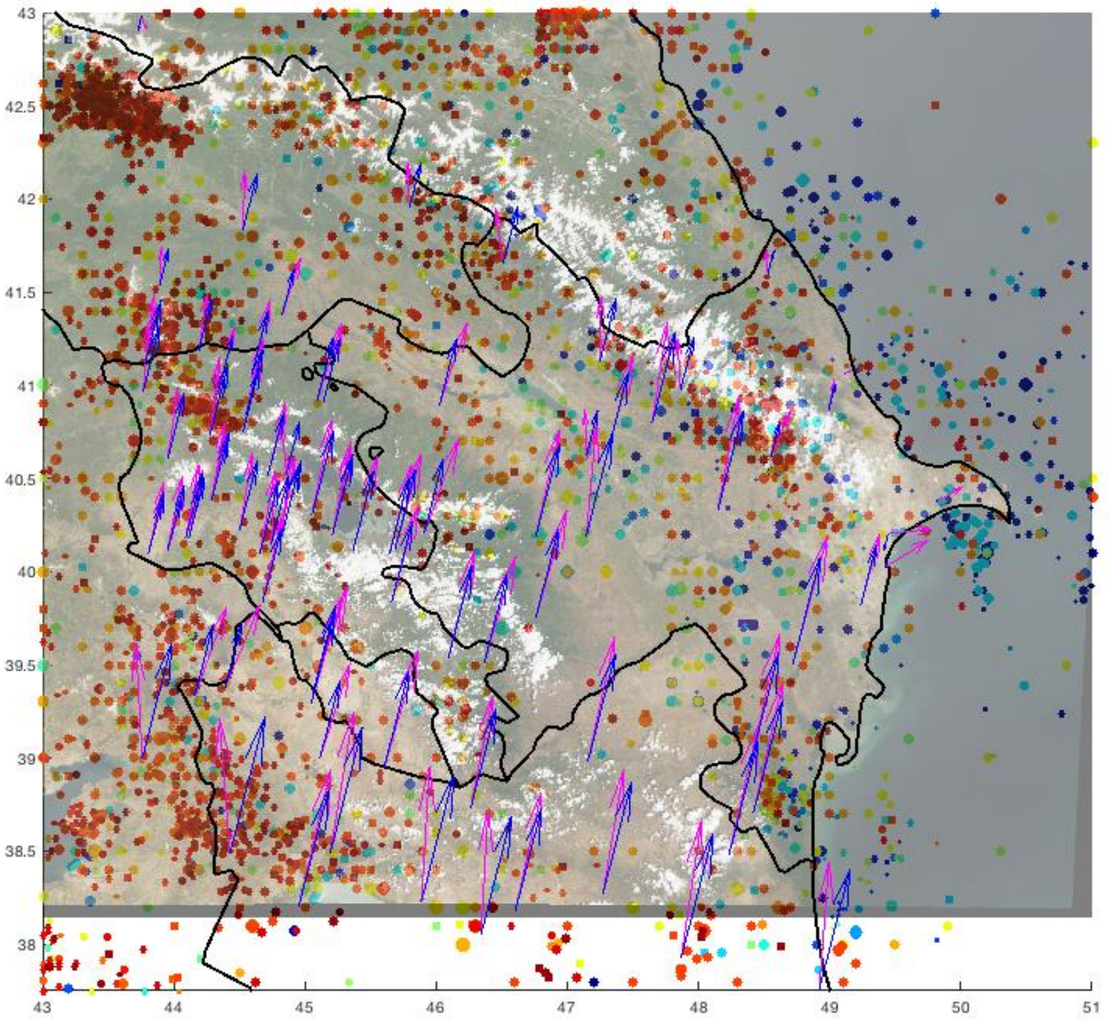
Seismic hazard assessment of southern slope of the Greater Caucasus on the basis of deterministic theory with integrated approach.

The main objective of the paper is to carry out seismic hazard analysis to quantitatively estimate and empirically define the expected hazard in the southern slope of the Greater Caucasus. In this study, we perform a strong ground motion simulation in the values of PGA for the southern slope of the Greater Caucasus from the integrated analysis of seismicity, engineering geology, effects of soil and rock to seismic wave amplification, attenuation characteristics and site response.



Mountains of the Greater Caucasus extend between the Black and Caspian seas. In our study we concentrate on the Balaken-Zagatala, Sheki-Gabala and Ismailli-Shamakhi seismogenic zones.

(Balaken-Zagatala, Sheki-Gabala, Ismailli-Shamakhi) (I; II; III, respectfully)



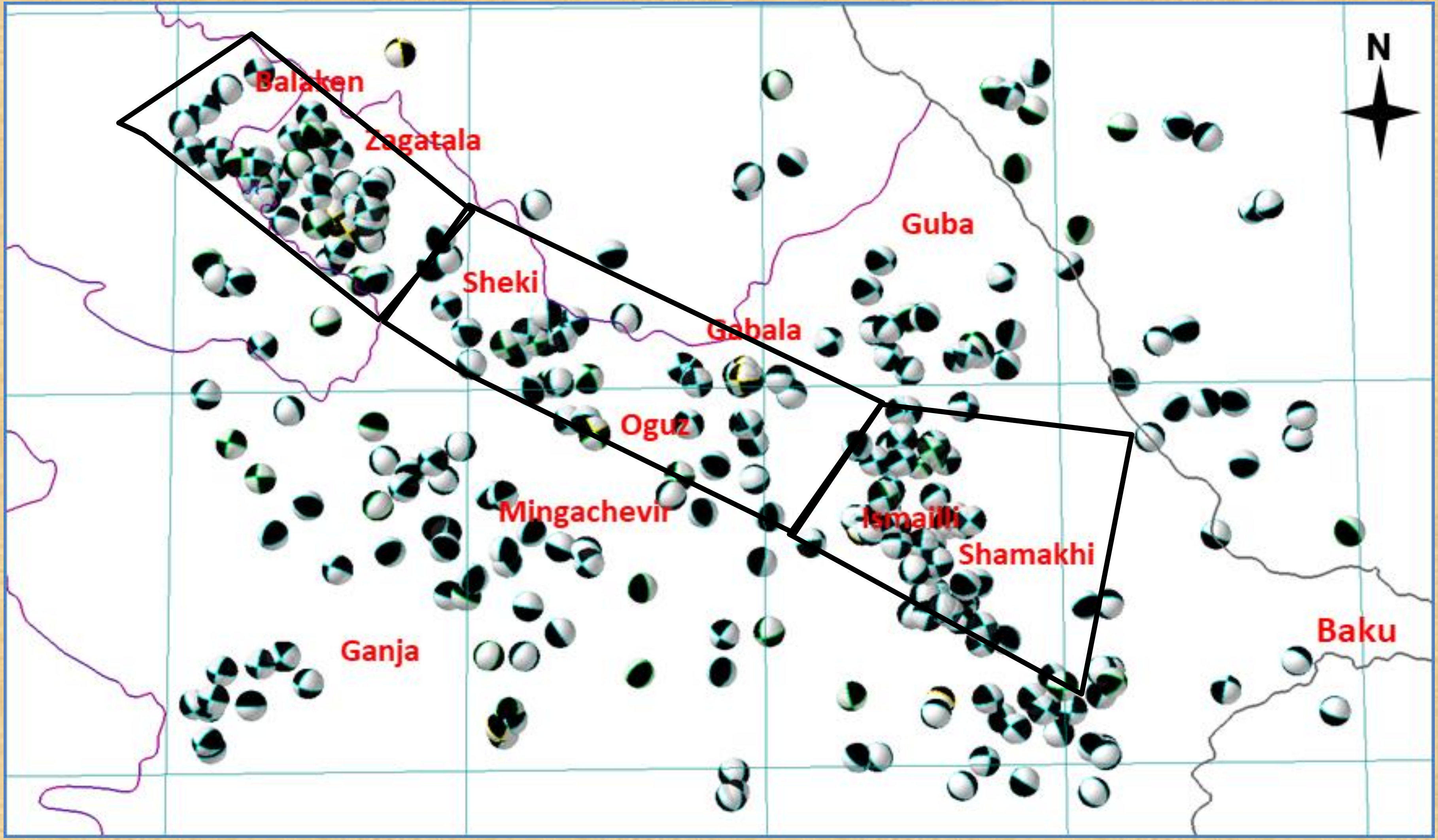
Red color– shallow earthquakes; blue color – deep earthquakes

Study area is situated in the active continent collision of the Arabian-Eurasian plates and involved in dynamics of lithospheric structural units of those plates (Jackson et al., 2002). The Greater Caucasus is wholly situated in an intraplate setting within the Eurasian plate.

Southern slope of the Greater Caucasus is characterized by two mountain ranges, with an average elevation of about 4466 m (Alizadeh et. al., 2016).

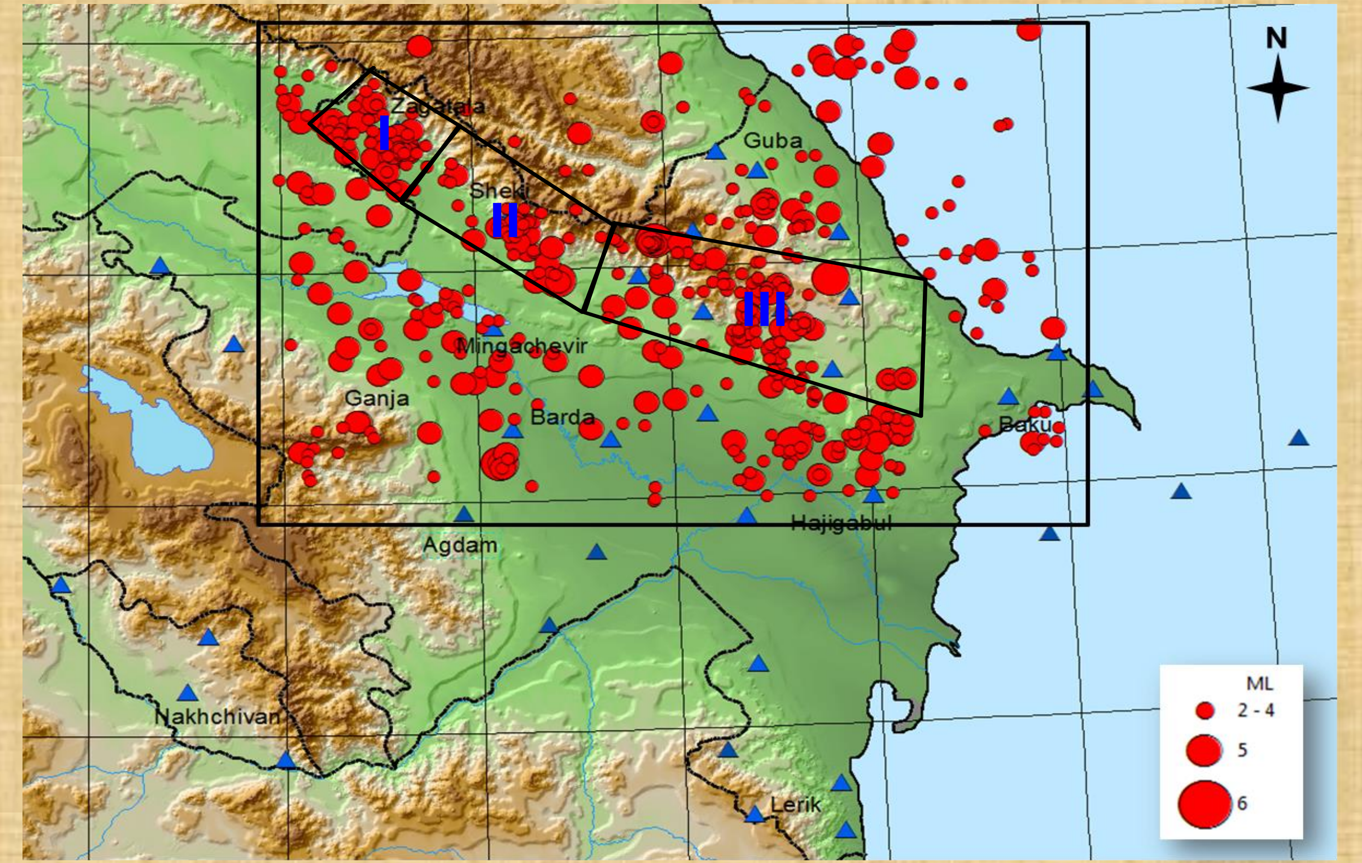
References: Reilinger et. al., 2006; Kadirov et.al., 2008; Kadirov et. al., 2012

Focal mechanism solutions for the period 2003-2018 years for earthquakes with M > 3



Balaken-Zagatala zone is characterized by the extension, and the displacements over those areas are mainly normal dip slips and normal dip slips with strike slip motion. The Sheki-Ismailli zone is mostly compression with the thrust and reverse fault types.

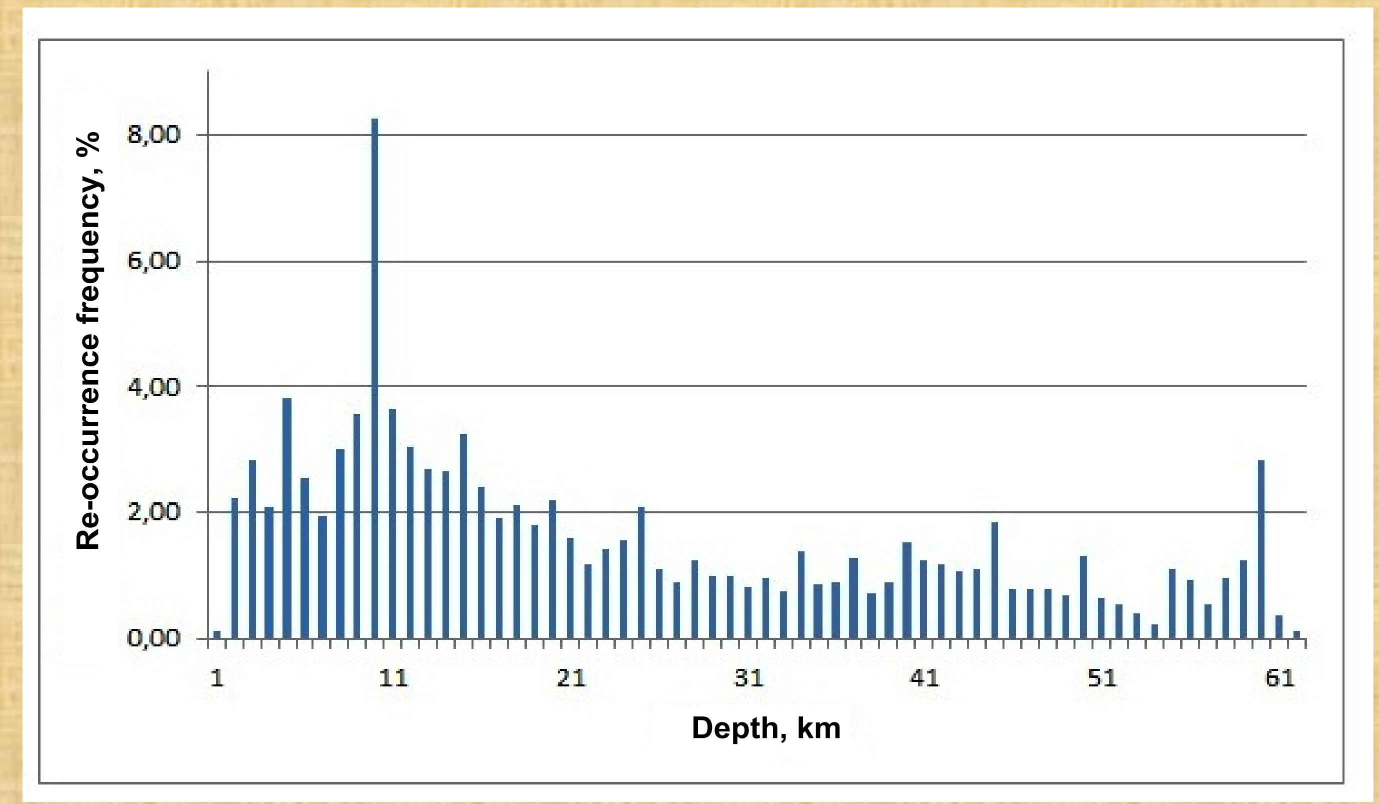
Distribution of earthquake epicenters (2012-2018)



I - Balaken-Zagatala;
II - Sheki-Gabala;
III - Ismailli-Shamakhi.

The analysis of earthquake distribution demonstrates that most of the strong earthquakes (M≥5.0) are confined within the crystalline basement

Mainly Zagatala and Shamakhi areas are distinguished by high seismicity, high density of seismic events. These areas are characterized by magnitude range of M3.4-5.9. Sheki area is relatively distinguished by low activity with magnitude range of M3.1-3.4.



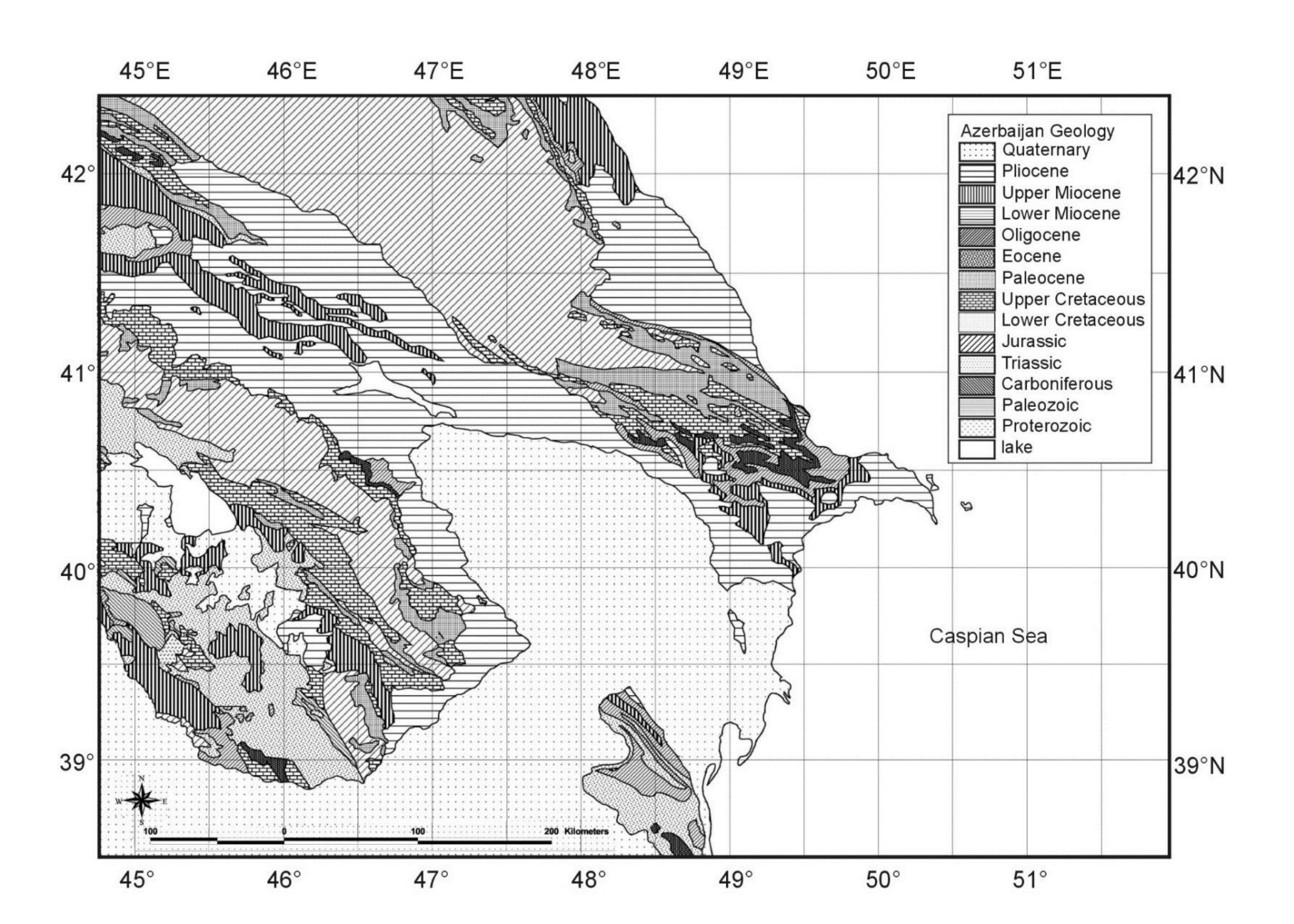
During 2003-2018, 8% of earthquakes (about 235 events) occurred at the depth of 10 km ($M_L \geq 3.5$)

PGA is the most widely used parameter to describe the shaking amplitude related to a seismic event, and for determining components of horizontal and vertical motions. Different methods exist to compute the PGA:

- PGA estimated with attenuation laws, these relate magnitude and distance of an event with acceleration.
- PGA vs intensity scale (MSK-64). This uses the intensity-acceleration relationship.
- PGA value is calculated with a methodology which depends on the type of data available.

- Macroseismic data of the target earthquakes (magnitude, depth, epicentral distance, hypocentral distance);
- Lithology;
- Vp and Vs;
- Amplification factor.

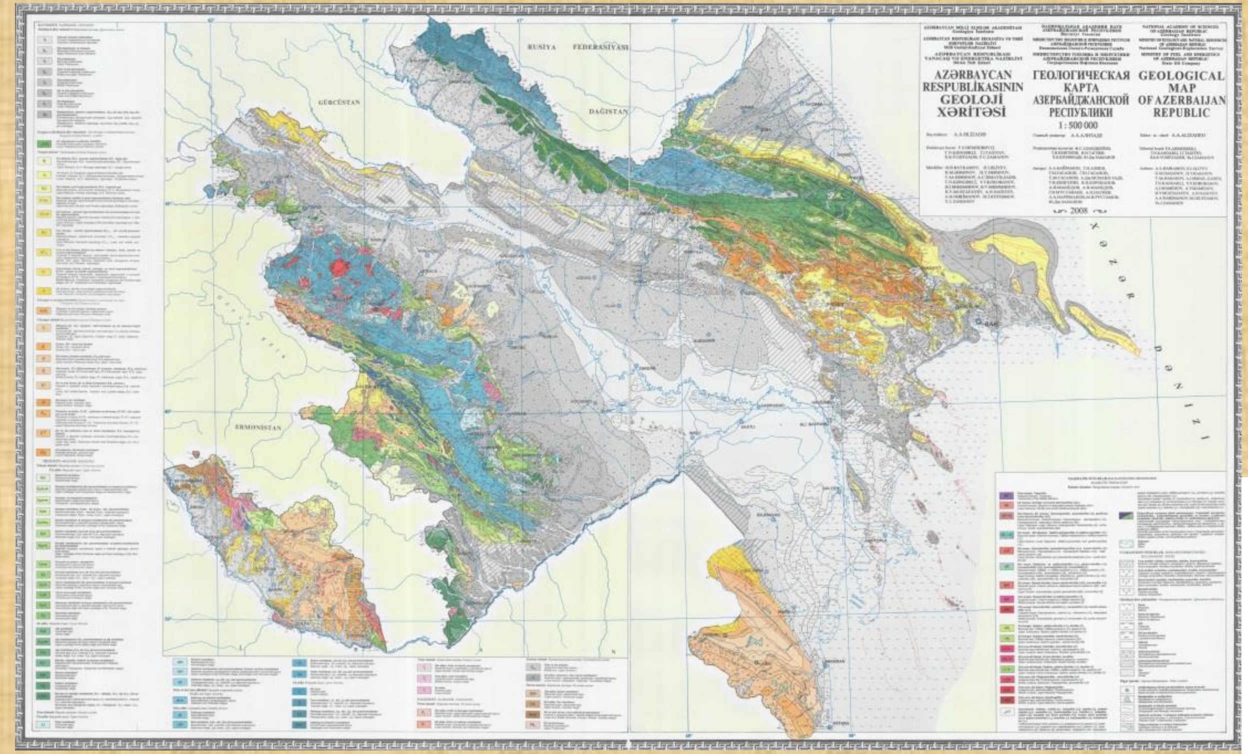
Lithology and stratigraphy



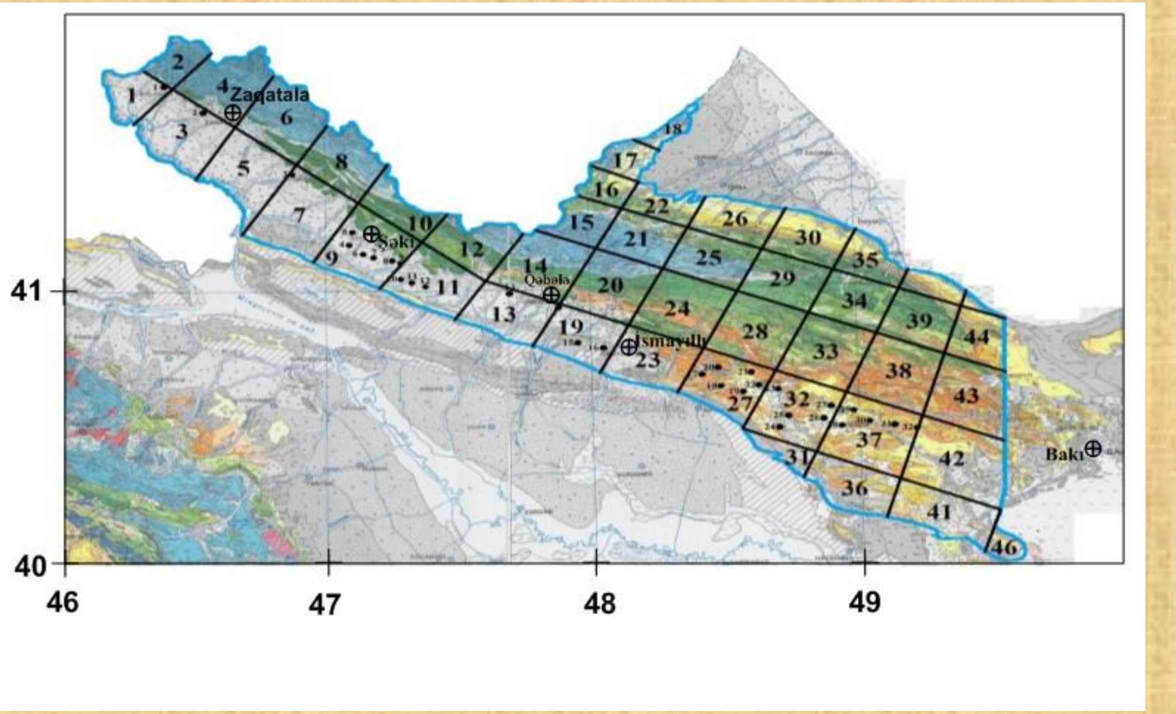
Mostly, loamy hard sandstones, limestones, with shale and clays with Jurassic up to Pliocene age

Age	Lithology	Vp, km/s	Vs, km/s	Density, kg/sm^3	Amp
Cenozoic, Holocene (modern deposits)	argillites, limestone, marlstone, sandstone	1.50	0.35	1.9	1.10
Cenozoic, Quaternary, Upper Pleistocene	thin-layered sandstone	3.30	2.02	2.35	0.53
Cenozoic, Quaternary, Lower Pleistocene	argillites and sandstone	2.10	0.50	2.00	0.95
Cenozoic, Neogene	dolomite, marlstone, sandstone	2.67	0.88	1.98	0.75
Cenozoic, Paleogene	limestone, siltstone, marlstone	2.23	0.69	1.87	0.83
Mesozoic, Cretaceous	sandstone, siltstone and clayey shale	3.93	1.63	2.38	0.58
Mesozoic, Jurassic	siltstone, marlstone	4.18	1.82	2.49	0.55

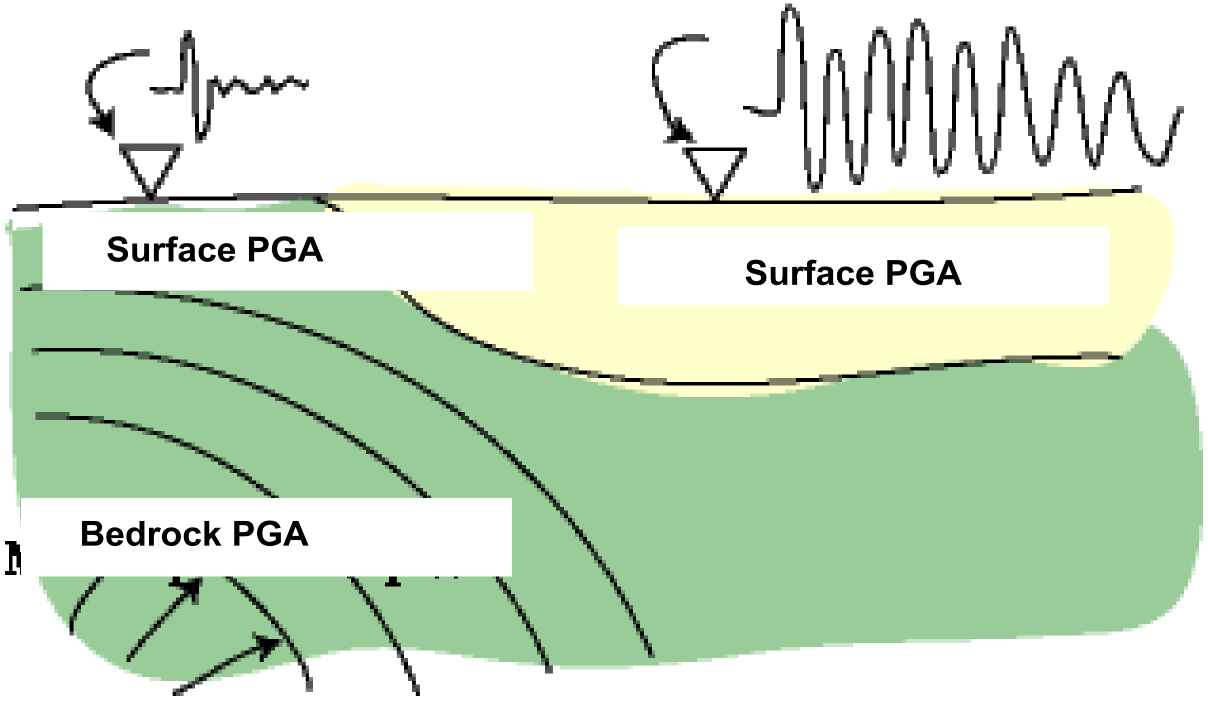
Deterministic seismic hazard assessment (DSHA) approach: seismic scenario method.



Basemap of the study area with meshes. Geology map of Azerbaijan 2008. *M 1:500.000.*



Peak Ground Acceleration



46 cells of the study area

Formula for estimation of the expected values of the maximum amplitudes

For far events:

$$\lg A_p = 0.80\,M - 2.3\,\lg R\,(km) + 0.80,$$

for $A<160$ **см/с**^{2}

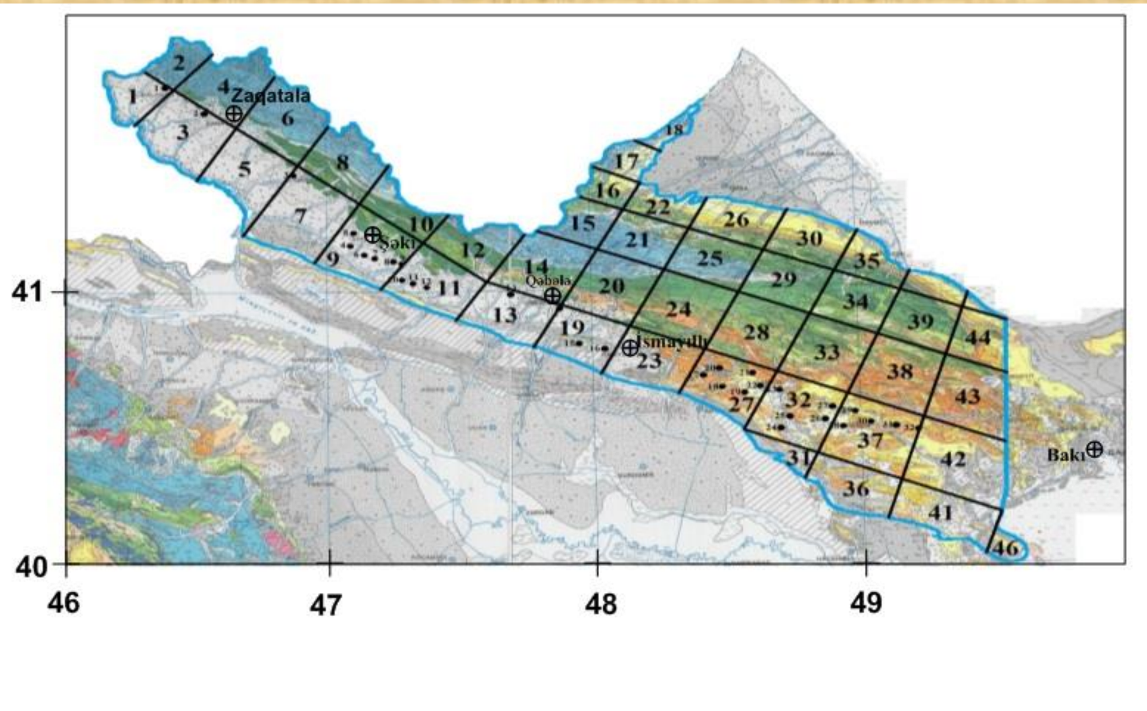
For near events:

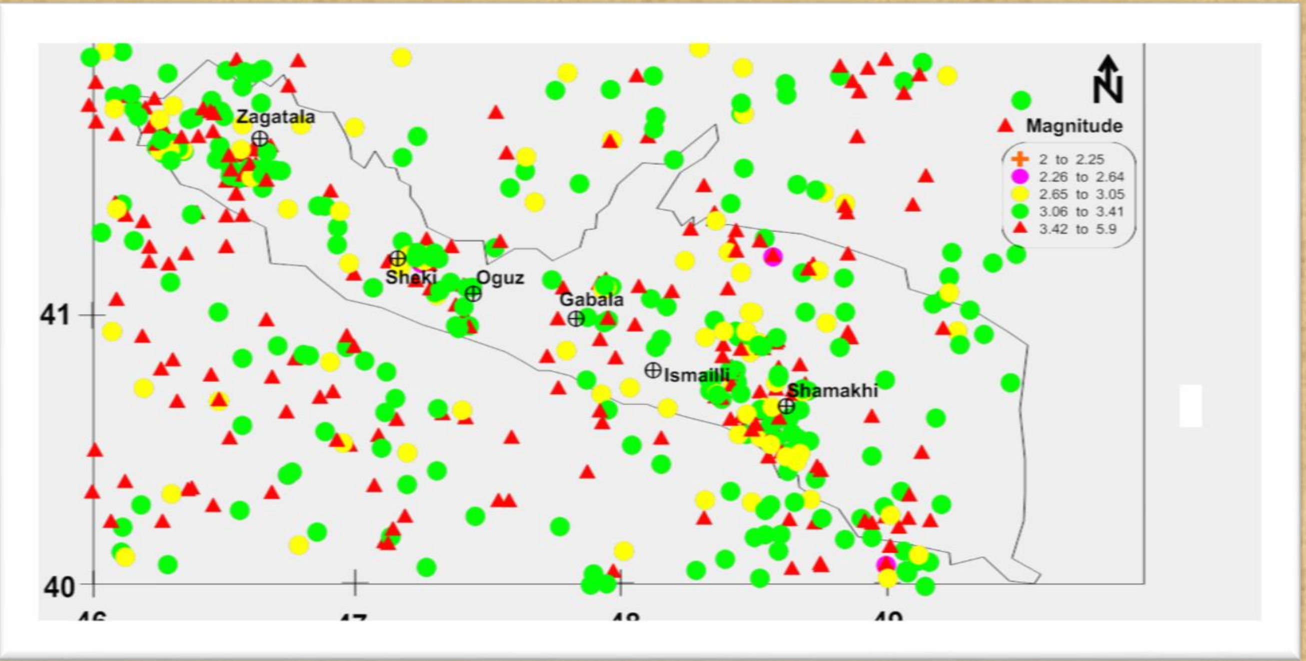
$$\lg A_p = 0.28\,M - 0.8\,\lg R\,(km) + 1.7$$

for $A\geq160$ **см/с**^{2}

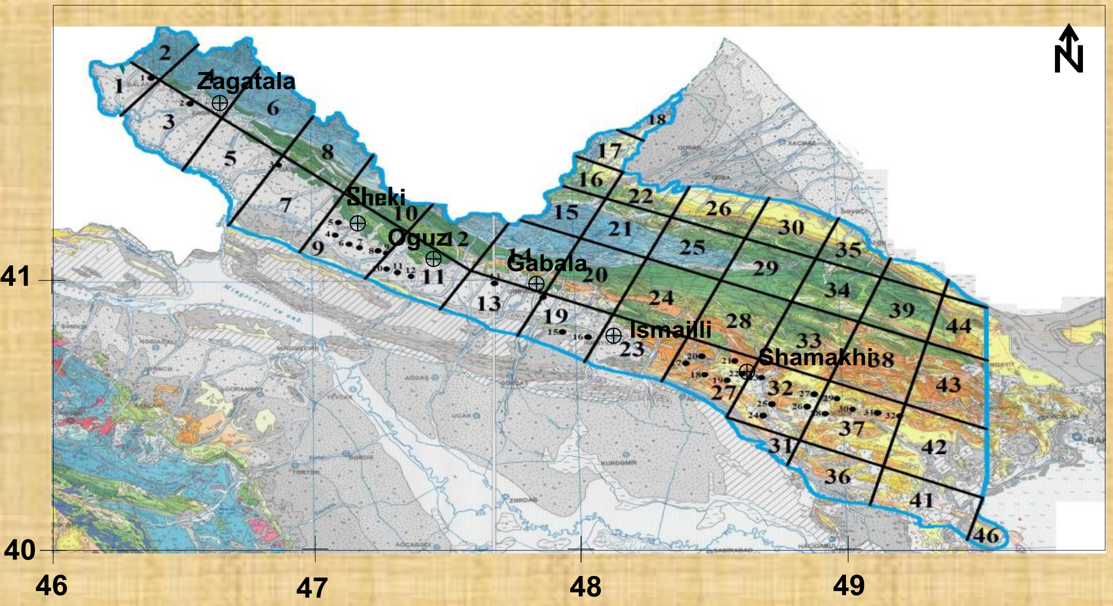
Ap – peak acceleration (gal);
M – magnitude;
R – hypocentral distance (km).

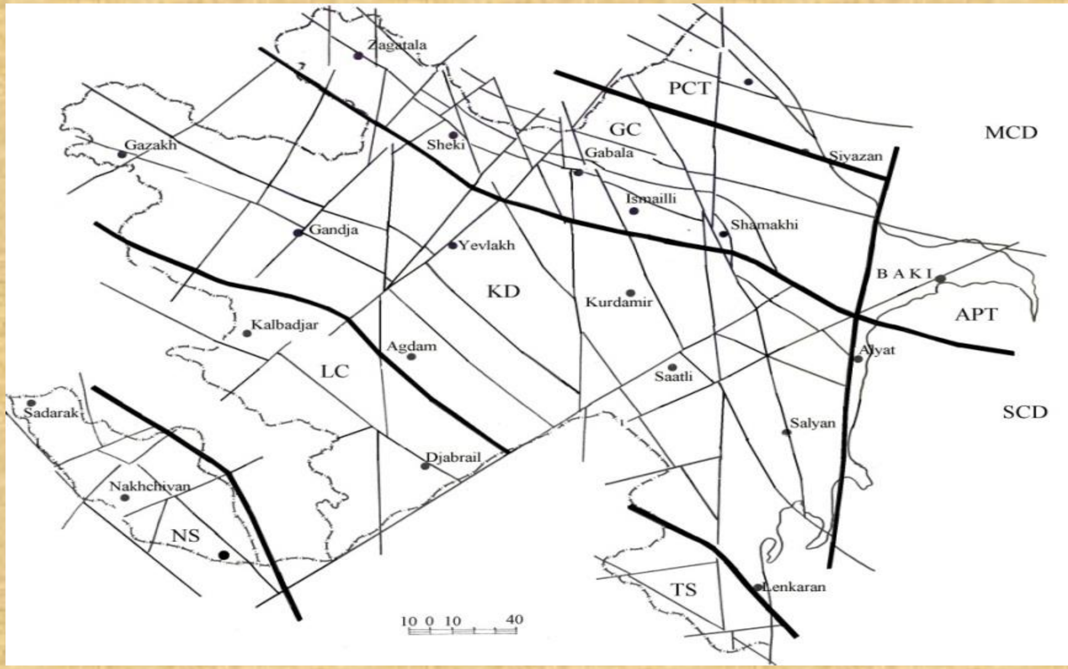
Earthquake distribution map for the period of 2003-2018 yy



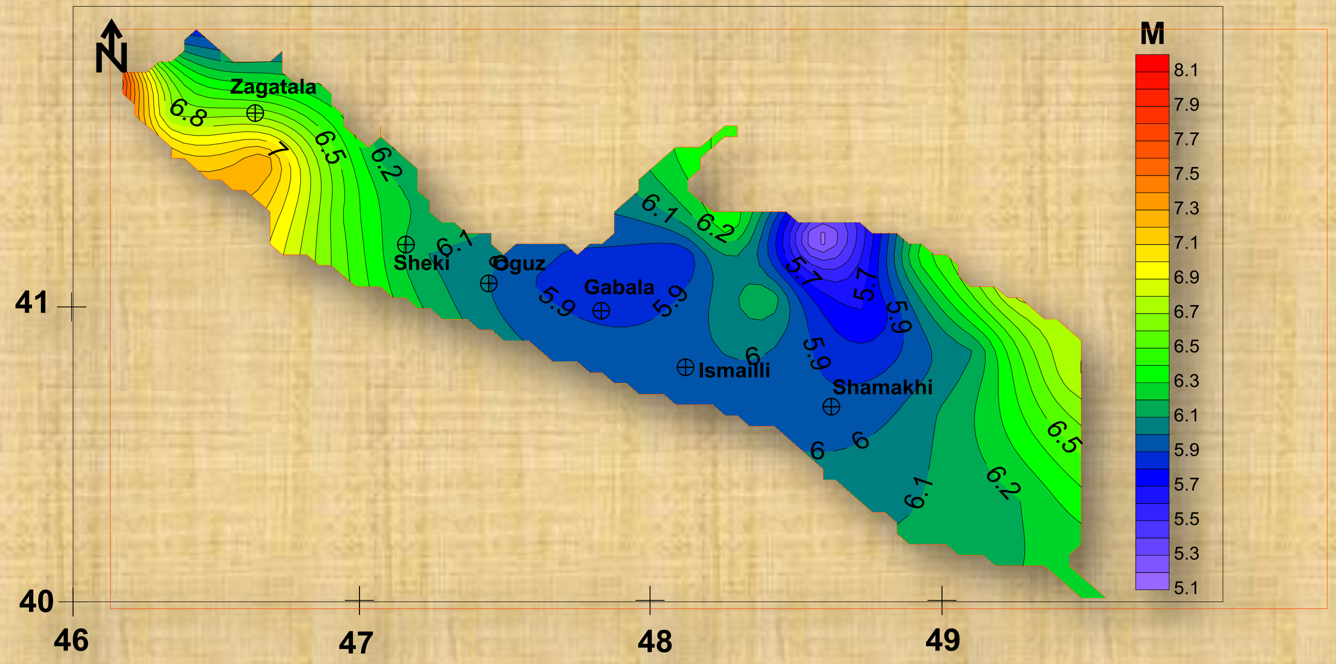


Average Earthquake Magnitude Estimated for Various Sources (fault pattern)



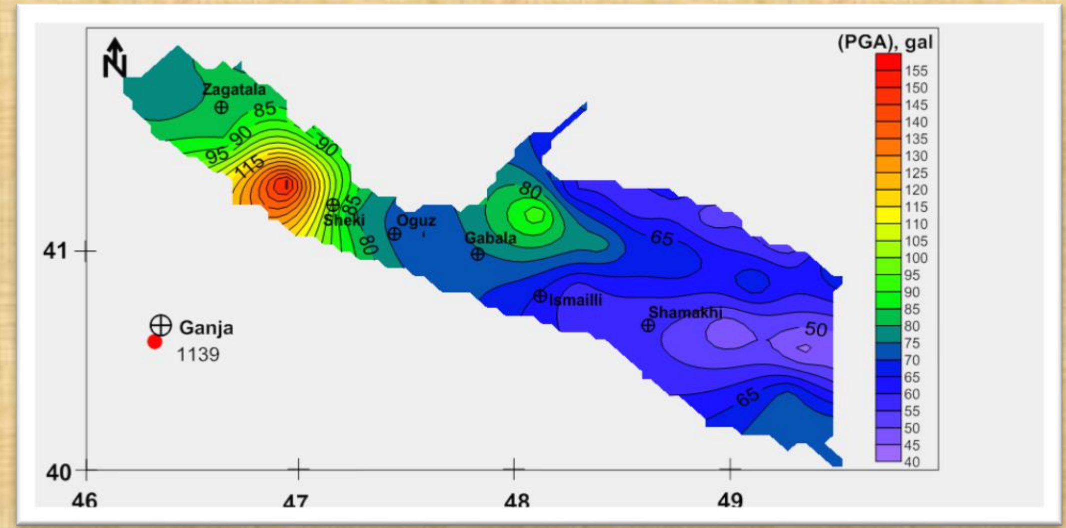


Hazard assessment analysis on 67 active faults tracing in the southern slope of the Greater Caucasus, considering the fault's location, size and length, calculating magnitude for those faults and lineaments estimated by empirical correlations. Maximum earthquake of Mw 8.0 is estimated for the western area zone and is used to generate one of the seismic scenarios of the region.

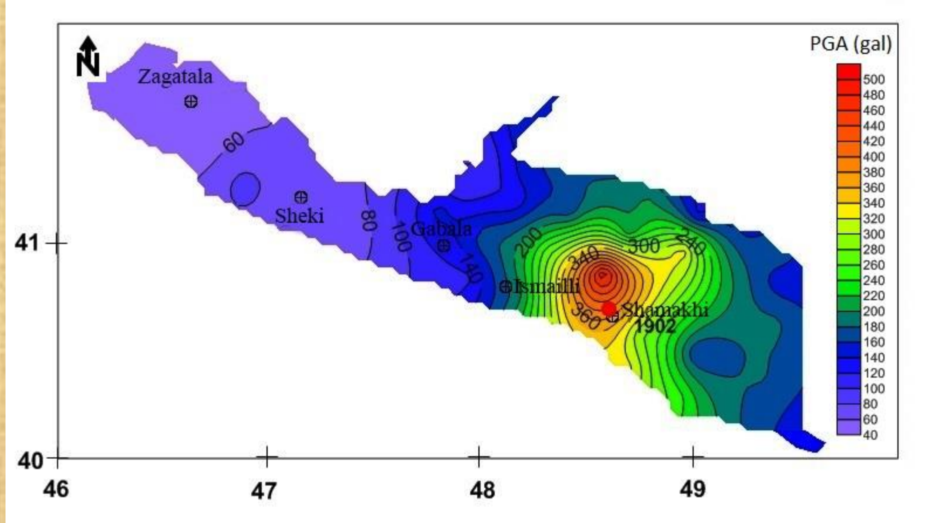


Using the empirical relationship (local and international)

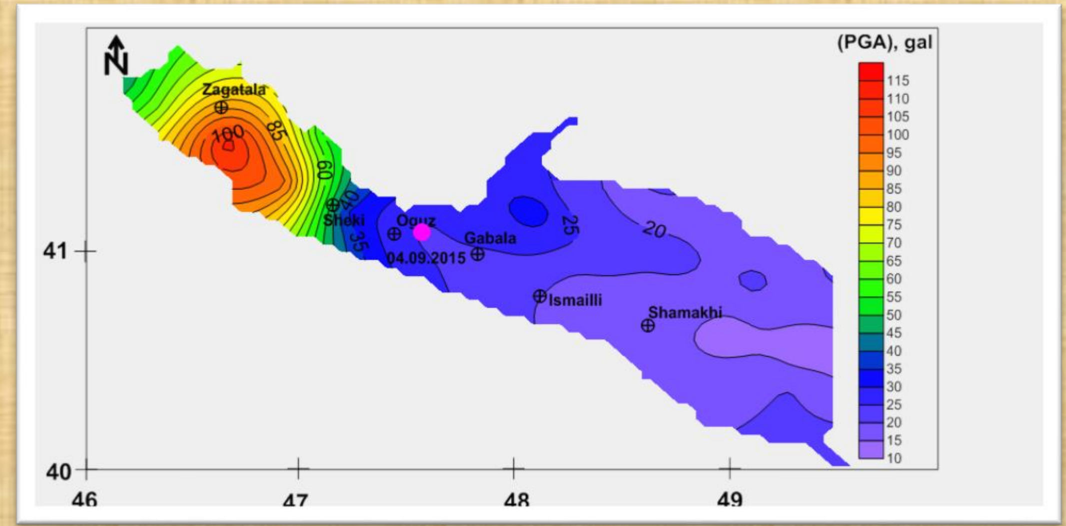
Gubin, 1984; Riznichenko, 1976; Toksoz, 1979; Ulomov, 2000; Utsi, 1961; Shebalin, 1971; Bonilla et.al., 1995; Mammadli, 2007



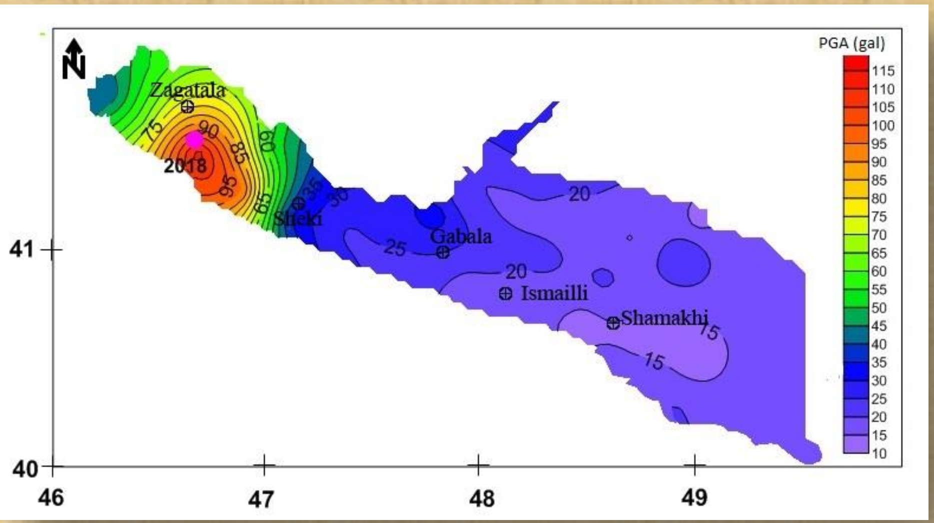
M6.8; h15 km **PGA=140-145 gal**



1902: M6.9; h15 km. **PGA=420-440 sm/s²**



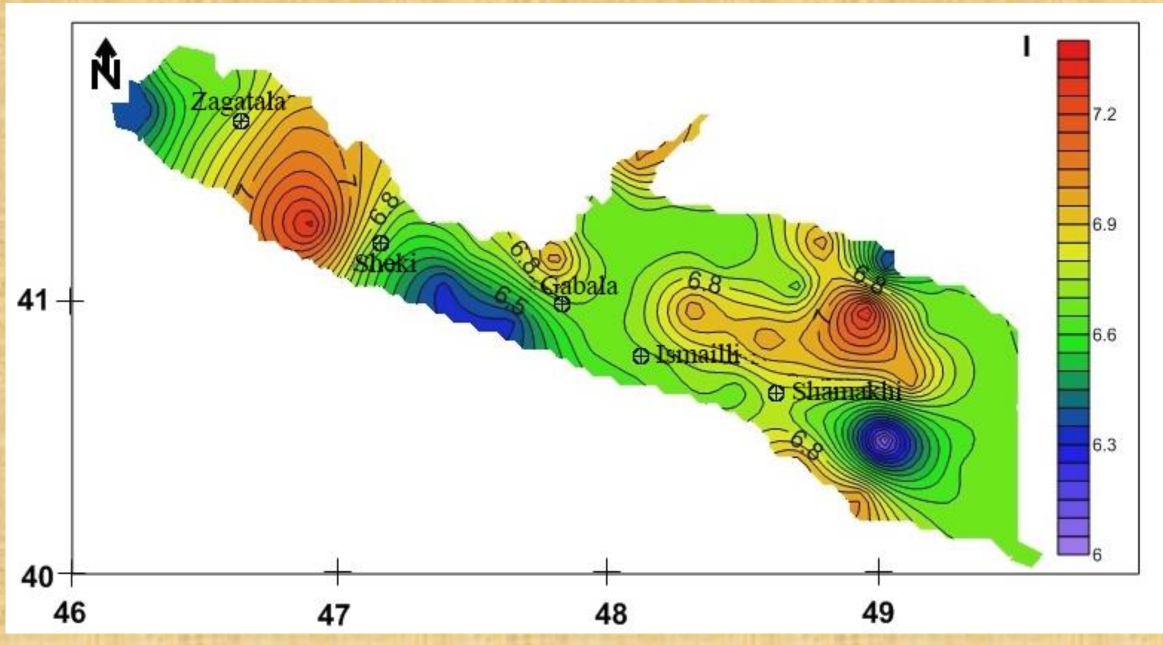
2015: M5.9; h13 km. **PGA 95-100 gal**

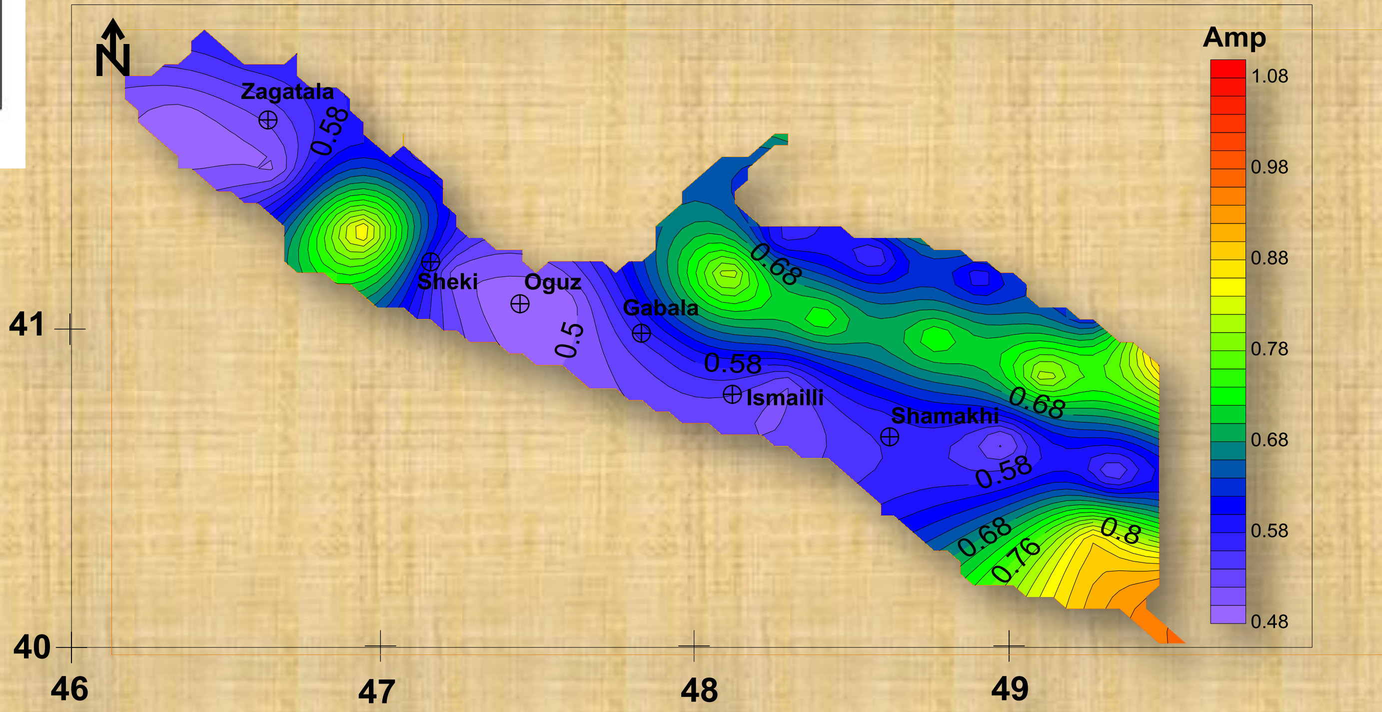


2018: M5.5; h10 km. PGA **95-110 см/с²**

PGA maps from scenario earthquakes demonstrate that the very high PGA is scattered in the west and east part of the study area. Independently from the epicenter of target earthquakes, the low and very low PGA is scattered in the central part of the study area.

Intensity and Amplification map





Conclusion

Demonstrated that ground displacements are various and not obviously oriented towards seismic source.

Seismic intensity increase is observed in the areas with soft-cemented sandstone-clay deposits, although there are inclinations of sandstone, limestone and sandy marl in them with various thicknesses.

These areas are characterized by high values of amplification factor

There are areas with sharp decrease of PGA values, most probably interlinked with damping factor of the ground

THANK YOU VERY MUCH