Rock glaciers evolution in Late Glacial and Holocene inferred from the new palaeoclimatic data

Răzvan Popescu[1*], Alfred Vespremeanu-Stroe[1], Nicolae Cruceru[2] and Olimpiu Pop[3]

[1] Faculty of Geography, University of Bucharest, N. Bălcescu Bd. 1 Bucharest, Romania, razvan.popescu@geo.unibuc.ro

[2] Faculty of Mathematics, Informatics and Natural Sciences, Spiru Haret University, I. Ghica Str. 13 Bucharest, Romania

[3] Faculty of Geography, Babeș-Bolyai University, Clinicilor Str. 5-7 Cluj-Napoca, Romania

Overview

Rock glaciers are landforms made of mountain permafrost creeping under the effect of gravity and characterized by a particular topography of ridges and furrows ended with a steep front. By decoding their present morphology and understanding their altitudinal distribution, a variety of aspects of the past climatic conditions can be inferred because inactive and relict rock glaciers are located in warmer climates in comparison to their necessary morphogenetic conditions (Frauenfelder and Kääb 2000). Most of the rock glaciers from SC are of small dimensions (0.05km2), they have a faded morphology and are covered in different proportions with soil and vegetation indicating their inactive or relict state, characteristic to the marginal permafrost conditions of Southern Carpathians. That is because most of the rock glaciers are located in positive mean multiannual air temperatures. Several field studies performed in the last decade indicate that permafrost is present in rock glaciers above 1950 m a.s.l. in the highest massifs of SC, with a relatively more widespread distribution in the granitic massifs (Vespremeanu-Stroe et al., 2012; Onaca et al., 2013; Popescu et al., 2015; Onaca et al., 2015).

New palaeoclimatic information

Several recent palaeoclimatic studies brought valuable information regarding the climate oscillations during the Late Glacial and Holocene in the region of the Romanian Carpathians. They were based on speleothems (e.g. Tămaș et al., 2005) and glacial lake sediments analysis (e.g. Magyari et al., 2012, Toth et al., 2015). Other studies investigated in detail the glacial traces (especially moraines) and inferred the timing and extent of SC glaciers from the Last Glacial Maximum to the Holocene (Reuther et al., 2007; Urdea and Reuther, 2009; Kuhlemann et al., 2013; Gheorghiu et al., 2015; Ruszkiczay-Rüdiger et al., 2016). All these information can be used for a better understanding of the glacial-permafrost interactions and rock glaciers genesis at the end of the last glaciation and also of the periods of activity of rock glaciers from different altitudinal floors.

Approach and analysis

We computed the contemporary mean annual air temperature (MAAT) at the mean elevation of each rock glacier, the annual potential incoming solar radiation and the offset necessary (ΔMAAT) for each rock glacier to be active. The necessary period for each rock glacier development was than estimated using the length, surface, morphology characteristics and using a mean creep rate.

Rock glaciers vegetation cover and Pinus mugo growth ring analysis on three rock glaciers from Retezat Massif are also presented and discussed in relation to the possibility of the past and present rock glaciers activity. In the same time, the results are discussed in the context with the recent studies on rock glaciers activity (Vespremeanu-Stroe et al., 2012; Necșoiu et al., 2016) and with other in situ measured data (Popescu and Vespremeanu-Stroe, unpublished data).

Preliminary results and discussion

The low altitude SC rock glaciers are located in MAAT conditions well above 0°C and would need a ΔMAAT of at least 3-4 °C to be active. According to Kääb et al. (2007) rock glaciers from the Alps are active between +0.5 and -8°C and those with MAAT between 0 and -1…-2 °C are often climatically destabilized and fast moving landforms. They formed after the local glacial retreat probably in Oldest Dryas and were active for a short period of time, from a few hundred years to at most one thousand years. That could explain the smaller surfaces and faded morphology of low altitude rock glaciers besides their lower debris supply from the secondary mountain ridges. In turn, high altitude rock glaciers, above 2000 m present near 0°C MAAT, some of them close to -1 °C, but they seem rather inactive. The only notable exceptions could be Judele rock glaciers and the upper sectors of Valea Rea and Galeșu rock glaciers from Retezat Massif. These high altitude rock glaciers are better developed in surfaces and lengths indicating a prolonged activity period of more than one thousand years and a more consistent debris supply. In the same time they should have experienced more intense creep processes that could counterweight their younger ages, probably Younger Dryas or early Holocene. Whether glaciers were widespread in SC during the Younger Dryas or not is still a debated issue (Gheorghiu et al., 2015; Ruszkiczay-Rüdiger et al., 2016). If glaciers were largely absent in the Younger Dryas in SC it is probable that the most high altitude rock glaciers from SC were born in that period and were active only until the beginning of the Holocene, no more than the 8.2 ka cold event. They should have maintained their status until the present after they became inactive and relict and they could not have been reactivated in the Holocene cold phases. When permafrost favorable conditions emerge after a warm phase new protalus lobes cover the relict rock glacier body and become new rock glaciers. However, this evolutionary model seems not suitable for the most shaded and cold rock glaciers like Judele which looks active in the present with very small creep rates though (Popescu and Vespremeanu-Stroe, unpublished data). Even more surprisingly, a new study (Necșoiu et al., 2016) indicate that a medium altitude rock glacier like Pietrele from Retezat Massif was still active in the last 46 years and also in the last 7 years in spite of its vegetated ridges. Its creep rates are currently below 1 cm/year. If the movement is caused by permafrost creep it would imply that SC granitic rock glaciers above 2000 m with fragmentary patches of permafrost in their bodies were active during the entire Holocene and the vegetation cover was possible because of their low creep rates.

The Pinus mugo shrubs installed almost simultaneous across the rock glacier areas between 1950 m and 2150 m a.s.l. beginning with the year of 1830 CE (Valea Rea) indicated a reduction in rock glaciers speed after the end of the Little Ice Age. We conclude that more in situ topographical and dendrological (growth ring) data and on a longer time scale are needed in order to validate the actual rock glacier dynamic state. Some absolute age dating methods could also be applied on rock glaciers boulders in the attempt to infer their ages.