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DIFFERENTIATED SCENARIO-BASED ASSESSMENT OF EARTHQUAKE HAZARD IN THE OIL AND GAS DEPOSIT AREAS OF THE ABSHERON PENINSULA

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Summary. The objective of this research is a differentiated scenario-based seismic hazard assessment of the territories of oil and gas fields on Absheron peninsula through analysis of distribution of peak ground acceleration (PGA) and calculation of site amplification factor. Azerbaijan's hydrocarbon deposits are mainly located in the South Caspian oil and gas basin, as well as on the territory of the Absheron peninsula, where more than 80 oil and gas fields are located. By using probabilistic seismic hazard analysis and clustering of seismic events that occurred in the southern part of the Caspian Sea in 2000, the magnitude of the Caspian Sea (Mw 6.1; 6.2, 25.11.2000) seismic event for the current study as a scenario earthquake was assumed to be 6.3. To plot models of the PGA distribution in the study area, the values of the amplification factor of the site effect were calculated based on the analysis of boring data and lithological materials. Calculated values of PGA according to the macroseismic data of the Caspian earthquake vary within 100-380 gal in the field of Balakhany-Sabunchi-Ramany oil fields, which is one of the first oil fields of the Absheron peninsula and also is the territory of research.

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Introduction

Long-term studies of the geological and geophysical characteristics of the Absheron peninsula show that the peninsula is characterized by complex tectonics, geomorphology, a variety of lithological composition and the rock components. On the Absheron peninsula, Quaternary deposits are widely distributed in the central part of the peninsula and are characterized by the presence of various structural and orographic areas. The Baku oil and gas region is a large region in terms of oil production and reserves on the territory of Azerbaijan. The oil fields of the region are located on the territory of the Absheron peninsula (Surakhany, Balakhany, Sabunchi, Ramany, etc.) and the adjacent water area of the Caspian Sea. The main offshore oil and gas fields are Azeri-Chirag-Gunashli, Shah Deniz, Oil Rocks, Bahar, Sangachal, etc. (Guliyev et al., 2009).

The Absheron peninsula is located in the central part of the Alpine-Himalayan seismic belt and is involved in the dynamics of lithospheric structural units of the Arabian and Eurasian plates. Potential seismic hazard for the Absheron peninsula represent the earthquakes of the North Absheron seismogenic zone, which is caused by the south-eastern continuation of Main Caucasus fault system. The Absheron peninsula was exposed to the hazards of earthquakes from neighboring Shamakhy-Ismayilli and the Caspian Sea focal areas (Babayev, 2003).

Methodology

In this research, Balakhany-Sabunchi-Ramany oil fields, located within the Absheron peninsula, was used as a case study for differentiated scenario-based assessment of earthquake hazard.

For achieving differentiated scenario hazard assessment, we calculated the peak ground acceleration (PGA) and intensity of earthquakes from the 25 November 2000 Caspian scenario earthquake (M=6.3) taking into account the influence of the subsurface soil, which includes both physical (elastic wave velocities, density, attenuation), geometric characteristics of layers (thickness, shape of the boundaries) and site effects (Babayev, Telesca, 2014).

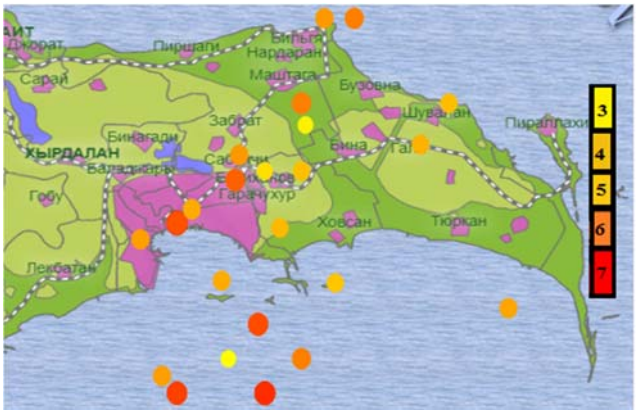

Fig. 1. Distribution map of earthquakes of the Absheron peninsula for 1942-2023 years. Legends represent the magnitude variations

This study consists mainly of S-waves, because S-waves, in most cases, have the most destructive effect. To estimate the values of the maximum amplitudes of seismic waves at the bottom of the soil layer, Aptikaev-Kopnichev formula was used (1):

$$\text{Lg } A_p = 0.28\ M - 0.8\ \text{Lg } R\ (\text{km}) + 1.7, \quad \text{if } A \geq 160\ \text{sm/s}^2 \tag{1}$$

where, A_p – peak ground acceleration (gal);
M – earthquake magnitude;
R – hypocentral distance (km)

The amplification factor of the seismic waves through formations were calculated, using the SHAKE software (with values of 0.95 and 1.86). As a result, distribution models of surface peak ground acceleration and seismic intensity, according to the data of the scenario earthquake with an epicentral distance of 35 km and magnitude of M = 6.3, was plotted.

Discussion

The plotted differentiated seismic hazard model of the Balakhany-Sabunchi-Ramany oil fields made it possible to present in more detail the degree of seismic hazard by estimating the distribution of peak ground acceleration (PGA) at surface in relation to the shakings at the bottom of the layers (Telesca et al., 2012).

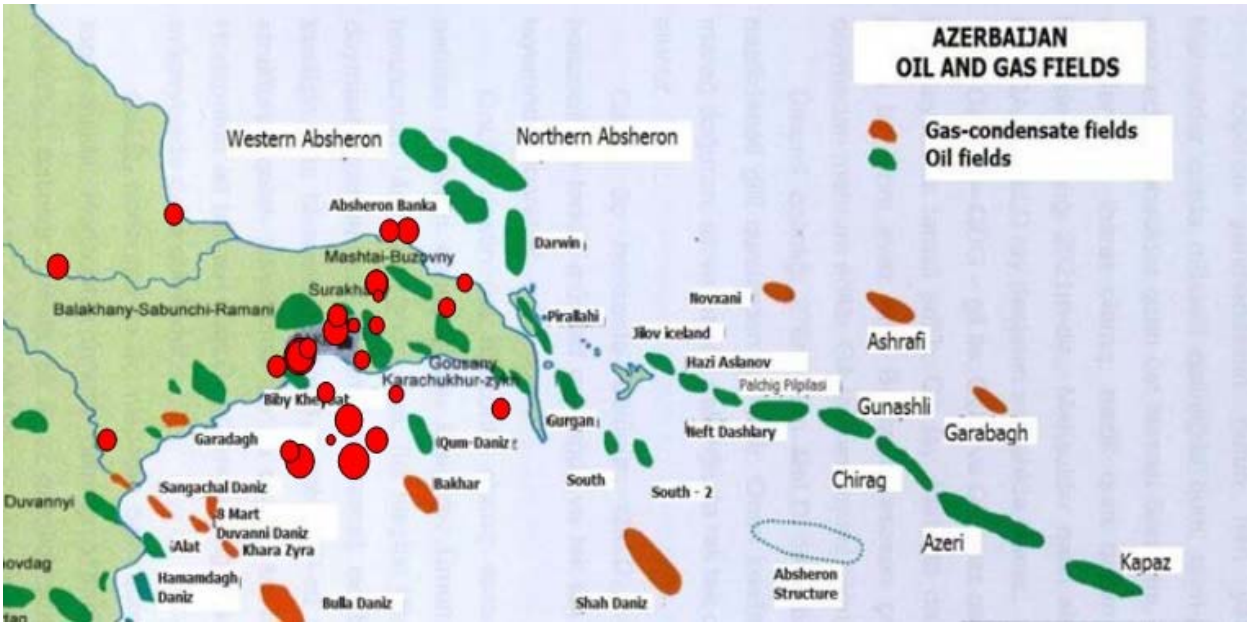

Fig. 2. Map of the distribution of seismic events (M=4.0-7.0) on the Absheron peninsula for 1975-2021

Based on the plotted model, it is possible to observe the attenuation of PGA on the territory of the Balakhany-Sabunchi-Ramany oil and gas field, which is associated with a high content of sands, sandy-clay materials directly in the ground of the deposit, sandy loam, loam, which contribute to the attenuation of seismic energy.

Although the PGA does not fully characterize the assessment of ground shakings that does not include the frequency, periods and duration of seismic oscillations, peak ground accelerations are widely used worldwide as the main criterion. Macroseismic intensities also remain a convenient parameter for assessing earthquake damage. The MSK-64 intensity was obtained based on the empirical relationship with surface peak acceleration values.

Conclusion

It was revealed, that as a result of a scenario earthquake (the scenario Caspian earthquake of 2000), most of the oil and gas zones of the Absheron peninsula is characterized by seismic impacts with an intensity of VII, as well as with the identification of VIII-intensity zones. As a result of the Caspian earthquake of 2000, selected in this study as a scenario, considering the influence of ground properties, the surface peak ground acceleration observed in the central parts of the Balakhany-Sabunchi-Ramany deposits reaches up to 240 gal and more (Babayev, Telesca, 2014).

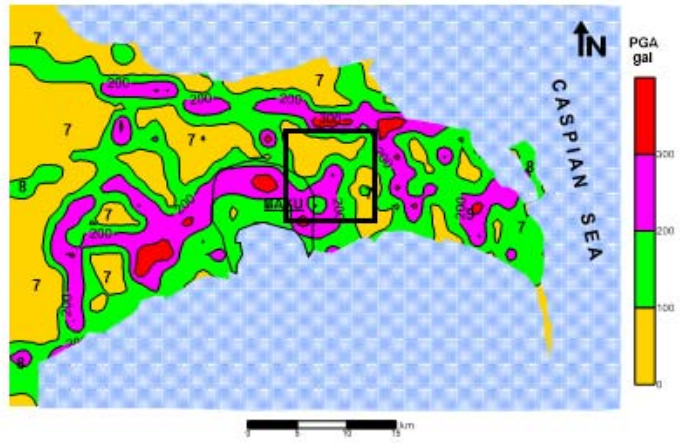

Fig. 3. Distribution map of the values of peak ground acceleration and intensity on the Balakhany-Sabunchi-Ramany field. The research area is highlighted by a square

In calculation of the peak ground acceleration at surface, the geological structure from the upper part of layers to the underlying layers with a loose composition and high plasticity was modeled taking into account the thickness of composition, content and density of layers, the velocity of P- and S-waves. The results show that the main influence on the amplitude of seismic oscillations is exerted by the thickness of a relatively low velocity zone of quaternary sediments that lie on limestones, clays and sandy clays of various thickness. In future, this model of the peak ground acceleration distribution at surface and intensity can be used in studies of the impact of earthquakes with various magnitudes and epicentral distance on the productivity of oil and gas fields.

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