Short Communication

Rock Glaciers and Periglacial Phenomena in the Southern Carpathians

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ABSTRACT

Glacial and periglacial phenomena in the southern Carpathians are an undoubted reality. Climatic conditions and lithology favour the existence of rock glaciers, block fields, cryoplanation terraces, ploughing blocks and solifluction. The highest frequency and the most complex of rock glaciers are found in granites and granodiorites within northerly cirques and valleys of the Paring and Retezat Mountains, whereas less frequent and predominantly embryonic, protalus rampart-type forms occur in epimetamorphic precrystalline schists. Water temperatures below 2 °C of the springs emerging in summer from the fronts of some rock glaciers point to local permafrost conditions possibly still existing today.

RÉSUMÉ

Dans les Carpates Méridionales, le relief glaciaire et périglacière représente une réalité incontestable.

Les conditions climatiques et lithologiques favorisent l’existence de glaciers rocheux, de champs de blocs, de terrasses de cryoplanation, de blocs glissants et de phénomènes de solifluxion.

Concernant les glaciers rocheux, la plus grande fréquence et les formes les plus développées et les plus complexes se trouvent dans les granites et granodiorites des cirques et des vallées se situant sur le versant nord des Montagnes de Paring et Retezat.

Les formes de glaciers rocheux sont plus rares et plutôt embryonnaires (protalus ramparts) dans les schistes cristallins épimetamorphiques. Des températures d’eau inférieures à 2 °C, mesurées dans des sources émergent à la base de quelques glaciers rocheux inactifs et actifs, indiquent la présence actuelle de conditions de pergélisol.

KEY WORDS: Rock glaciers Periglacial Permafrost Carpathians

INTRODUCTION

Although rock glaciers in the southern Carpathians have been recognized only during the last decade, early descriptions suggesting rock glacier occurrences were given by de Martonne (1911) for the Tatra Mountains and by the same author (de Martonne, 1907) for the southern Carpathians. In 1926 de Martonne even noticed some relations between rock glaciers and moraines. Sirce and Sficlea (1956) and Sirce (1971) reviewed the situation in the Paring and Retezat Mountains, whereas Ichim (1978) gave a general overview of rock glaciers in the Romanian Carpathians. Urdea (1985, 1988a, b) has dealt with the rock glaciers in the Retezat Mountains. Ongoing field investigations confirm the existence of more than 300 rock glaciers in the southern Carpathians (Figure 1).

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GENERAL CONDITIONS AND FIELD OBSERVATIONS

Glacial cirques and valleys as fundamental geomorphic elements in the landscape of the southern Carpathians originated from Pleistocene glaciers which reached altitudes of around 1100 to 1200 m a.s.l. during their maximum extension. The interaction of paraglacial processes (cf. Johnson, 1984) and periglacial phenomena produced a variety of landforms. Rock glaciers are mesofoms (cf. Gui ter, 1973) that characterize certain areas (Figure 2). Rock glaciers situated below about 2000 m a.s.l. are relict forms covered by Pinus mugo, whereas rock glaciers at higher altitudes can be classified as inactive to active according to temperature of 1.2-1.8 °C measured during summertime in springs which emerge from their fronts (cf. Evin and Assier, 1983; Haeb erli, 1983, 1985).

Climatic conditions in the highest belt of the southern Carpathians are characterized by cold temperatures (Figure 3a). The dominant circulation pattern involves air masses which rise on the northern and northwestern slope of the mountains. Cooling of such air masses takes place at a dryadiabatic lapse rate (1 °C/100 m) up to the level of condensation and at a wet-adiabatic gradient above this limit. The long-term average of mean annual air temperature is 3.3 °C at Paring (1585 m a.s.l.), −0.5 °C at Tarcu (2180 m a.s.l.) and −2.6 °C at Omu (2505 m a.s.l.). Hence, mean annual air temperatures above 2200 m a.s.l. are generally below about −1 °C, an isotherm which is considered to approximate the lower boundary of discontinuous permafrost in the Swiss Alps (Barsch, 1978; Haeberli, 1978). At such altitudes, the number of annual freeze/thaw cycles is higher than 125 and frost is possible during the entire year. Besides characteristic days (Figure 3b), the high degree of continentality favours the occurrence of rock glaciers. The climatic conditions of the altitude stations Tarcu and Omu, as depicted on Figure 3(c), show that winter precipitation in the high mountains is low and that summer months are cold and humid.

The widespread occurrence of glaciogenic landscapes on the northern slope of the southern Carpathians favours the appearance of rock glaciers in cirques and glacial valleys: the steep rock walls protect them from incoming direct solar radiation and also offer a large quantity of frost-shattered blocks. In fact, the production of frost-shattered blocks is of primary importance for the evolution of block fields and rock glaciers. Especially, the granites and granodiorites typically outcropping in the Retezat, Paring, and Tarcu Mountains are very sensitive to frost weathering (gelation coefficient: 20-41) and usually furnish large blocks. Crystalline
Figure 2  Distribution of rock glaciers in some massifs of the southern Carpathians.
Figure 3 Climatological data for the southern Carpathians: a = mean air temperatures and characteristic intervals; b = daily characteristics; c = climatograms for Omu, Tarcu and Paring stations.
Figure 4 Outline and surface morphology of selected rock glaciers in the southern Carpathians.
epimetamorphic schists produce smaller frost-shattered debris, leading to a higher content of fines in the corresponding deposits and soils. Solifluction and ploughing blocks are frequent in such zones.

Rock glaciers greatly vary in size and shape (Figure 4). Their length \( (L) \) is related to the altitude \( (A) \) of the nearby ridges by Urdea (1988a,b):

\[
L = 2.8A - 6031, \ r = 0.849
\]

Only incipient forms (protalus ramparts) and slightly lobate-type rock glaciers exist in the Godeanu Mountains. Large lobate forms of rock glaciers sometimes develop into tongue-shaped features and exhibit remarkable surface dimensions (Minda: 840/600 m, Gheresiu: 280/1300 m, Rosile: 360/1180 m) in the Paring Mountains. In the Fagaras Mountains, two tongue-shaped rock glaciers (Doamnele, Izvorul Grohoteșului) occur together with a number of protalus ramparts and lobate rock glaciers. A great variety of shapes—from protalus ramparts to lobate, spatulate, tongue-shaped and intermediate—is encountered in the Retezat Mountains. The largest rock glaciers are tongue shaped, oriented to the north, and situated in north-facing glacial cirques. Here, the most favourable conditions for rock glacier formation seem to exist: 83% of the rock glaciers in the Retezat Mountains and 95% in the Paring Mountains can be found in north-facing cirques and glacial valleys. Many of the rock glacier surfaces show remarkable patterns of longitudinal and transverse furrows and ridges, probably resulting from extending and compressing flow (Figure 4).

Differences in the number, shape and size of rock glaciers in individual mountain ranges can be explained by differences in rock types and altitude. Incipient/protalus rampart-type rock glaciers in crystalline schists of the Fagaras Mountains occur on both northern as well as southern slopes, the most illustrative situations being those in Doamnei cirque (Caldarea Pietrosa = rock bucket), in the Racorele or in the Burian cirques of the northern slope, and at Izvorul Grohotesului (rubble springs) on the southern slope. Erosion on steeply inclined cirque floors in some locations on the Fagaras Mountain north slope prevents the accumulation of large debris deposits. In the Paring and Retezat Mountains, rock glaciers are the most characteristic elements of the postglacial relief. The density of rock glaciers in the higher belt of the Retezat Mountains is 46/100 km\(^2\), with the most representative situations being those of the cirques and glacial valleys of Pietrele (=rocks), Valea Rea, Galesul, Vasiel, Bucura, Taul Negru, Stirbu and Custura. Well-developed rock glaciers in the Paring Mountains are found in the cirques of Rosile, Gemenarea, Gheresiu, Cilescu and Iezerul. Few incipient/protalus rampart-type rock glaciers exist in the Galbena, Borascu, Zanoaga and Morarul cirques of the Godeanu Mountains, which are composed of crystalline schists and are of lower altitudes than the Retezat, Paring and Fagaras Mountains by some 200–300 m. Moreover, the number of ridges and steep rock walls furnishing frost-shattered debris is small. In the Vlasia Mare, Vlasia Mica, Bulzul and Stina Mare cirques on the southern slope of the same mountain range, relict phenomena exist which may have been affected by debris-covered glaciers during the last stages of Pleistocene glaciation.

Block fields and cryoplanation terraces develop under similar conditions to those of rock glaciers and are most frequent in the Retezat and Paring Mountains. Solifluction lobes, garlands and ploughing blocks are more characteristic of the Godeanu and Fagaras Mountains.

CONCLUSIONS

Rock glaciers in the southern Carpathians are widespread and represent characteristic landscape elements. They are well developed in the granites and granodiorites of the Paring and Retezat Mountains, where blockfields and cryoplanation terraces are also frequent. Less numerous and smaller forms (incipient and protalus rampart types) occur in the crystalline schists of the Fagaras and Godeanu Mountains. The variety of relict forms below about 2000 m a.s.l and inactive to active forms at higher altitudes undoubtedly reflect the evolution in time and space of discontinuous permafrost in the southern Carpathians.

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REFERENCES


