

# Geomorphological Zoning of Racha Region for Geopark Planning

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## Abstract

Geomorphological zoning and complex relief research were conducted in the Racha region, which is located in the Caucasus, in the northwestern part of Georgia, south of the Greater Caucasus, in the central part of which there are Precambrian and Paleozoic crystalline substrates (gneisses, migmatites, crystalline shales) and granitoid intrusions of different ages. The Caucasus axis and higher massifs are built of granitoid, gneiss, and metamorphic shales. The oldest rocks (600 million years old) are found at the highest points and the age of the rocks decreases in the vicinity of the hypsometry steps (70 - 30 million rocks). The geological structure of the region has made a significant contribution to the formation of relief landscapes. Karst, erosion-denudation, volcanic, periglacial relief, and various interesting forms are formed here: caves, valleys, canyons, glacial and rocky lakes, waterfalls, deep valleys, mineral waters, and more. The peculiarity of the relief also influenced the mining geological history (5000 AD) and the creation of ancient settlements. Here, still in ancient Racha, at the head of the main river, Rioni, ancient settlements were formed due to iron, gold, and copper metal, which is confirmed by archaeological monuments.

## Keywords

Geopark, Geomorphology, Geology, Natural Monuments, Tourism, Sustainable Development

## 1. Introduction

The relief of the study area is mountainous. The average height is 1700 m. The lowest point of the relief is 380 m, near the village of Zeda Ghvardia, Ambrolauri Municipality, on the left bank of the Rioni River. The highest point is the peak Chanachakhi—Oni Municipality, 4460 m above sea level. The forms of relief

formed here due to of tectonic and exogenous processes are glaciers, karst, gravitational, etc. Forms represent.

Racha consists of Ambrolauri and Oni municipalities, together with Tsageri (Lechkhumi) and Lentekhi (Svaneti) municipalities and together form the Racha-Lechkhumi and Kvemo Svaneti regions.

## 2. Materials and Methodology

The research process took two years. The research included the processing of materials obtained during the expedition and local scientific literature. I made analytical digital maps based on the materials collected through the GIS program. I have identified three geomorphological zones in the region that describe in detail the complex geological areas in the region, the terrain morphostructures, the geologically dangerous or interesting areas, just the beautiful landscapes. The presented study is complex, on the basis of which the analysis was made.

Based on the field research, I have compiled a list of important relief forms that should be granted the status of a natural monument (glacial lakes, peaks, waterfalls, canyons, etc.). The coordinates of completely natural objects were determined by GPS and recorded on a digital map. The routes of access to natural monuments and the complexity of the areas were also determined.

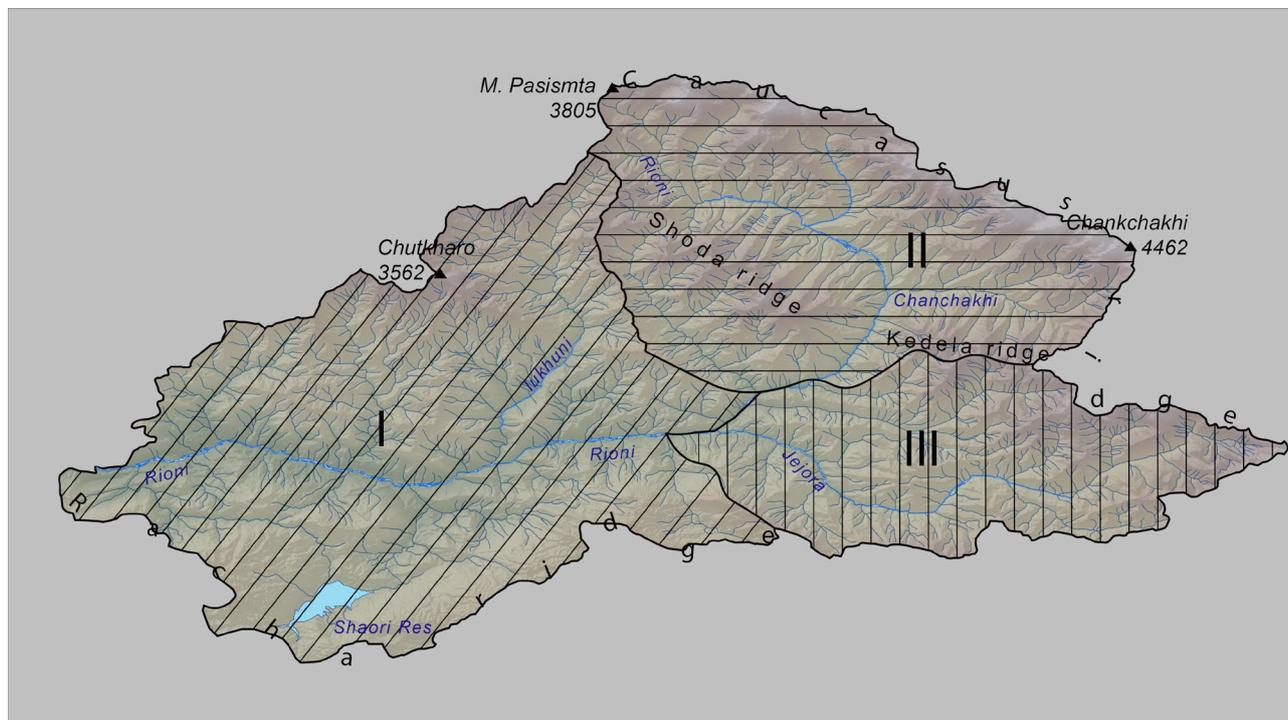
## 3. Results

The region is located in Sinclin and is built of Oligocene and Lower Miocene clays, sandstones, conglomerates (Maikop series), and marine molasses. Syncline is divided in the middle by the small ridge of Labechina, in the eastern part of which is Racha, and in the west the territories of Lechkhumi. The wings of the syncline are of Oligocene age, while the Racha Range to the south and the Saelio Range to the north are built of Cretaceous limestone where is the beautiful Khidikari Rock. Khidikari deserves the status of a natural monument because it is also a historic defensive structure.

Racha region has seismotectonic zones active with strong earthquakes. This is due to the strongly differentiated movement of the terrain. Two structural units collide here: the Caucasus ridge and the Georgian belt. There is both vertical and horizontal movement in the region; For example, studies have shown that the central part of the Caucasus rises by 10 - 15 mm per year., Shoda-Kedela ridge is equal to 7 - 8 mm per year, Racha-Lechkhumi syncline wings 4 mm per year, except On vertical slopes, the Racha ridge experiences a horizontal movement to the northeast (Khotevi 2.9 mm). Mountain Racha hollow up to 4 mm per year [1].

### **Geomorphological characterization of the relief and important areas**

Morphological, morphometric features, geological structure, tectonic movement, according to the relief characteristics in Racha, there are several areas (**Figure 1**).



**Figure 1.** Racha geomorphological zones: I. Kvemo Racha relief types and distribution areas; II. Types of relief and distribution areas of Upper Racha; III. Jejor and Gharuli Basin.

## Racha Geomorphology

### I) Kvemo Racha relief types and distribution areas

In the northern part of Kvemo Racha, there are

1) *Highland relief with remnants of old glaciation, landslide development, produced on the substrate of marl and clay shales, limestones, sandstones, and Upper Lias shale-sandstones of Valanjin, Middle and Upper Jurassic.* The distribution area is the southern slope of the Lechkhumi ridge, from the peak Taa-rikoni (2577 m) to the Lukhuni (2988 m). It includes rivers: Ritseula, Kodilask-hevi, Zhrinev, Khoristskali, Sokhartulistskali, Latashurastskali, rivers Kajiani, Lukhunistskali headwaters. In this zone, there are forms of Quaternary glaciation, moraines and trogs (rivers at the headwaters of Ritseula and Zhrinev, at an altitude of 1900 - 2000 meters). Glacial terrain, cirques, trogs, valleys, Moraines, glacial boulders, porphyries create a clear picture of the scale of glaciation [2].

2) *Medium height mountain—artisanal, with erosion Strong distributed relief, formed in a series of upper Lias shales.* This type of relief extends in the middle and lower part of the southern slope of the Lechkhumi ridge, the rivers: Lukhunistskali from the headwaters to the confluence of the Rioni, Ritseula, and its tributary, the Akhiskhele. River and its tributaries: Sadolkoma, Kaskhenvake, presented zone is mainly modified and represented by anthropogenic landscapes. Of particular interest in this zone are the deep valley of the river Lukhunistskali and the terraces on the left, where are 6 terraces. There are no terraces on the left side of the river, indicating that on the right side of the valley, there is a terrain that moves vertically (Uravi, Likheti, Abari).

3) *Chutkharo—a highland diabase porphyritic massif of sandstone with signs of modern and ancient glaciation.* In this zone is the southern part of the Lechkhumi ridge, with a jagged ridge with sharp relief. During the fourth period, due to intense glaciation, in the Chukharo-Kupri section, glaciers moved in all directions, as evidenced by glacial forms, moraines, trogs. The highest part of the relief is formed by Chutkharo (3562 m), Samtskhle (3562 m), Caretta (3354 m), Salomgruano (3084 m), Mkvatsishkhe (2881 m), Kvatsikhe (2356 m), Kupra (2338 m). On the southern slope of Lechkhumi, there are sharp descents.

4) *Medium-height mountain-valley relief, developed on a substrate of porphyry ridges and Cretaceous limestones of Bois.* Includes the northern part of Racha syncline, which extends south through the porch ridges of Bios (Cretaceous limestone). Relief is narrow, canyon-like valleys with asymmetric ridges (Salio ridge, which has a southern slope with strong sloping slopes and cornice forms). On the Saelo ridge is the beautiful canyons, which deserve the status of a natural monument (**Figure 2**). Flattened areas at 1400 - 1500 meters, short meridian valleys, the remaining steps of the snow avalanche (on the left slope of the river Askistskali gorge) Anti-ascending valleys (from the lower Sarmat to the area there is constant vertical movement, during which there is deep erosion [1].

5) *Right terrace slope of Rioni Valley, developed by landslides, formed on Oligocene, Middle, and Lower Miocene substrate and Sarmatian clays, sandstones, limestones, and marls.* In the Racha syncline, there is a valley of the river Rioni with frequent meandering and bed expansion. There are nine terraces on the right side of the river Rioni, but there are no terraces on the left side; the main reason is vertical movement.

6) *Middle and lowland of the southern wing of Racha syncline, tectonic erosion,*



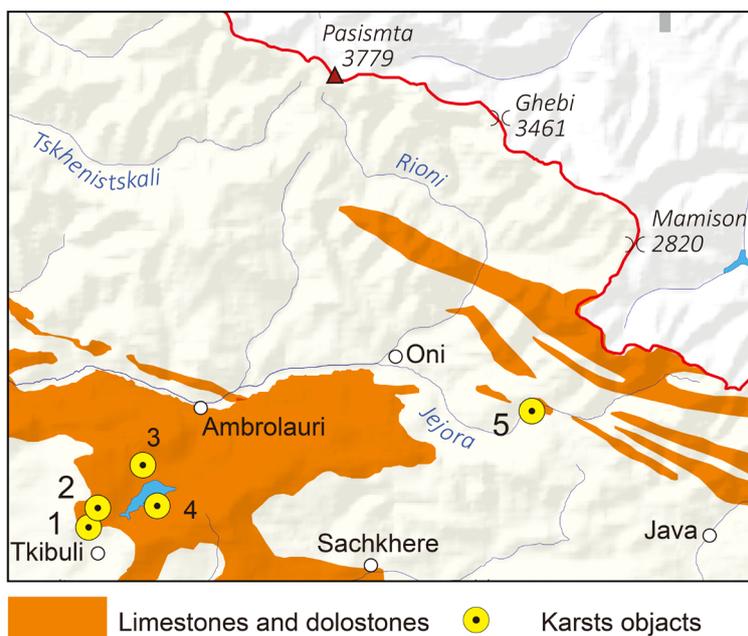
**Figure 2.** Khidikari, photoed by Tamar Chichinadze.

and karst relief limestone strip, developed on the substrate of Cretaceous and Eocene limestones, marls, and sandstones. This type of relief extends from the top of the Racha ridge to the Racha-Lechkhumi syncline. There are three sub-types of relief:

a) Medium mountainous, wrinkled-karstic relief of the northern slope of the Racha Range, developed by limestones of Lower Cretaceous Urgonian facies, on a substrate of marls and sandstones. The middle ridge of Racha belongs to the type of relief under consideration, the height of which varies from west to east in the range of 1500 - 2000 m (M. Leknari—1746 m, M. Tskhrajvari—1569 m, M. Satsalike—1996 m), 2200 - 2400 m (M. Khikhata—2239 m, M. Potskhvrevi—2402 m). The ridge has an alternation of peaks and passes. Racha ridge geomorphologically is not only within the borders of Racha; it continues in the west in the form of Khvamli and Askhi limestone ridges and in the east, it extends to the Caucasus, to the ridge. Due to the rocks of Racha ridge (built of lower Cretaceous limestones), the humid climate, flat relief, karst forms, caves, wells, siphon forms, depressions are frequent [3].

Racha limestone massif starts from the Lechkhumi area and continues to Likhi ridge. Only 590 km<sup>2</sup> of the Racha limestone massif enters the territory of Racha region. The highest point is 2402 m. It is a lynx, and the estimated depth of the inner voids reaches 1200 meters therefore it has not been fully explored, although there are probably 45 gaps and caves, of which 32 caves explored (Figure 3).

### Racha limestone massif



**Figure 3.** 1. Tskhrajvari Cave—Important paleological cave (ursus spelaeus); 2. Muradi Cave—Interesting cave with beautiful examples of pool speleothems; 3. Nikortsinda cave—the cave with ice in carbonate rocks; 4. Shaori polje—the biggest karst polje in the Caucasus region; 5. Tsona cave—important paleontological cave (human's former dwelling) [5].

Speleologists divide the karst mass into three parts: Racha limestone massif: Shaori-Satsaliki, Tskhrajvari-Leknari, Khikhata-Shkmeri districts [4].

#### **Racha limestone massif**

b) *Low two-layered, erosive-karstic relief of the southern part of Lower Racha, with deep V-like valleys, developed on the substrate of Upper Cretaceous and Eocene limestones and marls.* This zone represents: the Racha Range, the Rioni River Basin and the Shaori Reservoir. In the western part, this type of relief is on the right bank of the river Shareula (Upper Cretaceous and Eocene limestones, marls, clays). Karst forms are associated with caves, mineral springs, canyons, caves, ravines (kheora, krikhula). Volcanic forms (Namanev Mountain 1368 m), karst lakes (Chiki Lake, Cheleaghele Lake), Waterfalls (Tkhmori, Znakva) are frequent in this sub-zone.

c) *Tectonic-erosive relief of the Shaori Cave at the bottom of the accumulation; Developed on the substrate of marls, barren limestones, and quaternary loose sediments.* It is the north of Racha ridge In the part which is triangular shape and occupies mainly the Shaori Reservoir. Reservoir nutrition depends on groundwater. The relief rocks of Tafoba are limestone in nature and are characteristic of Karst springs, wells, and siphon forms.

7) *Racha-Lechkhumi syncline depression hill, terrace, and landslide relief developed on the third and fourth clays, marls, sandstones, and alluvium substrate.* This type of relief includes the bottom of the Rioni River valley, which coincides with the Racha-Lechkhumi syncline, which is built of Pliocene and Miocene clays, marls and sandstones, which are replaced in the east by porphyries, sandstones, and Jurassic clays, which is why Landslide processes. Presented relief forms are accumulation ridges, terraces, ravines, ravines, gravity cones.

#### **II) Types of relief and distribution areas of Upper Racha**

Geomorphological characteristics and relief forms of Upper Racha: 70% of the territory is hypsometrically high mountains. This district starts from the southern slope of Lechkhumi ridge, m. From Lukhuniver (2988 m), it includes the ridges of Shodi and Kedela, which are divided in the middle by the river Rioni. A ridge is a longitudinal direction, characterized by alternating peaks and passages. In the northern part of the Shodi ridge, compared to the branch of the Lechkhumi ridge, the dividing Sasvanostskali and Lukhunistskali (Lukhuni pass—2675 m, Shavtskaro—2584 m) is low, the ridge gradually ascends to the south. Here we meet: M. Budzgora 3236 m, (on Sakao ridge, Shodi branch), M. Shod Mountain 3609 m., M. Sakao Mountain 3130 m., M. Laghora 3152. The hypsometric step of the Kedela ridge rises to the east and crosses the Caucasus ridge. Its highest peaks are M. Dolomite Mountain 3226 m, M. Getske 3426 m. Shoda-Kedela ridge is the ridge of the Horst-Sinklin structure, Developed on upper Jurassic and Cretaceous layers (carbonate flysch). The main river Rioni divides the Shoda-Kedela ridge into two parts, which are characterized by frequent canyon valleys, narrows, trophic valleys, moraines, landslides, and more. The northern part of this zone is the Caucasus ridge. Only a small part of the Caucasus, M. Price from the mountain (3779 m), up to Chanchakha (4462 m) borders the Ra-

cha region, this section of the ridge is the central part of the Caucasus, a crystalline massif that is the highest and gradually decreases to the east (Mamison Pass—2820 m). It is a mountain range in the Central and Western Caucasus Relief developed on crystalline ridges of the Paleozoic period, Horst-Anticline ridge, with intense upward movement. To the south is the relief of the middle and highland subdivisions, developed on the lower Jurassic ridges (caves, passages). This area includes Bodurash, Dombitsver, Molise (M. Kamajini 2396 m), Red Mountain ridges, trogs and canyon valleys. The relief forms in Upper Racha are accumulation, ravines, trog, valleys, moraines, glacial boulders, landslides, steep slopes, jagged cliffs, and more [6].

I consider Sasvano Lakes a natural monument of Upper Racha, located in Oni municipality, at 2373.5 m above sea level. On the watershed ridge of the rivers Rioni and its right tributary, the Sasvano River, the lakes are of glacial origin. Geomorphologically it is located in the sub-zone of highland relief, on the upper Jurassic and Cretaceous ridges (carbonate flysch). In terms of exogenous processes, erosion-denudation processes, floods, and snow avalanches occur in the area. The best time to visit the area is June-September [7].

Upper Racha has a geological history of 200 million years and 5000 years of mining geology. It is mainly related to the metallurgical regions, the central part of the Caucasus, and its south with skirts. Archaeological discoveries have shown that our ancestors were well versed in several ways of mining, working in it, and extracting ore (Figure 4). They knew the necessity of laying horizontal, inclined and vertical tunnels along the cliffs. They were well versed in the laws of physics

### Archeological monuments

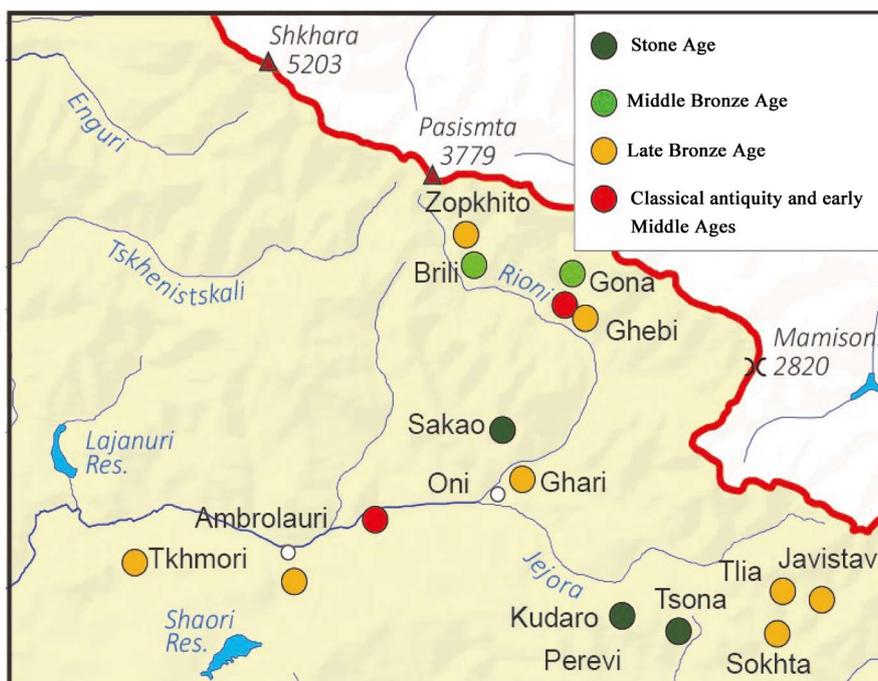


Figure 4. Map of archeological sites [5].

related to ore mining [7].

### III) Jeji and Gharuli Basin

The area is between the branch of the Racha Range and the main ridge of the Caucasus. Racha ridge goes to m. To Zekara, where it narrows to the south, and then m, it continues to Khikhata. The Caucasus ridge reaches an average of 3400 meters on this section, where the peaks are: Khalatsa 3938 m, Kvazha, Kozikhokhi 3687 m, Saukhokhi 3711 m, Zhedo 3452 m, Zekara, Ukivileta, Veluanta (the second branch of the Caucasus). The ridge is sharp and asymmetrical. There are the following forms of relief on the territory: Glacial: moraines (rivers: Gharula, Kvazha), Door-type glacial (Saukhokhi), circuses, trogues (Gharula river valley, Jeji river valley), frost-mechanical depletion (resulting relief) Dolomistsveri (Gheske, Kvaja, Saukhokhi, Khalatsa, Zekara) Erosive mountain relief and erosive river forms, karst forms, caves), landslide forms (mainly found in the Jeji basin), and others [8].

There are several objects here that I think deserve the status of a natural monument, for example, Tskhmori waterfall, Kvedi Lake.

## 4. Conclusions

As a result of the presented study, the geomorphological zoning of the region includes three main zones, where subzones are also separated. Each zone has common characteristics of relief forms, age of rock rocks, landscape characteristics and more.

The first zone has seven subzones as they are characterized by a variety of terrain. The hypsometric step varies from 390 m (Racha-Lechkhumi syncline) to 3562 m (Lechkhumi ekdi). The geomorphological structure of the terrain has created a diverse landscape. Due to the fact that the middle and lowland areas of this zone are inhabited, the natural landscapes are modified to 300 - 1000 m. Already complex morphological processes are intensified due to anthropogenic influence, Constant floods, and landslides.

In the second subzone—Upper Racha, 70% (More than 3000 meters) of the relief belongs to a high mountain. Small settlements are shrinking even more. Landscapes are changing due to the extraction of mineral resources and the construction of hydropower plants. Constant current processes are landslide, rock avalanche, and snow avalanche.

The middle and highland (2000 - 3000 m) reliefs presented in the third zone, a subzone of the monoclinic ridges, develop on the porous Bayo ridges, which are relatively low in the eastern part and higher in the north. Persistent exogenous processes are rock avalanche, landslide, and snow avalanche. Most landscapes are pristine.

The complex geomorphological and geological processes of Racha region have contributed to the formation of beautiful landscapes: caves, karst lakes, glacial lakes, valleys, canyons, cliffs, rocky lakes, waterfalls, ancient mines, etc.

Many areas of tourism can be developed in the region, which is more impor-

tant in terms of nature conservation and economic benefits.

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### Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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