GEOCONSERVATION VALUE OF THE PERIGLACIAL LANDFORMS IN RILA

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ABSTRACT. The effects of freezing and thawing drastically modify the ground surface in a periglacial environment. The types of modification include the displacement of huge amounts of soil materials, rock boulders, and the formation of unique landforms. Along with the typical glacial formations like cirques, glacier valleys and carlings, periglacial landforms also have their place in the concept for development of Geopark Rila. Despite the low geodiversity of the mountain, the glacial forms give an alpine appearance to its relief and a high aesthetic value of the high mountain landscapes. The main challenge in presenting geological information to the general public is the interpretation of glacial and periglacial processes. The choice of representative geosites implies a balance between their scientific rationale and the opportunity to be presented in an interesting and attractive way to the visitors to the geopark. That is why the aesthetic, ecological and historical aspects of the geosites are added to the high scientific value. The highly expressed fossil glacial relief of Rila, inherited from the last Würm ice age, continues to be the subject of modern geocryogenic processes and undergoes an active periglacial processing, which can be demonstrated in the most visited high parts of the mountain. Along with the well-known horns, cirques and glacier valleys, which are typical glacial landforms, many geocryogenic formations due to desquamation and solifluction processes, are encountered: periglacial moraines (scree slopes), cryonival cirques, avalanche channels with erosional scree cones, as well as the rounded regolith covered peaks, which have their own specific name in Rila – chals. The periglacial landforms and the fossil glacial relief are an integral part of the modern high mountain landscape of Rila, which attracts thousands of admirers of the alpine nature. The implementation of a holistic concept of conservation, education and sustainable development of Geopark Rila in combination with all other aspects of the natural and cultural heritage can bring the desired economic benefits and prosperity to the whole region.

Keywords: Geopark Rila, periglacial landforms

ГЕОКОНСЕРВАЦИОННА СТОЙНОСТ НА ПЕРИГЛАЦИАЛНИТЕ РЕЛЕФНИ ФОРМИ В РИЛА

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РЕЗЮМЕ. Въздействието на замръзването и размръзването променя драстично земната повърхност в условията на периглациална среда. Промените включват преместване на големи количества почвен материал, скални късове и оформяне на уникални релефни форми. Заедно с типичните глациални форми като циркуси, ледникови долини и карлинги, периглациалните релефни форми също имат своето място в концепцията за разработването на Геопарк Рила. Независимо от ниското георазнообразие на планината, ледниковите форми придават алпийски облик на нейния релеф и висока естетическа стойност на високопланинските ландшафти. Основното предизвикателство при поднасянето на геоложката информация на широката публика е интерпретацията на ледниковите процеси. Изборът на представителни геотопи предполага баланс между тяхната научна обосновка и възможността да бъдат поднесени по интересен и атрактивен начин за посетителите на геопарка. Затова към високата научна стойност се добавят естетическите, екологичните и историческите аспекти на геотопите. Силно изразеният фосилен глациален релеф на Рила, наследен от последния Вюрмски ледников период, продължава да е обект на съвременните геокриогенни процеси и е подложен на активна периглациална преработка, която може да бъде демонстрирана в най-посещаваните високи части на планината. Наред с добре изразените хорни, циркуси и ледникови долини, които са типични ледникови форми, тук се срещат и много геокриогенни форми, образувани вследствие на процесите на десквамация и солифлюкция: периглациални морени (сипейни венци), кронивални циркуси, лавинни улеи със сипейни ерозионни конуси, както и заоблените покрити с реголит върхове, които в Рила имат специфично наименование - чалове. Периглациалните форми и фосилният ледников релеф са неразделна част от съвременния високопланински ландшафт на Рила, който привлича хиляди почитатели на алпийската природа. Осъществяването на една цялостна концепция за опазване, образование и устойчиво развитие на Геопарк Рила, в комбинация с всички други аспекти на природното и културно наследство, може да донесе желаните икономически ползи и просперитет на целия регион.

Ключови думи: Геопарк Рила, перигрaциален релеф

Introduction

The glacier formations are at the base of the concept for the development of Geopark Rila. Despite the low geodiversity of the mountain, the glacial landforms give an alpine shape to its relief and high aesthetic value to the high mountain landscapes. The well expressed fossil glacial relief of Rila (Glovnya, 1969), inherited from the Würm Ice Age, provides unlimited possibilities for interpretation of the varied glacial processes for the general public. The development of promotional materials and their presentation in an attractive and accessible way for the tourists will increase the public awareness of Rila's geological history and the opportunitiy to develop sustainable all-season tourism. Simultaneously with the remarkable glacial landforms - horns (carlings), cirques and glacier valleys, the higher parts of the mountain are affected by the modern geocryogenic processes, which further shape the fossil glacial landforms. Viewing the most characteristic supraglacial forms - the cryogenic cirques and supraglacial moraines, it is difficult to set the boundary between glacial and post-glacial activity. For this reason, the periglacial landscapes are a wide field for demonstrating the results of the typical glacial activity during the Würm Ice Age and recent frost weathering modifying the high mountain relief. In this article, a retrospection of the most frequent landforms of frost weathering is made, with an emphasis on accessible and demonstrable sites with well-developed periglacial processes and phenomena in the most visited higher parts of Rila Mountain.

Geodiversity

Rila Mountain is built mainly of granitoids and partially by Neoproterozoic metamorphic rocks cropping out in its northern, western and southern parts. For this reason, the fossil glacial landscape, formed during the Würm Ice Age, was mainly developed in granitoid rocks belonging to the Rila-West Rhodopean Batholith characterized by Valkov et al., (1989) as a complicated igneous massive, with four phases of magmatic activity. The first phase includes rocks of granodiorite to quartz-diorite composition, forming several separate bodies: Belmeken, Kapatnitsa and Grancharitsa. During the second phase, medium and coarse-grained biotite granites are introduced, which are most widely represented within the batholith forming four bodies: West Rhodopes, Musala, Mechivrah and Shpanyovitsa, situated around the bodies of the first phase. Three bodies are outside of the batolith: Kalin pluton, Badin and Banya bodies. The third phase includes fine-grained granites to plagiogranites, forming several small bodies - Monastery, Semkovo, Gargalak and Chavcha. Their contacts with the host metamorphic rocks and granitoids of the earlier phases are intrusive. The fourth phase is represented by aplitoid and pegmatoid granites forming small stock-like bodies or veins.

Kamenov et al. (1997) and Peicheva et al. (1998) subdivided the granitoids into three petrographic types: I. Coarse-grained, and occasionally porphyric amphibole-biotite and biotite granodiorites; II. Equigranular, medium-grained biotite and rarely two-mica granites; III. Fine-grained, biotite-muscovite aplitoid granites occurring as lenses, veins and stocks. The boundaries of these types coincide generally with previously distinguished by дрValkov et al. (1989) phases as the third and fourth phases are united into a single petrographic type.

According to Kamenov et al. (1999) Rila-West Rhodopean Batholith consists of two differing in age and tectonic position plutons. Granodiorites of the first type are part of the older (~80 Ma) sinmetamorphic pluton with calcium-alkaline character and mantle magma with crust substance. Granites of the second and third type in age 35-40 Ma are genetically connected phases of postmetamorphic pluton with high potassium-calcium-alkaline character.

The metamorphic rocks in the northwest part of the mountain belong to the Rupchos Group (Kozhuharov, 1984) or Malyovitsa Lithotectonic Unit (Sarov et al., 2011a). Recently they are reviewed in the light of the approach for characterization of the metamorphic rocks developed for the purpose of Geological mapping of the Republic of Bulgaria at a scale 1:50 000 (Hrischev et al., 2005) – Chepelare motley metamorphites of the Rupchos metamorphic complex (Sinnyovsky, 2014, 2015; Sinnyovsky, 2014; Atanasova, Sinnyovsky, 2015; Tsvetkova, Sinnyovsky, 2015). They crop out between Sapareva Banya and Blagoevgradska Bistritsa River. In the southwest part of Rila metamorphic rocks are represented by the Maleshevtsi Group of Zagorchev (1984) (Ograzhden Lithotectonic Unit after Sarov et al., 2011b) and Troskovo Group of Zagorchev (1989), respectively Maleshevtsi and Troskovo metamorphic complexes after Milovanov et al. (2009). Here crop out also the motley metamorphites of the Predela metamorphic complex (Milovanov et al., 2009). Among the metamorphic complexes are located Urdina, Malyovitsa, Dzhendema, Monastery and Pearl Lakes, as well as part of the Seven Rila Lakes. The rest of the Rila’s tarns are among the granitoides of the Rila-West Rhodopean Batholith.

Geocryogenic landforms

Geocryogenic (periglacial) processes and phenomena are a collective term to denote the various cryogenic processes occurring during the freezing and thawing of soils and rocks: frost weathering, cryoclasticism, geocryogenic denudation, gelifluction, cryosolifluction. Matthes (1900) introduced the term “nivation” to designate all aspects of frost weathering by the late-lying snow patches in summer. The geocryogenic landforms created as a result of these processes are the consequence of the periglacial weathering associated with the repeated daily and seasonal freezing/thawing in the high-altitude belt at 2200-2800 m above sea level. The most common geocryogenic landforms in Rila are the talus or scree slopes/fields and cryonival cirques formed mainly in the granitoids of the Rila-West Rhodopean Batholith.

The scree slopes or supraglacial moraines are formed as a consequence of the frost weathering which attacks the rock massive through the joints and leads to the separation of blocks. The process whereby glaciers excavate to best effect in hard rock is by „plucking”, or „quarrying” entire blocks, called “joint blocks”. The manner in which the glacial quarrying process operates is described by Matthes (1930) as follows: “Any joint block in the bed of a glacier, such as that marked A, which is for any reason unsupported or weakly supported on its downstream side, is particularly susceptible of being dislodged, for the force of the glacier is exerted upon it at a small angle forward from the vertical, as indicated by the arrows. The block A and its side companions having been removed, the block B and those flanking it will next be unsupported and ready for removal, and so the process will continue farther and farther up the valley” (Fig. 1).

This weathering model is observed on the slopes of almost all cirques and glacial valleys in Rila carved by the Würm glaciers in the granitoids of the Rila-West Rhodopean Batholith (Fig. 2). The main role for the loosening of the joint blocks plays the repetitive freezing/thawing of the water which fills and extends the joints. Due to the temperature changes the blocks are moving away from each other, separating from the rock massive and falling gravitationally on the slope.

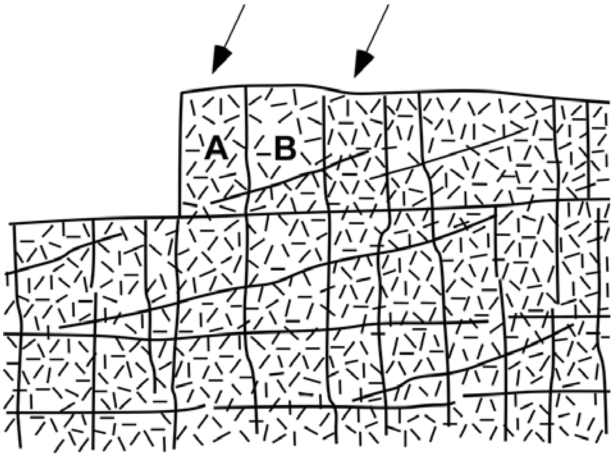

Fig. 1. Glacial excavation of hard rock by „plucking", or „quarrying" of joint blocks (after Matthes, 1930), responsible for the formation of the through valleys and lateral periglacial moraines (scree slopes)

Fig. 2. Dislodging of joint blocks according to Matthes (1930) from the headwall of the Icy Lake cirque along the joints in the granite of the Musala Body of the Rila-West Rhodopean Batholith

Fig. 3. "The Saws" between Musala and Malka Musala Peaks is an arête formed by the Icy Lake cirque and unnamed cirque in Maritsa River valley cropping out and sharpening by the modern desqumation process

The highest part of the wall from which the blocks are detached is formed by the power of the glacier and the structure of the bedrock. For cirquses this is the headwall, which is extremely steep. Desquamation of the bedrock between neighboring cirques results in sharp mountain ridges - arêtes. A typical example in Rila Mountain are "The Saws", formed in the granite of the Musala Body of the second phase of the Rila-West Rhodopean Battolith between Musala and Malka Musala Peaks (Fig. 3). It was formed during the Würm glaciation by the Ice Lake cirque and the opposite unnamed cirque in the Maritsa River valley. Here the bedrock continues to be exposed and sharpened by the modern desquamation process.

Fig. 4. Scree slope on the southern wall of the Grunchar cirque with well expressed sorting of angular phaneritic granodiorite boulders of the Belmeken Body of the first phase of the Rila-West Rhodopean Batholith

Fig. 5. Scree (talus) cones ("stone horseshoes") at the beginning of Malyovitsa Glacier Valley below the „Cocks" arête

The scree (talus) slopes in the cirque began to form during the glacial phase when the glacier filled the back of the cirque bowl with angular boulders, some of which were scraped off the rock when the cirque bowl was carved, and remained at the bottom. The other boulders were poured on the ice and after melting they fell on the other pieces at the base of the headwall. The contemporary cryogenic processes continue to shape the scree slopes, adding new angular boulders and fine material from the cirques walls. Due to their huge mass, the largest blocks reach farthest at the foot of the slope, while the smaller blocks are "captured" on the slope between the other scree boulders (Fig. 4). This predetermines the gravitational sorting of the particles in the scree slopes. Because of their poor transport, they are angular and often form scree cones called the "stone horseshoes" (Glovnya, 1969) at the base of the avalanche troughs (Fig. 5).

The lateral supraglacial moraines on the slopes of the glacier valleys are of the same genesis. Usually in the lower parts of the slope lateral glacier moraines with well-rounded boulders are situated. Above them supraglacial moraines composed of angular boulders are located. However, they are sometimes mixed with the bottom and the lateral moraines, so the angular boulders are usually scattered across the valley, as is the case with the Malyovitsa Glacier valley (Fig. 6).

Fig. 6. The bottom of the Malyovitsa Glacier is dotted with angular boulders of pegmatoid-aplitoid granite of the Monastery Body of the fourth phase of the Rila-West Rhodopean Batholith and amphibole-biotite gneises of the Chepelare metamorphites

Fig. 7. Among the bottom moraine deposits in Malyovitsa Glacier valley huge erratic boulders are encountered with dimensions more than 10 m

Here the typical U-shaped glacier valley is dotted with edged blocks of pegmatoid-aplitoid granites of the Monastery's Body of the fourth phase of the Rila-West Rhodopean Batholith and amphibol-biotype gneisses of the Chepelare metamorphic complexe of the Rupchos Metamorphic Complex (Malyovitsa lithotectonic unit). There are also huge erratics with dimensions up to 8-10 m (Fig. 7). Together with the large angular boulders, frost weathering delivers fine material that fills the interboulder spaces. As Kanev (1988) noted, "temperature weathering continues even before our eyes". Every year after the melting of the snow on the steep cirques walls fine weathered rock particles descend from the rocks and move downslope. They remain unnoticeable among the large boulders or at the bottom of the ice lakes, but can easily be seen on the white background of the snow patches (Fig. 8).

According to most authors, the formation of the supraglacial moraines began in the ice age and continued with geocryogenic denudation in the interglacial period. That is the case with the cryonival cirquses. They are also the product of frost weathering, but some of them arose in the ice age, especially those of southern exposure.

Fig. 8. The fine scree particles descending from the rock due to the frost weathering are clearly visible on the white background of the snow patches

The snow erosion is related to the processes of gelifluction, gelifraction, rock falls, frost landslides, eluvial weathering and rock abrasion known under the general term nivation. The erosion effect of this process results in the sloping of oblique planar negative nivation cavities by constant wetting of the rock pad around and under the melting seasonal snow patches, which facilitates the gelifraction of the bedrock. As a result of the ablation, the nivation hollows are gradually expanded and recessed into the slope as they gradually become circular in shape and turn into nivation (cryonival) cirques. Over time, the volume of the circular bowl is increasing and it begins to accumulate more and more snow, and the headwall becomes steeper and provides shade for a longer period of time, resulting in longer melting snow. According to Derbyshire et al. (1979), at a slanting slope, the material obtained from the gelifraction is deposited at the base of the snowbank and finally it is exported from the subnival gelifluction in front of the cirque by forming gelifluction terraces (Fig. 9), which can easily be confused with glacier moraines.

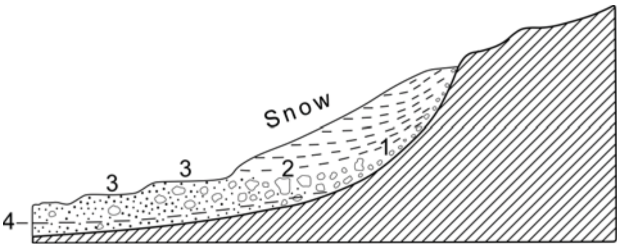

Fig. 9. Section across the snowbank deposits of a cryonival cirque (after Botch, 1946 in Derbyshire et al., 1979): 1 – destroyed particles by the frost weathering; 2 – stone pavement; 3 – solifluction terraces; 4 – upper boundary of the frozen soil

Cryonival cirques occur mainly on the southern slopes of the mountain. They have slanting slopes on which scree slopes are rarely encountered (Fig. 10). As a rule, there are no tarns in these cirques. According to Glovnya (1969), the cryonival cirques are "a transitional form between the glacial and periglacial relief, both in age and in geomorphological features, but their geocryogenic origin always appears". This means that the strict boundary between the glacial and the supraglacial origin of the cirques can hardly be established. Following the logic of glacial cirque formation, the bottom of which is carved under the influence of the ice weight, it can be easily concluded that the main reason for the lack of tarns in the cryonival cirques is the low density and the small mass of snowbanks.

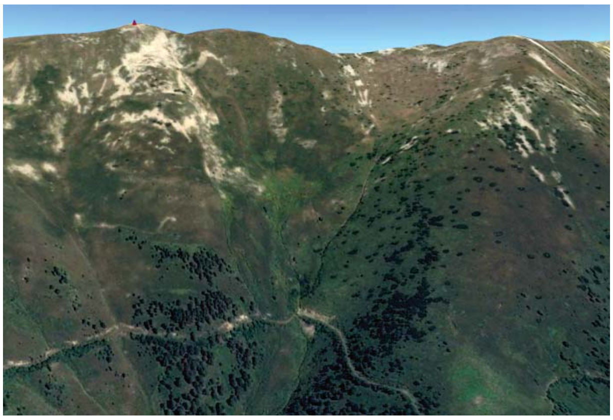

Fig. 10. Cryonival cirques on the northern slope of the glacier valley of Ilijna River in SW Rila, below the summit of Teodosiev Karaul (2666.7 m)

In fact, not all cirques with slanting slopes without tarns are of cryonival origin. Appropriate examples are the cirques in the feeding area of the Ropalitsa Glacier (Musala part of Rila). Regardless of its southeast exposure on the southern slope of Maritsa Chal (2765.2 m), the Ropalitsa cirque is definitely of glacial origin. The rest of the cirques east of Beli Iskar River valley - Grunchar cirque, Yakoruda Lakes cirques and Banenska Lakes cirques are of the same origin. These are the feeding zones of the short glacier valleys, where end moraines are found (Kuhlemann et al., 2013). In spite of its large area, the Ropalitsa cirque remains suspended from the small cirque south of elevation 2531.4 m, with a displacement of about 150 m, proved by the Ropalitsa waterfall (Fig. 11). Therefore, not Ropalitsa cirque but namely this cirque gives rise to over 400 m deep and 4 km long glacial valley of the Ropalitsa Glacier.

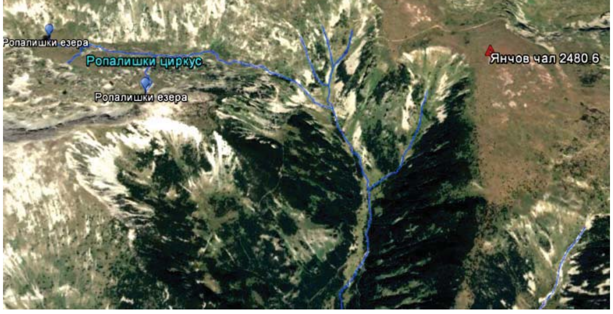

Fig. 11. Satellite image of the Ropalitsa glacier feeding zone including Ropalitsa cirque and two unnamed cirques south of elevation 2531.4 m and Yanchov Chal (2480.6 m)

The glacier valley was further fed by another small cirque, located SW from Yanchov Chal (2480.6 m). These cirques, considered by Glovnya (1969) to be cryonival, are smaller than the Ropalitsa cirque and do not differ from the other cryonival cirques on the southern slopes of Rila. However, the fact that they are deeper than the Ropalitsa cirque confirms their glacial origin. In order to incise deeper than the Ropalitsa cirque, they obviously contained larger ice volumes despite their southern exposure. This can be explained by the faster movement of the ice sheets due to the greater slope of their bottoms, which has delayed the “inflowing” of the ice sheet of the Ropalitsa cirque. It was only possible thanks to the intensive firn feeding.

Conclusions

The periglacial morphostructural landforms are an integral part of the modern high mountain landscape of Rila. They are gradually superimposed on the fossil glacial relief of the mountain modeling it by fragmentation of the bedrock and formation of cryonival cirques, scree slopes and cones. Each of the described forms can be presented to the visitors of Geopark Rila in an attractive way through information boards with schematic interpretations, graphics and photos in an accessible for the wide public language. An important stage in the interpretation of geocryogenic processes for the purpose of geotourism is their differentiation from the fossil glacial landforms and the demonstration of the results of their influence on the Wurm glacial relief. Places where modern geocryogenic processes now operate are at an altitude higher than 2000 m. For this purpose, representative outcrops should be selected, located in widely accessible and popular places. Such are the Nehtenitsa area with direct access to the Yakoruda Lakes, Mecha Polyana with access to Malyovitsa, Kirilova Polyana along the Monastery River with access to the Fish Lakes, the Seven Rila Lakes and the Musala Lakes, accessible by lift, Semkovo with access to the Redzhep and Vapski Lakes, the Macedonia hut with access to the Chernahtitsa Lakes, the Mermera and Rilets Peaks. Information boards and pointers for the high mountain glacial landscapes should be located at the starting points like Borovets, Beli Iskar, Mala Tsarkva, Govedartsi, Sapareva Banya, Dupnitsa, Blagoevgrad, Rila, Razlog, Belitsa, Yakoruda, Kostenets, Raduil.

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