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PHYSICAL-GEOGRAPHICAL FACTORS OF THE GEODYNAMICAL PROCESSES ACTIVATION (THE REGION RACHA-LECHKHUMI)

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Abstract*. Racha and Lechkhumi is a mountainous regions characterized with complex relief and geological structure. Here, nearly all kinds of hazardous geodynamical processes such as landslides, mudflows, erosion, rock flows, avalanches, karst and suffosive phenomena are observed, though the most frequent are landslides, mudflows and erosive processes and washing-off of river banks. The activation of the geodynamical process, hazard of large-scale development of gravitational phenomena are extremely increased by the fact that the whole region territory is prone to earthquakes of intensity 7-9. Among the factors taking part in geodynamical processes the most noteworthy are geological, geomorphological, climatic and anthropogenic factors. The large-scale map (1:50 000) of distribution of geodynamical processes in the Racha – Lechkhumi region, has been compiled on GIS.*

Key words: *Erosion, landslide, mudflow, Racha -Lechkhumi*

Introduction

The territory of Racha and Lechkhumi is one of the mountainous regions of Georgia, where erosive and other hazardous geodynamical processes (landslides, mudflows, avalanches, rock flows, etc.) take place in different degrees.

The economic damage caused by them is enormous and dangerous for the environment. Among all the well-known geodynamical processes in Racha – erosion (with different types), landslides and mudflows are the most hazardous phenomena.

Study area, material and methods

Regions Racha (Ambrolauri and Oni Municipalityes) and Lechkhumi (Tsageri Municipality) are located in the northeastern part of Western Georgia on the southern slopes of the Caucasus. The hypsometric levels of the territory vary from 320 m (Tvishi Cliff) to 4462 m (Mount Chanchakhi, Great Caucasus Ridge).

The research is based on a complex physical-geographic, field, cartographic and GIS methods. The research was based on the existing published literary and foundation material about Racha -Lechkhumi region. Namely, Transcaucasus Medium-Sized Landscape Map [1], also Topographic Maps Racha -Lechkhumi region (scale: 1: 50 000, 1: 100 000) and statistical data [2, 3]. The important component was the field expedition research conducted in 2019- 2022.

Results

Among the factors, which have a unique role in generating geodynamical hazardous processes, the main ones are the lithological structure, history of the relief development and age, morphologic characteristics of the mountain region, hydrologic conditions, behaviour of soil and vegetation cover and also anthropogenic factors.

Its complex geological structure distinguishes the relief of Racha – Lechkhumi. The top of the Caucasus Ridge has a horst-anticline structure. Its crystalline core reaches 4000-4500 m above sea level and is outcropped because of erosive processes; it is composed of pre-Palaeozoic and Palaeozoic granite, gneiss and schist [4].

Characteristically the complex, segmented relief, 22% of the territory is occupied with lowlands, 78% is covered with mountains and foothills with high-mountainous. In the relief's development, together with tectonic and erosive-accumulative, karst, gravity and other processes, the modern and old glaciations have an active role.

In the development of geodynamic processes the orographic properties of the territory, hypsometric disposition and exposition, sloping of the relief surface, fragmentation degree and etc. are of great significance.

The moderately sloped relief (15-20%, 20-25%) occupies most of the area, totalling 30.4%, extremely sloped relief (25-30%) covers 14.5%, steep slopes (30-35%) make up 19.2% and sheer cliffs cover 2.8% of the territory.

In Racha – Lechkhumi, the modern erosive processes are widely distributed in flysch, terrigenous and volcanic sediments, there are two kinds of erosion: vertical and lateral. Surface washing-off (with soil erosion) is widely distributed here. In most of the territory, vertical erosion is observed. It is observed in the areas of nearly all tributaries of the rivers Rioni, Tskhenistskali, Lajanuri and Jejori because of the great thickness of the deluvium cover, an abundance of atmospheric precipitations and flow of underground waters at little depths [2,3]. Vertical erosion is extreme during summer rains and snow melting periods. At the same time, vertical erosion becomes more severe because of ploughing activities on slopes, which are highly slanted. It is hazardous regarding the development of liquid impact erosion. Lateral erosion is observed almost everywhere, and hundreds of hectares of fertile soil are degraded for this reason. Terraces are intensively washed down in town Ambrolauri, Tsageri, villages of Chrebalo, Shardometi, Sori, Gvirishi, Chalistavi, Orbeli, Tsiperchi, etc.

Erosion, potential hazards of landslides and mudflows are influenced by precipitation quantity. On the one hand, precipitation distribution during a whole year is more significant for the generation of erosion.

Seasonal distribution of atmospheric precipitations over the whole territory of Racha – Lechkhumi is as follows: in Racha there are two peaks of precipitation fall: maximum – in May (105-215 mm) and in October (99-202 mm), minimum – in August (79-163 mm) and in January (79-162 mm). In Lechkhumi precipitation falls: maximum – in June (114 mm) and in October (122 mm), minimum – in August (87 mm) and in January (106 mm). On the territory of Racha the most quantity of atmospheric precipitation is observed in Kharistvala (2178 mm annually) that is mainly conditioned by its orographic conditions, On the territory of Lechkhumi 1292 mm annually [5, 6].

The precipitation quantity during one rainfall is also significant. Flow formation and erosion development is highly influenced by precipitation intensity, i.e., the quantity (mm) of water that falls in a unit of time. During heavy rains, when water falls on the surface so rapidly that the soil cannot absorb it, a surface flow is formed and it washes the soil off. The more persistent and long-lasting the torrential rain is, the more dramatic is the effect of the erosive processes. During drizzling rains, even in case of high quantities of precipitations, soil washing-off is not observed or it is quite inconsiderable.

Erosive processes are highly influenced by considerable variation of daily air temperature. In Racha, average annual air temperature varies from 11.4° to -2.4°. The coldest month is January (-0.2°,-12°) and the hottest month is August (23.8°). In the most part of the territory (at 500-1600 m above sea level) the annual temperature amplitude is 22°-23°, whereas in the high-mountainous zone it is 19°. In spring low temperature at night causes soil freezing. During daytime the surface of a thin soil layer thaws, becomes saturated with water and is easily washed off.

While studying erosive processes it is essential to take into consideration the structure of the soil cover, also the water permeability of the soil, on which the value of the surface runoff depends greatly and which is the major reason for soil washing-off.

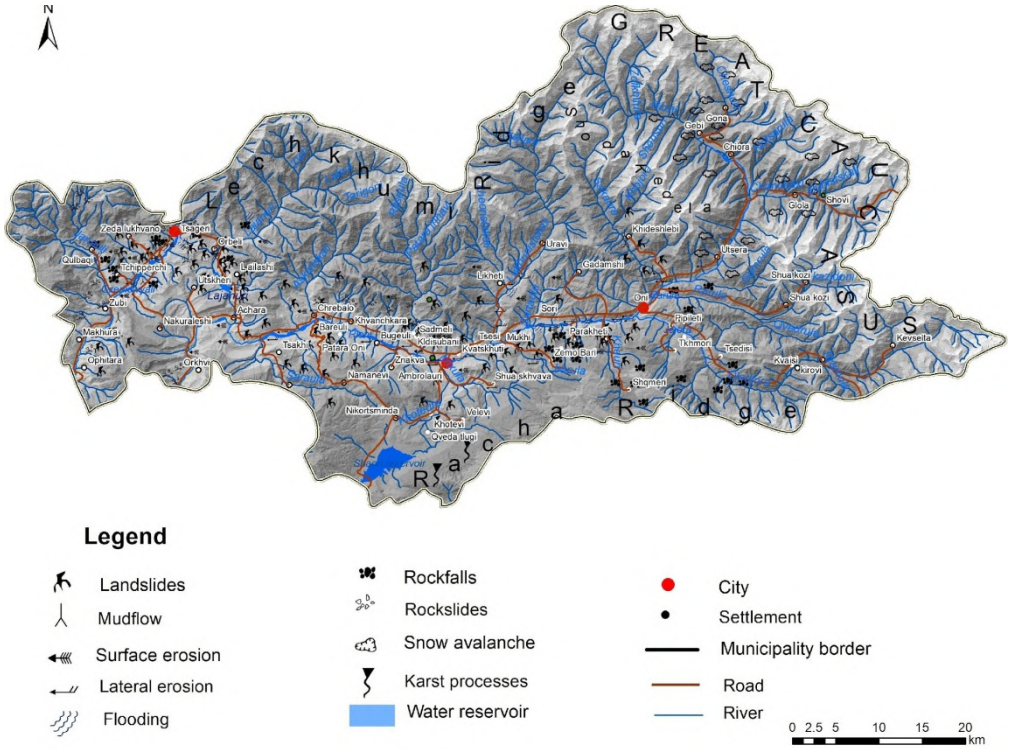
In the study region, when the daily quantity of the atmospheric precipitation is 100-120 mm and more during torrential rains and there is a significant slanting of slopes, then liquid impact erosion takes place. In the zone of forest dark grey and humus-carbonate soil, on the 10-15° slopes, where hoeing cultures are grown, after one torrential rain (0.5 mm/min) 20-25 t/ha soil is washed off (table 1).

Table 1. Washing soil off arable lands Racha-Lechkhumi

Municipality	**Arable lands completely (Thousand ha)**	**Relief inclination**	**Washing soil off arable lands in year t/ha**	**Degree of soil erosion Metric t/ha**		
				Low	Medium	High
Ambrolauri	2.7	$15\text{-}20^0$	5-10;	1.0.	0.8	0.3
Oni	1.4	$25^0>$	5-10; 20-25	0.7	0.5	0.1
Tsageri	1.5	$25^0>$	5-10; 15-20	0.6	0.5	0.2

On the territory of Racha, in Ambrolauri Municipality, from moderately slanting slopes (15-20°) 5-10 t/ha soil is washed off annually, while in Oni Municipality 20-25 t/ha soil is washed off on extremely slanting (more than 25°) slopes, Tsageri Municipality 15-20 t/ha soil, from more than 25° slanting slopes [7,8].

Erosion is in tight relation with vegetation cover. Vegetation cover always decreases the development of erosion or completely stops it. Erosive processes, especially lateral erosion, are one reason for landslide formation. The main factor that causes generation and activation of landslide processes are complex geologic structure, distribution of rocks with low physical properties on large areas, deep fragmentation of relief and excess of extremely slanted surfaces, a large number of tectonic clefts, high seismic activity, variation of climate conditions and contrasting meteorological elements. Activation of landslide processes highly depends also on anthropogenic economic activities.



Distribution of geodynamical processes in the Racha – Lechkhumi

In Oni Municipality, the area of the Somitso Landslide is 550 ha, the Zhashkva Landslide area is 1500 ha, the volumes of which vary from several thousand m^3 to tens and hundreds of millions of cubic meters. The volume of the Chorda Landslide is 150 mln m^3, and the Zhashkva Landslide volume is 200 mln m^3 (in Oni Municipality), in Tsageri Municipality, landslides: Sairme, Lukhvano, Orbeli, Lajana, Lailashi, Ckhuteli, Gveso, Surmushi, Gagulechi, Spatagora, Leshkedi, Okureshi, Larchvali, Chalistavi, Zaragula etc.

The most active landslides are observed in Parakheti, Shardometi, Tsedisi and Ghebi. The 1991Racha Earthquake with magnitude 7.2 and intensity IX, which along with the 1988 Spitak Earthquake (Armenia), is the strongest among the earthquakes recorded in the Caucasus so far, in village Chorda triggered a massive landslide (volume 150 mln m^3) that destroyed the village of 70 households. Landslides with volumes of 170-200 mln m^3 were formed on the territories of Zhashkva and Bajikhevi.

According to the landslide damage and hazard risk zoning of the territory of Georgia, Racha belongs to extremely high (0.9-0.7) and high (0.7-0.5) risk categories [3].

According to the risk of damage caused by mudflow processes on the territory of Georgia, the region of Racha „includes an extremely “great hazard” (0.8-0.6) area, which covers the middle mountain and high mountain belts of Racha, the zones of Jurassic slates and terrigene-carbonate flysch. It mainly covers the territory of Oni and Tsageri Municipalities. The “considerable” mudflow area covers the middle mountain and low mountain belts in Ambrolauri Municipality and the low mountain belt in Oni Municipality.

The area of “weak” (less than 0.01) mudflows covers the foothill zone, the part of the Racha Ridge built of carbonate rocks. Mudflows are most characteristic of the rivers originating from the Shoda-Kedela Ridge

(the head river Rioni): Sakhrikilo, Gizhura, Shodura, Lagora, Sakaura. In summer 2020, as a result of the flood and mudflow caused by overflowing of the rivers Sakaura (the right tributary of the river Rioni) and Rioni, the Tbilisi-Oni main highway was substantially damaged, a bridge collapsed, village Lagvanta and several other villages were left entirely isolated from the regional centre and were enormously damaged. Mudflows are common in the basins of the rivers Kondarula, Tchioriskhevi, Shkhiroruli, Dagoruli, Rubodzali, Sasvanostskali, Barula, Shardometiskhvi, Tcheshora, Seva, Parakheti, Tskhenistskali, Jonouli, lajanuri.

Based on the studies of the properties of geomorphologic and composing rocks there are certain regularities in the formation of mudflow foci. Foci transformed by erosion and erosion-landslide processes dominate in the foothills and low mountain zones; gravitational-landslide processes are observed in the middle mountain zone; in high mountain zones there are gravitational processes formed due to solifluction and snow avalanches. Mudflows are formed in the alpine-nival belt and so called “glacial mudflows” are observed in Quaternary glaciation sediments and moraine sediments of the modern glaciers.

On August 3, 2023, a catastrophic glacial mudflow developed in the Bubistskali River Gorge, which was caused by the coincidence of hydrometeorological (intensive melting of the glacier and residual snow cover, atmospheric precipitation in the form of rain, high atmospheric air temperature) and geological events (rockfall at the headwaters of the gorge; landslide-erosion processes). The mudflow of the Bubistskali, a right tributary of the Chanchakhi River, first became a mudflow and then a flowing landslide. The total volume of this mass is 1 million m^3 and still covers the resort area [9]. As a result of the disaster, buildings were destroyed in the Shovi resort area, 33 people died.

The quantity of mudflows is increased due to exceeding the average long-term precipitation norm and also anthropogenic load, especially forest clearance.

Conclusion

The analysis of the physical-geographical factors of Racha-Lechkhumi enables us to make the following conclusions: the mountainous, extremely fragmented relief, the climatic conditions, often unreasonable economic activities (clearance of soil-conserving forests, wrong land farming activities on mountain slopes, washing-off of pastures) contributes to the rapid development of liquid impact erosion that later causes washing-off processes in the upper layers of arable lands.The vegetation cover plays a significant role regarding soil-conserving, especially the forests of timber trees [10].These are oak-oriental hornbeam and oak-hornbeam forests, which can be assigned to the category of forest non-prone to erosion.

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