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On the Lithology, Topography and Weathering Controls on the Distribution and Morphometry of Mountain Rockwalls in the Romanian Carpathians

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Mountain rockwalls (RW) dynamics is modulated by (thermal) weathering patterns and intensity and, in the same time, experience a strong structural and lithological control. This work presents the inventory and morphometric analysis of ca. 800 rockwall surfaces in the formerly glaciated Romanian Carpathians (44°30' - 47°45' N, 21°30' - 27°10' E) concentrating on rock surfaces distribution (density, frequency, orientation) and area, slope and relative height). Additionally, extensive rock surface thermal monitoring was used to estimate the present differential freeze-thaw regime on the rock slopes in the 1800 – 2544 m altitude range, in order to assess the influence of frost processes on rockwalls morphodynamics. Rockwall surfaces were identified based on Google Earth® imagery, while their morphometrical characteristics were derived from the 25 m resolution EU-DEM digital surface model. Rock surfaces mapping was done for 24 mountain massifs. The identified RW surfaces sum around 20 km2 and were grouped into three main categories based on the rock type: sedimentary (limestones and conglomerates), metamorphic (schists, mica-schists, gneisses and para-gneisses) and igneous (granites and granodiorites). The altitudinal distribution (mean altitude) shows the high elevation of rockwalls accomodated on granites and metamorphic schists (> 2150 m a.s.l. on all exposures) which are generally associated with former Pleistocene glaciations and subsequent (periglacial) reworking (peaks, high crests or headwalls), compared to sedimentary rocks (1600 – 1800 m a.s.l.) which generally reflect a strong structural control (hogbacks, cuesta fronts, tectonic slopes, suspended synclines). Metamorphic and igneous rock surfaces show the lowest individual mean height (45 – 50 m) and area (< 10x103 m2) on each exposure, in comparison to sedimentary rocks which reach significatly higher mean height (150 – 180 m) and surface coverage (7 times larger than on schists and granites). In terms of aspect, both frequency and mean covered area show that rockwalls are generally more developed on the north-facing slopes in the detriment of the southern ones (5:1 ratio). Correspondently, the analysis of frost weathering reveals important differences between the north and south-facing rock surfaces, as the first experience deep continuous freezing throughout most of the cold season whereas the latter is subject to high day-night thermal amplitudes and up to 120 diurnal freeze-thaw cycles per cold season. This reflects into the characteristics of weathered rock fragments, the rate of weathering and we assume into the long-term resultant configuration of the slope. The freeze-thaw magnitude distribution follows a similar pattern, with larger amplitudes imposed by site-specific conditions (especially the microclimate) and 2-3.5 times higher intensities for diurnal frost cycles that occur on the South in comparison with the North-exposed RW. The overall frequency and extension of the RW sustain the presumption that south-exposed rock surfaces are the most affected by surficial weathering processes on all rock types. The differences become larger (3-3.5) when the northern slopes are placed into negative macro-features (i.e. a glacial cirque or valley) and smaller when found in positive features (i.e. towers, rock needles, tors).