Landform Analysis, Vol. 10: 11–17 (2009)

The spatial patterns of the Tatra high-mountain landscape structure

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Abstract: The paper focuses on the identification and classification of spatial patterns in the relation to landforms and geomorphic processes considering the middle-scale and micro-scale of the high-mountain landscape. These determine not only the shape of patches or the character of boundaries, but also the character of fragmentation, the heterogeneity of patches, the gradient and the tendency of patches development. Georelief, especially its spatial morphodynamic attributes, represents relevant phenomena of the landscape which facilitate to understand the scale and hierarchy of the landscape structure. The algorithm of this study is based on the spatial identification of landforms, processes and patterns considering large-scale aerial photographs, a field reconnaissance and the partial classification. The main aim of this paper is to create the classification system of spatial patterns as the physiognomic spatial attributes of the landscape structure mosaic in the high-mountain areas. The genesis of spatial structure patterns and their formation enables us to understand better the origin of the high-mountain landscape structure, its function and contents in this environment. Such a classification can be regarded as a basis for the quantitative statistic analyses of the landscape structure and for the detailed research of spatial patterns.

Key words: high-mountain landscape structure, geomorphic forms and processes, spatial patterns, Tatra Mts.

Introduction

The landscape structure as one of three main characteristics of the landscape is, in the relationship to georelief, the result of not only long-lasting geomorphic processes, but also of relatively short-term morphodynamic disturbances, mainly in the mountain or high-mountain areas. The landscape structure represents a spatial differentiation of the interactions between the comparatively stable landscape components and dynamically formed landscape elements (Ružička, 2000). In this research, I concentrated particularly on the identification and classification of spatial patterns in the relationship to certain geomorphic processes and the attributes of the constituent genetic forms of the middle-scale and micro-scale landscape. The geomorphic forms and the following processes determine not only the shape of patches or the character of boundaries, but also the character of fragmentation, the heterogeneity of patches, the gradient and the tendency of patches development within the limits of the basic matrix. Georelief, especially its spatial morphodynamic attributes, represents relevant phenomena of the landscape which facilitate to understand the scale and hierarchy of the landscape structure of the high-mountain areas (Hreško, 1998; Hreško & Boltižiar, 2001; Boltižiar, 2009).

The aim of this paper is to submit a proposal of the classification system of the spatial patterns in the form of a ‘catalogue’ regarding the physiognomic spatial attributes of the landscape structure mosaic in the high-mountain areas. Thus, the suggested classification can be regarded as a basis for the quantitative statistic analyses of the landscape structure and the detailed research of spatial patterns.

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Study area

The study area comprises the Tatra Mountains or the exact part above the upper timber line that is termed as the high-mountain landscape. It covers the whole subalpine, alpine and subnival level, approximately above the contour line 1,500 m above the sea level; and according to our analysis in the GIS equipment, it comprises (without the Polish part) the area of 27,482 ha, i.e. 0.6 % of the Slovak Republic.

Methodology

The introductory phase of the study of spatial patterns dealing with the Tatra high-mountain landscape involved the acquisition of infrared aerial images, thematic maps, and particularly, the terrain research directed at the observation of relief influences on the spatial differentiation of the landscape structure elements. The rich photographic documentation was taken during the fieldwork. The methodology of this research is displayed in Figure 1.

The analysis of the influence of constituent geomorphic processes on the formation of diverse spatial patterns functioned as the first step. The individual processes were identified using the geomorphic map (Lukniš, 1968), the map of debris flows (Mahr, 1973), the map of avalanche tracks (Kňazovický, 1978), and data taken from the literature; however, mainly concentrating on the interpretation of aerial photographs and the direct observation in the field.

The next step was fulfilled by the study of genetic geomorphic landforms, whose genesis, age, structure and affecting relevant relief processes seem to be crucial to the formation and further development of spatial patterns. I used the method of the analogue interpretation of vertical infrared aerial photographs taken by Eurosense, s. r. o. Bratislava, to identify the exact types of spatial patterns of the Tatra high-mountain landscape. Employing the previously published concepts together with photographs' analysis and information acquired during the field research, one can identify the definite types of patterns on the landforms, which can be gradually transformed into schematic outlines. Afterwards, I created the morphogenetic classification in the form of a 'catalogue', as a consequence of physiographic spatial attributes of the Tatra high-mountain landscape and its mosaic.

During its creation, I took into consideration the following principles:

1. I defined the basic geomorphic meso-forms and microforms of relief according to the Lukniš's map (Lukniš, 1968); and some other landforms.
2. The 'catalogue' contains a part of the aerial photograph with identified spatial patterns on the relevant landforms. The real terrestrial photograph of such a field landform with the pattern is placed underneath the image. It is accompanied by the outline of the landform or its part with the schematically drawn repatriation of the following landscape structure elements: vegetation (dwarf pine and thallus-herbaceous stands), rocks, debris slopes and destructed areas, including the mentioned spatial pattern.
3. I decided on the basic matrix (colourfully distinguishable) for each individual case or pattern in the outline; for example: dwarf pine stands, thallus-herbaceous stands, rocks or debris slopes.
4. The exact spatial patterns were depicted by visually perceived geometric elements, the degree of fragmentation and external physiognomy. These are effectively represented by their schematic outline, in which the colour of the background substitutes the content of matrix and the colour of other elements stands for the content of patches or corridors (dark green – dwarf pine stands, light green – thallus-herbaceous stands, brown and brown-orange – rocks, grey, yellow, light brown – debris slopes, orange – destructed areas, blue – lakes, water streams). In the outlines, I introduced the vertical zone (belt) of the occurrence of the patterns – subalpine (S), alpine (A) or the seguence between them (S/A).
5. The vegetation units, distinguished according to taxonomy, were mentioned under the schematic outline of all the patterns, frequently on the level of alliance typical for the chosen spatial pattern.
6. In the following lines, I listed geomorphic processes and their intensity (L – low, M – middle, H – high) that influence on the origin and further development of the patterns. The intensity was set on the basis of the expert assessment gained during the long-time observations and measurements in the field, or according to the degree of fragmentation of patches represented chiefly by vegetation.

Composing the morphogenetic classification of spatial patterns on the one hand, I considered the genetic landforms of different scales, and on the other hand, the attributes of morphodynamic processes (mostly their intensity). This classification can be applied as the background for the subsequent quantitative statistical analyses of spatial vegetation patterns using the methods of fractal geometry (McGarigal, 2002; Krummel *et al.*, 1987; Leduc *et al.*, 1994; Li, 2000; Milne, 1991a, 1991b, 1992; O'Neill *et al.*, 1988; Sugihara & May, 1990; Turner, 1989; Turner, S.J. *et al.*, 1991; Turner, M.G. *et al.*, 2001).

I verified numerous phenomena and the results of aerial photographs' interpretation by long-time intensive field research (2000–2008) aided by photographic documentation.

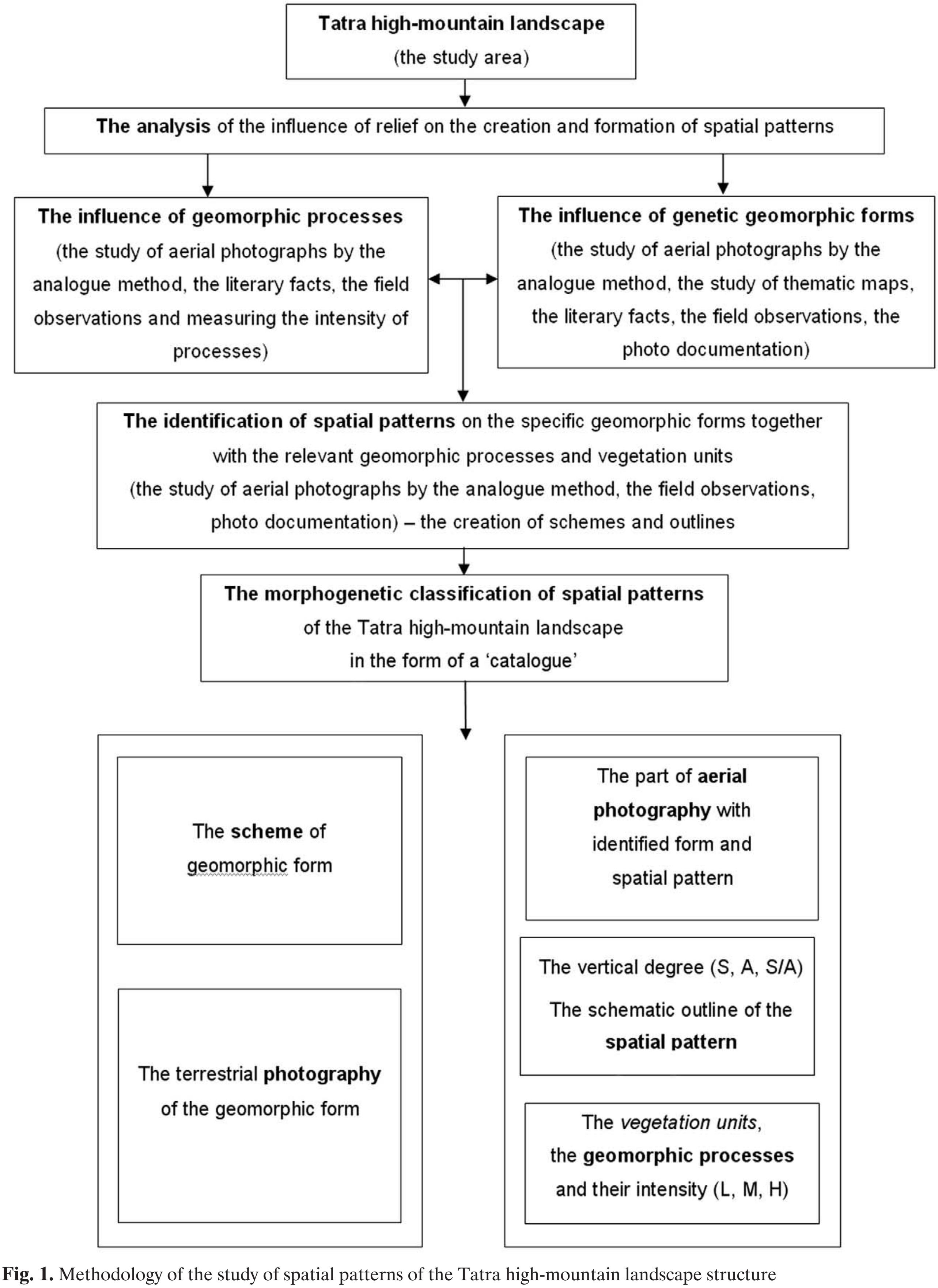

Fig. 1. Methodology of the study of spatial patterns of the Tatra high-mountain landscape structure

Results

To understand the present-day high-mountain landscape structure, one should unequivocally deal with the information about the effects of contemporary geomorphic processes in this extreme environment (Boltižiar, 2007; Hreško, 1994; Hreško & Boltižiar, 2001; Barka, 2004, 2005). As relevant processes of the Tatra high-mountain landscape, I regarded those of landscape formation, simply the geomorphic processes classified according to the main factor of destruction (Midriak, 1983) or on the basis of gravitational dominance, and the processes controlled by water: fluvial processes, gravitational processes, fluvio-gravitational processes, nivation-gravitational processes, cryo-gravitational processes (solifluction, gelisaltation), aeolian processes (aeolian corrasion, deflation and transportation), nivation processes, cryogenic processes (regelation, gelivation – congelifraction), antrophogenic processes, and organogenic (bio-) processes (phyto- and zoo- processes).

As relevant landforms, I regarded those of the Lukniš's geomorphic map of the High Tatras published at a scale of 1:50,000 (Lukniš, 1968). I extended this list by other landforms, which I considered to be important for the spatial differentiation of landscape structure elements. I distinguished 12 meso-relief landforms (rocks, uniformly graded slopes, periglacial debris slopes, landslides, debris and debris-flow cones, glacifluvial cones, Holocene floodplain, glaciated knobs, late Würm moraine, rock glaciers, protalus ramparts), and microrelief landforms (sorted soil circles, girland soils, aeolian and nivation patches).

In this paper, I mentioned few examples of a 'catalogue' containing the morphogenetic classification of spatial patterns (Figs. 2–4) on the three selected landforms (periglacial debris slopes, debris-flows cones, rock glacier) together with an outline of the spatial pattern, including relevant geomorphic processes, their intensity and also vegetation units on the level of alliance according to the terms by Mucina and Maglocký (Eds.), (1985).

Conclusions

The paper is aimed at a detailed recognition of the Tatra landscape structure above the upper timberline; it proposes problems or questions connected with the spatial diversification and the mosaic formed by the different types of patches, corridors and matrices that made the sundry types of spatial geometric patterns. These arise from the interaction of various factors reflecting the extreme environ-

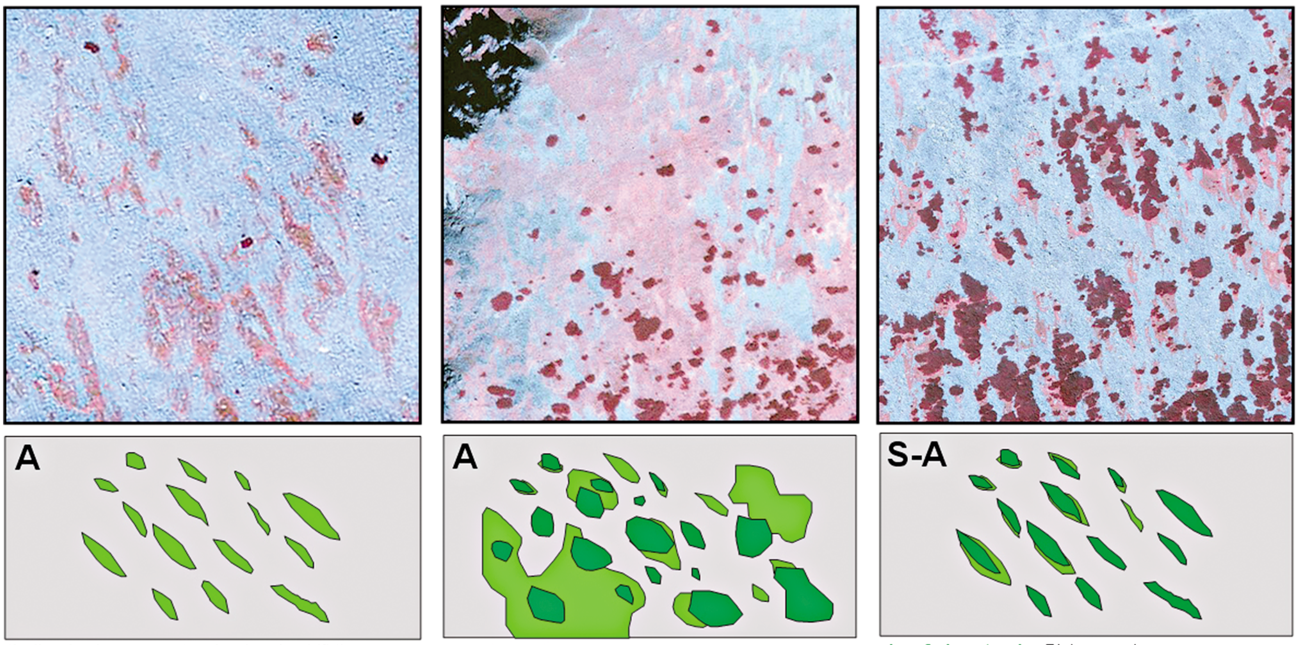

Fig. 2. Example of the spatial pattern identified on the periglacial debris slopes

ment of the high-mountain landscape. The significant position is adopted by the relief, its landforms and the related geomorphic processes.

Understanding the influences of georelief and the morphodynamic processes on the landscape structure results in the outline of morphogenetic classification, which considers the spatial patterns of the Tatra high-mountain landscape based on the interpretation of aerial photographs and the detailed fieldwork or research. The genesis of spatial structure patterns and their formation enables us to understand the deeper genesis of the high-mountain landscape structure – its function and contents in this environment. The morphogenetic classification of patterns represents an important informative and interpretative basis for the knowledge of the structure and the mosaic of the Tatra high-mountain landscape. We see the application of this work and the possibilities of such a research to methods of the landscape ecological planning, e. g. the exact specification and scientific approach to sensitivity and carrying capacity of the high-mountain landscape (Hreško & Boltižiar, 2001; Boltižiar, 2007).

Acknowledgements

The paper presents the results of two scientific projects APVV LPP-0236-06 "Landscape changes of Biosphere reserve Tatry in relation to changing social-economical and natural conditions" and VEGA No. 2/7027/7 "Evaluation of landscape diversity changes".

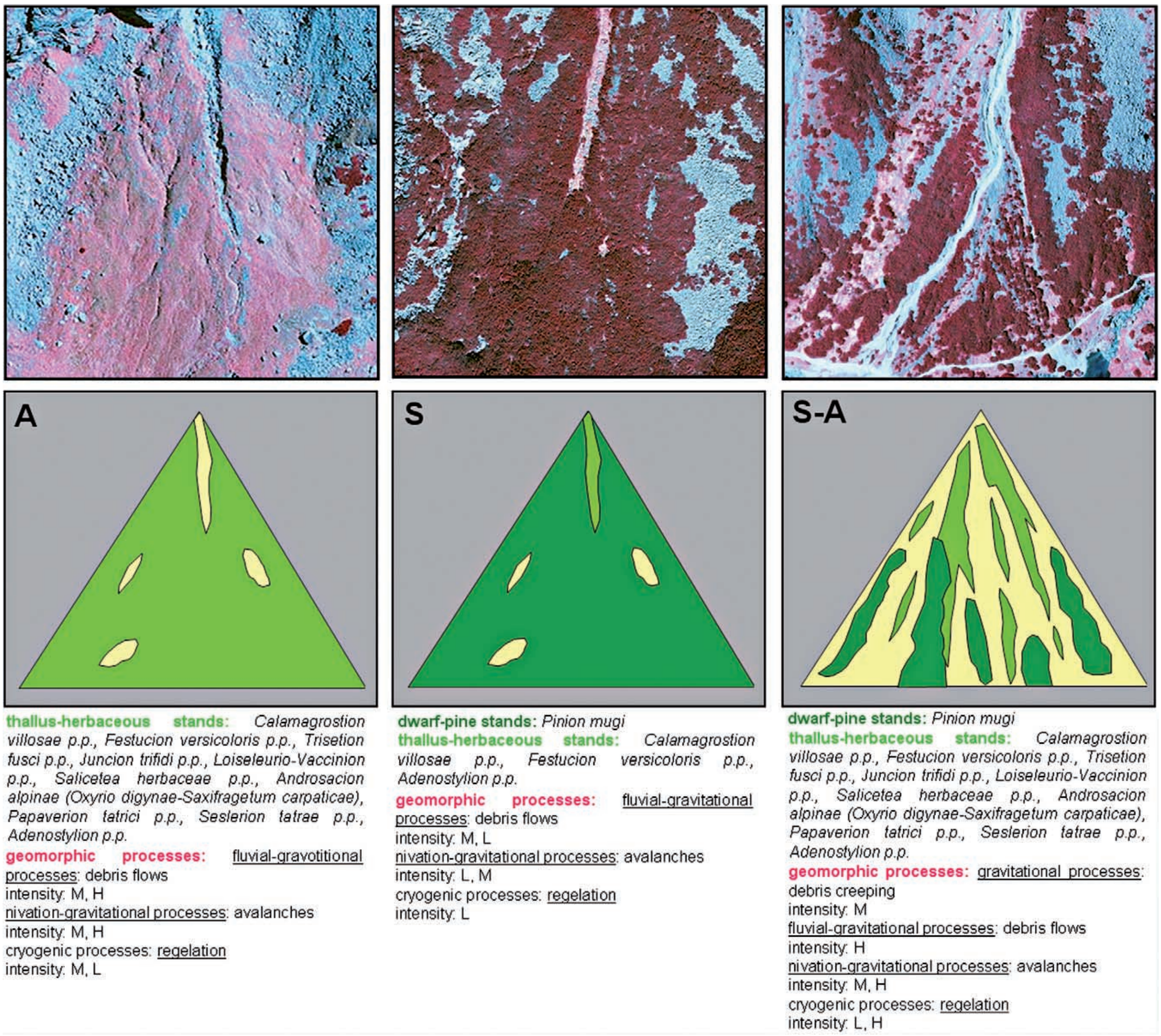

Fig. 3. Example of the spatial pattern identified on the debris-flow cone

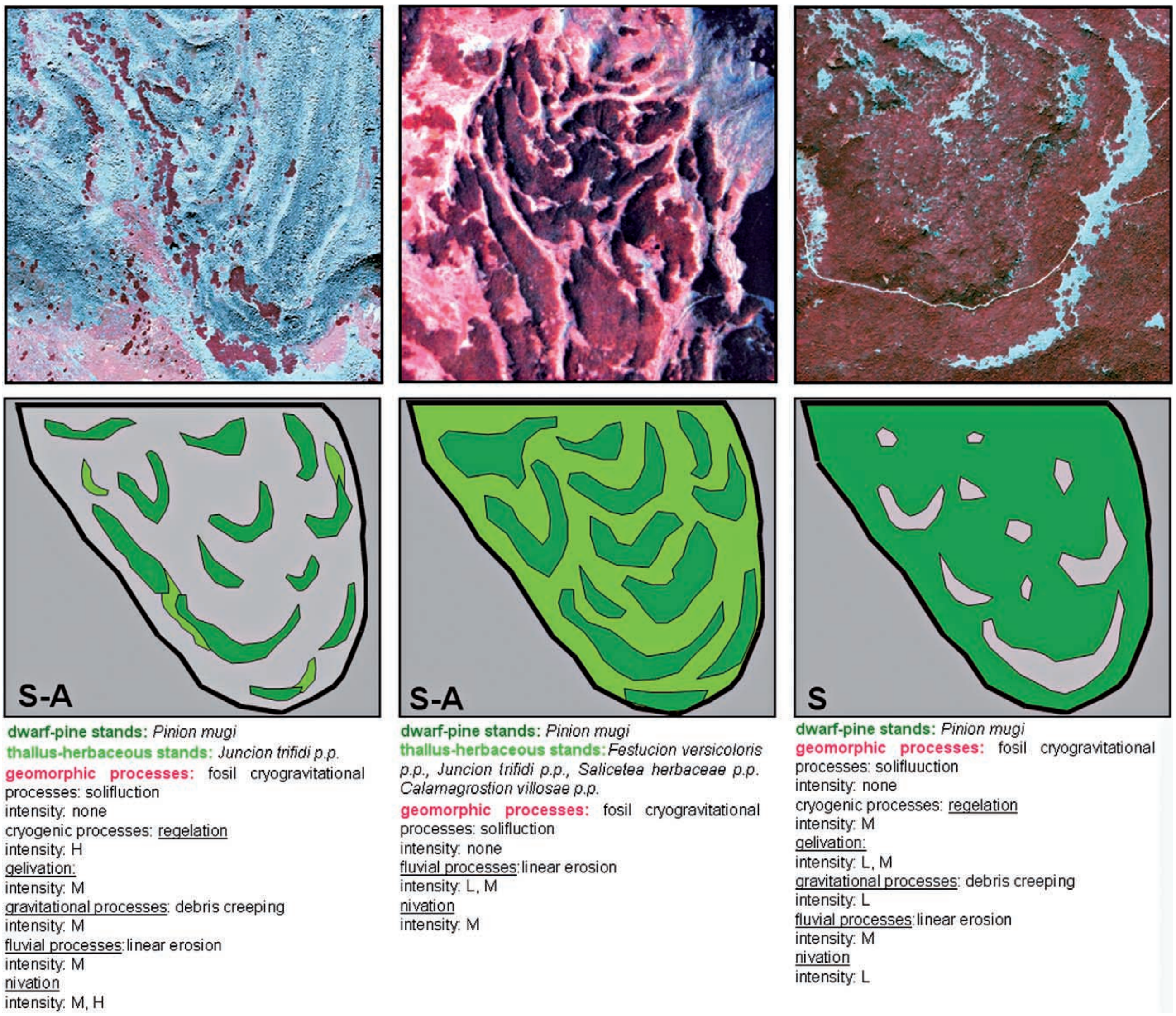

Fig. 4. Example of the spatial pattern identified on the rock glacier

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