Geological controls over rock glacier formation in the mountains of the Balkan Peninsula

Emil GACHEV[1,2]*
[1] *South-West University"Neofit Rilski", Bulgaria*
[2] *National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Bulgaria*
* Corresponding author: Emil Gachev. E-mail: emil.gachev@swu.bg, e_gachev@yahoo.co.uk

KEYWORDS: rock type, tectonics, rock glacier types, rock glacier morphometry

1 Introduction

Rock glaciers are among the most distinct features in periglacial morphology. Throughout the Balkan Peninsula these patterned accumulations of debris, which have been formed due to the presence of buried ice, are wide-spread in some of the high mountain ranges, mainly at altitudes above 2000-2200 m a. s. l. Rock glaciers are produced in specific climatic conditions, in the zone above the lower limits of permafrost and below the climatic snow line (Haeberli, 1985). Having in mind the present high mountain climate on the Balkans, most rock glaciers are considered relict, however the presence of sporadic permafrost was suggested for some of them, which have highest altitudes (Onaca et al., 2020).
Although the formation of rock glaciers is climatically determined, it is also strongly dependent on geological conditions: lithology and tectonics. The study here presented is focused on the particular role of geology for the presence of rock glaciers in the mountains of the Balkan Peninsula and for their morphometric and morphological diversity.

2 Study areas and methodology

The present study encompasses various rock glaciers from the Dinaric Range, the Thrace-Macedonian massif and some permafrost modified features from the Balkan Range. Both remote sensing and field detection were used to identify rock glaciers, morphometry measurements included aspect, area, inclination, front height. Relative dating at two rock glaciers was done by using an N-type Schmidt hammer. Lake bathymetry mapping was performed at one site to confirm rock glacier morphology.

3 Results and discussion

The most numerous and largest in size are the rock glaciers in the highest mountains of the Rila-Rhodope massif (Gikov and Dimitrov, 2010; Dimitrov and Gikov, 2011) (Fig. 1). The high mountain area of the Pirin Mountains has the greatest density of rock glaciers on the Balkan Peninsula, as well as the greatest number of rock glaciers in a single massif. Except for the drier and more continental climate of the Eastern Balkans, the reason for this abundance should be sought in the crystalline bedrock and the block-fault tectonic movements. Largest rock glaciers appear on granite and gneiss, while in areas where schists predominate very few or no rock glaciers have been formed (Gachev et al., 2017).
A number of rock glaciers is found in the eastern flanks of Prokletije Massif, in gabbro, granite and quartzite, while in the other, limestone parts of the mountain, as well as in the Dinaric range as a whole, rock glaciers are extremely rare, despite the favorable climatic conditions.

In general, carbonate rocks appear inappropriate for rock glacier formation, because of the small (pebble to cobble) size of the scree debris, and the karstic infiltration of waters, which hinders the retention of ground water and its transformation into permafrost. However, in high mountain limestone and marble areas a few rock glaciers do exist, but most of all in specific geological conditions, which involve the presence of embedded non-karstic layers to retain the penetrating waters – for example in flysch rocks, or in the zone of contact to such rocks (like the rock glaciers in Tymfi, Greece, studied by Hughes et al., 2003). In the marbles of Northern Pirin rock glaciers are also generally lacking, except for two large ones, formed on the contact with silicate rocks, which serve as water impermeable bedding (Gachev, 2020). Two suggestible rock glacier type debris lobes (still not studied in detail) are observed entirely within the marble, on the northern slope of Kutelo peak (2908 m). Their formation could be explained with the very low temperatures, now and at the time of their formation (at 2840-2870 m altitude) and the ability of marble to disintegrate to coarser fragments than limestone.

Figure 1 A rock glacier in gneisses on the northern foot of Lovnitsa peak, Rila Mountains.

Figure 2 A rock glacier in quartzite at the west slope of Ujkov krš, Eastern Prokletije Mountains (Bogičevica), Montenegro.

4 Conclusion

From the study here presented it has become clear that geology plays a crucial role in rock glacier formation, along with climate. The effect and control of geology over these emblematic landforms must not be underestimated, as this would lead to incorrect conclusions about the paleoenvironmental conditions in high mountain areas.

References

Dimitrov, P., Gikov, A. 2011. Identification and mapping of relict rock glaciers in Pirin Mountains using aerial and satellite images. *Proceedings of the 7th scientific conference "Space, Ecology, Safety"*, ISRT, Bulgarian Academy of Sciences, (Bg).

Gachev, E. 2020. Rock glaciers in mixed lithology: a case siudy from Northern Pirin. *Revista de Geomorfologie* 22(1):61-72

Gachev, E., Stoyanov, K., Ivanov, M., Bezinska, G., Magori, B., Sirbu, F.-S. 2017. Field observations of rock glaciers in the mountains of Bulgaria. *Problems of Geography, Bulgarian Academy of Sciences*, 3. 55-66. (iBg)

Gikov, A., Dimitrov, P. 2010. Identification and mapping of relict rock glaciers in Rila Mountains using aerial and satellite images. *Proceedings of the 6th scientific conference "Space, Ecology, Safety"*, ISRT, Bulgarian Academy of Sciences, (Bg).

Haeberli, W. 1985. Global variations of local asymmetry in glacier altitude: separation of north-south and east-west components. *Journal of glaciology* 51 (174): 469-482.

Hughes, P. D., Gibbard, P. L., Woodward, J. C. 2003. Relict rock glaciers as indicators of Mediterranean palaeoclimate during the Last Glacial Maximum (Late Wurmian) in northwest Greece. *Journal of Quaternary Science* 18(5) 431–440.

Onaca, A., 2020. Onaca, A., Ardelean, F., Ardelean, A., Magori, B., Sîrbu, F.-S., Voiculescu, M., Gachev, E. 2020. Assessment of permafrost conditions in the highest mountains of the Balkan Peninsula. *Catena*, 185 104288.