Landform Analysis, Vol. 10: 102–107 (2009)

Concept of landscape horizontal belts in the Polish Tatra Mountains

Jan Niedźwiecki*

Jagiellonian University, Institute of Geography and Spatial Management, Department of Physical Geography, Gronostajowa 7, 30-387 Kraków, Poland

Abstract: The history of changes of geoecological belts in the mountains exerts influence on the structure and functioning of the landscape. In many mountain regions, a convergence of two basic altitudinal lines occurs: the contemporary upper timberline and the cold Pleistocene snow line. The Tatra Mts. are an example of such a situation. These lines constitute the border between the high-mountain landscape and the landscape of mid- and low mountains (according to the Polish classification). However, this convergence also marks out the horizontal border across the profile of the valley, which separates the part with completely established high mountain landform complex (with postglacial cirques) from the remaining part of the valley. The montane belt can be also divided into two parts characterized by different landscape structure, due to existence of the influence of catenal processes from the subsystem of high-mountain belt. On these bases, the author introduces the concept of landscape horizontal belts in the mountain landscape of the Polish Tatra Mts., dividing the latter into three functional belts: the typical high-mountain landscape, the transitional landscape, and the typical landscape of mid- and low mountains.

Key words: Tatra Mountains, landscape belts, high mountains, mountain landscape, slope system

Introduction

The history of changes of geoecological belts influences the contemporary landscape structure and functioning in the mountains. There are two most important lines in the Tatra Mts.' landscape: the upper timberline separating the high-mountain landscape from the landscape of mid- and low mountains (Kalicki, 1989), and the cold Pleistocene snow line – the altitude, above which the high-mountain landform complex can be found. In the Pleistocene, the lowest altitude of the snow line in the Tatra Mts. was ca. 1,500–1,550 m a.s.l. This line is marked by the lowest locations of postglacial cirques. The contemporary timberline has a similar altitude: 1,500–1,550 m (Kotarba, 1987). However, the convergence of these two lines is not exact. The Pleistocene snow line is difficult to specify. Many authors place it between 1,423 and 1,665 m (Klimaszewski, 1988). The altitude of the upper timberline also varies from 1,370 to 1,670 m a.s.l. in the Polish part of the Białka Valley (Balon, 1992).

Troll (1973) noticed that there is a similar convergence of these two landscape boundaries in many mountain massifs glaciated in the Pleistocene. He introduced the line of the convergence as a lower limit of the high-mountain geoecological belt (the lower limit of actual cryonival denudation is given as the third criterion). Nevertheless, the border between the type of high-mountains and the type of mid-mountains seems to be not precise.

The author wants to pay special attention to the role of slope systems in the mountain landscape. Slopes constitute the majority of the mountain areas. Circulation of matter on slopes is an important factor in the landscape functioning. Shifts of energy and matter occur on every slope. They determine the landscape structure and influence the border between the two landscape types.

Balon's (1992) opinion that the lowest parts of slopes should not be excluded from the high-moun-

* e-mail: jniedzwiecki@geo.uj.edu.pl

tain morphogenetic system is crucial to the concept presented further in the paper. Nevertheless, the author proposes his own solution to the problem of slope systems which connect the two mentioned landscape types in high mountains. This is the main aim of the paper. As a result, the concept of landscape horizontal belts, different from the traditional altitudinal zones: geoecological belts (Kotarba 1987) and physico-geographical vertical zones (Balon 2000), is discussed below. Horizontal belts are understood as spatial units, referring to the horizontal extent of the landscape, and not to the height or altitude. Their boundaries can be delineated along slopes in contrast to vertical or altitudinal zones, the boundaries of which are delimited across the slopes. Geological belts in the Tatra Mts. can be given as the example of horizontal diversity of the landscape.

Two types of mountains and two types of landscape in the mountains

The traditional definition of high mountains includes three criteria (Troll, 1973):

1. Presence of the upper timberline.
2. Presence of the lower limit of the actual cryonival denudation.
3. Presence of the completely established high-mountain landform complex.

According to Troll (1972), the Alps and the Tatra Mts. are the only examples of high mountains in Central Europe. On the other hand, this author explains that the mid-mountains (*Mittelgebirge*) should be completely or almost completely covered with forest. As the examples of this type of mountains, he quotes Schwarzwald, Vosges, Harz, etc. The border between these two types of mountains seems to be not precise. Three altitudinal lines are given as a lower limit of high mountain belt: the actual timberline, the cold Pleistocene snow line, and the lower limit of the actual cryonival denudation. Nevertheless, some mountain ranges in Central Europe exceed these three lines, although these are not high mountains in Troll's understanding.

In Poland, except the Tatra Mts., the Karkonosze (*Riesengebirge*) range is also considered to represent high mountains (Jodłowski, in print). They stretch above three altitudinal lines given above. There are also a few postglacial cirques. Troll (1973) considers the Karkonosze Mts. to be mid-mountains, probably because the alpine relief of this range is not completely established. The Babia Góra massif is a little bit higher than the Karkonosze Mts. The existence of postglacial cirques is being discussed there (Łajczak, 2002), however, the Babia Góra massif probably exceed the Pleistocene snow line and it certainly exceed the actual timberline and the lower limit of the cryonival denudation (Jahn, 1958). It is also not clear how the Nizke Tatry Mts. (Slovakia) or high ranges of the Eastern Carpathians (e.g. Charnohora) should be classified. Their high-mountain landform complex is not completely established, but they are not "fully wooded or at least do not exceed very far above the upper tree-line" and they are much higher than the examples of mid-mountains given by Troll (1972) for Central Europe.

These examples show some misunderstandings in distinguishing two types of mountains (high- and mid-mountains): the criteria given for high mountains and for high-mountain belt are similar but not the same. High mountains in Troll's understanding should not only exceed the three lower limits of high mountain belt, but also the typical alpine relief should occur.

Moreover, it is not the only explanation for the term "high-mountain landscape" in Poland. In the Tatra Mts., the altitudinal differentiation of the landscape features can be characterized by diversity of the landscape types (Kalicki, 1989). In this classification, the high-mountain landscape is understood as the altitudinal belt over the actual timberline and the presence of high-mountain landform complex is not required.

It leads to the situation that in some mountain regions (e.g. the Babia Góra massif or the Karkonosze Mts.) there is the high-mountain landscape according to Kalicki's criteria and there are three lower limits of the high-mountain belt according to Troll (1973), however, the regions can not be classified as high-mountains. It's a terminological inconsequence.

In the author's opinion, Troll's (1972, 1973) definition of high mountains combines altitudinal and horizontal diversity of the landscape. Even though the three altitudinal borders are given, particular features of the high-mountain landform complex has also horizontal limits. It means that not every area which exceeds the three lower limits of high-mountain belt has a completely established high-mountain landform complex.

It becomes clear when we focus on diversity of the landscape features inside one mountain range, for example in the Tatra Mts.: the postglacial landforms are not distributed regularly in the high-mountain landscape. In the lower parts of valleys there is the same situation as above. Ridges are still higher than the upper timberline and the Pleistocene snow line, but the relief is not typical for the high mountains: there are no cirques, which are one of the most typical elements of the high-mountain landform complex, and in result also rockwalls occur rarely. The central parts of the Staroroboci ańska or Roztoka valleys can be given as the examples.

Differentiation within the landscape types

High-mountain researchers tend to focus on typical high-mountain landforms. They are interested in postglacial cirques, their slopes and ridges between them.

If lower parts of high-mountain slopes belong to the montane geoecological belt, it is difficult to separate two landscape types: the high-mountain landscape from the landscape of mid- and low mountains. They can exist in one slope system (geoecological catena). As a result, some parts of the former landscape type can be omitted in general models and concepts. For example, Kotarba (1987) gives a description of the geoecological belts in the Tatra Mts. Describing the subalpine belt, he focuses mainly on its location in the lower parts of slopes descending to the postglacial cirque bottoms. He does not describe its occurrence in other parts of a slope catena: on ridges or in the middle parts of slopes.

The functioning of the high-mountain morphogenetic system of the Tatra Mts. was described by Kaszowski (1987). The slope system which is located in the high-mountain belt is explicitly separated from the fluvial system located in the montane belt. The postglacial cirques constitute the border between them due to the accumulation of sediments on their bottoms. The convergence of the contemporary upper timberline and the lower limit of the postglacial cirques makes this border even stronger: it seems likely that all high-mountain slope systems finish in the cirque bottoms, from where there is a narrow fluvial connection with the lower parts of valleys, covered with forests. However, there are slopes in the high-mountain landscape (high-mountain belt) which descend directly to the valley bottoms. Hence, their catena ends in the landscape of mid- and low mountains (montane geoecological belt). In such a situation, the catena combines two landscape types (as well as two geoecological belts) and its upper part is not separated from the lower part of valley because sediments are not accumulated in postglacial cirques. This type of sediment transfer is not taken into account by Kaszowski (1987).

In the author's opinion, there is a type of horizontal landscape border dividing the valleys into two parts: one with postglacial landforms of snow accumulation (cirques) in the high mountain belt, and the second one without cirques and in which forests are present.

The montane geoecological belt can be also differentiated horizontally. In the Polish Tatra Mts., many lower ridges are covered by forest from the top to the bottom. Niżnia Kopka (1,323 m a.s.l.) can be given as an example. On the other hand, forest also exists in valleys in the centre of the Tatra Mts. In such location, the landscape of mid- and low mountains is influenced by the high-mountain landscape subsystem, which occurs above it. This influence is visible in the structure of the landscape (Fig. 1). In part B, the spatial units are smaller and their elongated shape results from the flows of a matter. Slopes beginning in the high-mountain landscape are long, steep and not forested, so the morphogenetic processes have a higher erosional potential. It differentiates the structure of the montane belt and also the pattern of the upper timberline (Balon, 1995). Because of that, the second horizontal landscape border can be delimited, in the author's opinion. This border should separate those areas where the whole slope catena is covered by forest from the areas where montane belt is under the influence of the high-mountain landscape subsystem.

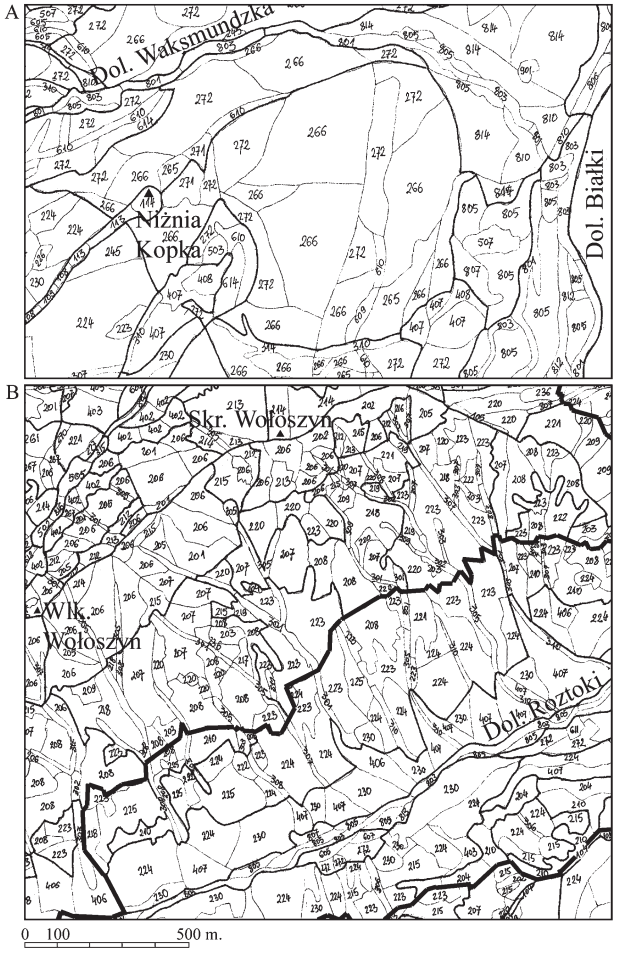

Fig. 1. The structure of montane belt under the infuence of high-mountain belt (B) and without it (A), on the example of fragments of the map of types of environments in the Białka Valley, according to Balon (1992)
A – slopes of Niżna Kopka (1,323 m a.s.l.); B – slopes of Wielki (2,155 m a.s.l.) and Skrajny (2,090 m a.s.l.) Wołoszyn; showing the numbers of types of spatial units; borders of spatial units are marked with the medium and thin lines, the thick line represents the upper timberline

The landscape horizontal belts

The remarks outlined above entitle one to advance a thesis of the existence of horizontal diversity in the mountain environment of the Polish Tatra Mts. Valleys are divided crosswise to their axes. Three landscape horizontal belts can be delimited (Fig. 2):

1. The **typical high-mountain landscape** can theoretically encompass three geoecological belts of high-mountain landscape: subalpine, alpine and subnival. But in fact, it sometimes includes also a part of the upper montane belt. It consists exclusively of these parts of valleys, which were the places of Pleistocene snow accumulation: mainly postglacial cirques with their slopes and intervening ridges. Their slopes are characteristic due to the common occurrence of rockwall-talus cone sequence. The morphogenetic slope system of this landscape belt is separated from the fluvial system of the lower part of a valley (Kaszowski, 1987), because of existence of the functional entireties (catchments) formed around the postglacial cirques (Kalicki, 1986).

2. There are no postglacial cirques in the **transitional landscape** and rockwalls seldom occur. However, a whole sequence of geoecological belts can be found in this horizontal landscape belt. The subnival belt is rare. The majority of ridges decline through alpine and subalpine belt to the timberline, while the character of their relief changes from the alpine to the mid-mountain one. The slope system is not separated from the fluvial system by the accumulation of matter in cirques. The high-mountain landscape type and the mid- and low mountains landscape type coexist in slope catena what influences the functioning and structure of the latter landscape type. The presence of the upper timberline is typical for this belt. The subalpine belt occurs in the middle part of the slope catena and on the ridges. The following postglacial landforms can be found: postglacial valleys, slopes and ridges shaped by periglacial climate, moraines. However, the areas which were never glaciated can also be found in this landscape belt.

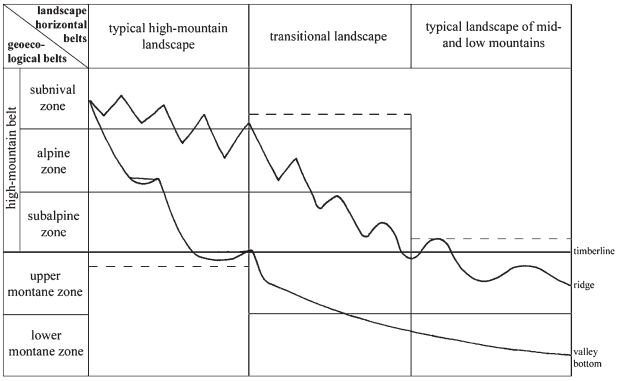

Fig. 2. The scheme of landscape horizontal belts in the Polish Tatra Mountains
Not typical appearance of species of the landscape is marked with a dashed line

3. The **typical landscape of mid- and low mountains** encompasses the areas, where the whole sequence "ridge-slope-valley bottom" can be found within the lower and upper montane belt. In Troll's (1972) opinion, mountains slightly higher than the upper timberline also represents the type of mid-mountains. Following his view, the author includes to this landscape horizontal belt the massifs with summits reaching the subalpine belt if the passes surrounding them do not exceed the timberline. The criterion of postglacial landforms is not essential in the case of this belt.

Therefore, the landscape belts differ in the following features:

a) the sequence of geoecological belts and presence (or not) of the relation between the high-mountain landscape and the landscape of mid- and low mountains (as well as relation between the high-mountain and montane geoecological belt);
b) the type of landform complex, especially presence (or not) of postglacial cirques;
c) the existence (or not) of separated catchment systems (in typical high-mountain belt);
d) the structure and functioning of the landscape (Fig. 1).

Geoecological catenas and the borders of landscape belts

The concept of existence of horizontal borders in the Tatra Mts. landscape is supported by the results obtained by Kalicki (1986). He noticed that the types of geographical spatial units are arranged according to altitudinal zonation, while functional relations run perpendicularly to them, along the line of slope catena. He elaborated a model of the Morskie Oko Lake catchment system. He also concluded that high-mountain landscape consists of functional entireties – catchments, concentrated around postglacial cirques. It is clear that this is typical only for the areas, where high-mountain landform complex with postglacial cirques exists. The other parts of high-mountain landscape were not investigated. Kalicki noticed as well that in different entireties different sequences of spatial units types occur on slopes. It means, in the author's opinion, that the types of geoecological catenas change in different parts of mountain valleys. It is author's conclusion that differentiation of the types of geoecological catenas can specify borders of landscape horizontal belts more precisely.

According to the Kondracki's and Richling's (1983) definition of the term "geoecological catena", it is a typical sequence of ecotopes along a landform

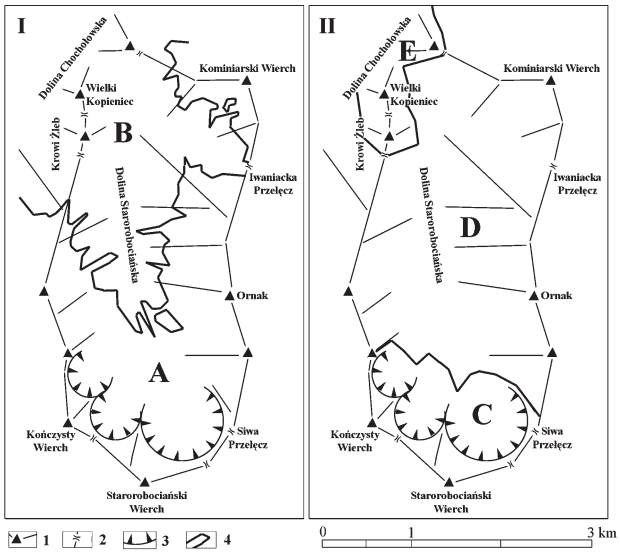

Fig. 3. The schematic course of borders of landscape horizontal belts compared to the course of the upper timberline, exemplified by the Staroroboclańska Valley in the Tatra Mts. (after Niedźwiecki, 2008)
I – landscape types; II – landscape horizontal belts; A – high-mountain landscape; B – landscape of mid- and low mountains; C – belt of typical high-mountain landscape; D – belt of transitional landscape; E – belt of typical landscape of mid- and low mountains; 1 – ridges and main summits; 2 – passes; 3 – postglacial cirques; 4 – upper timberline (I) and borders of landscape horizontal belts (II). Based on the maps by Klimaszewski (1988) and a tourist map of the *Tatrzański Park Narodowy* (2001)

profile. In the Opp's (1985) opinion, the ecotopes are connected by catenal processes – matter and energy flows along the slope profile. The border between the typical high-mountain landscape and the transitional landscape can be delineated along the local watershed between catchments of the lowest postglacial cirque in the valley and the remaining part of the valley. This line separates two types of geoecological catenas characterized by a different sequence of geoecological belts and morphological sequence (according to Balon, 1992). The border between the transitional landscape and the typical landscape of mid- and low mountains can be delimited along a local morphological depression (Fig. 3).

This is, of course, a theoretical model and the whole concept should be confirmed by field studies. The author assumes also that catena can consist of not only ecotopes, but of spatial units of chorical level as well (Niedźwiecki, 2006).

Conclusions

This paper is a theoretical one and some of the points listed below should be treated as hypotheses.

1. The border between the high mountains and the mid-mountains in Troll's (1972, 1973) understanding is not precise. Not every area which exceeds the three lower limits of high mountain belt has a completely established high-mountain landform complex and can be classified as the high mountains.
2. Troll's (1972, 1973) classification combines altitudinal and horizontal diversity of the landscape, because particular features of the high-mountain landform complex are not distributed regularly in the high-mountain landscape.
3. The high-mountain areas can be divided horizontally crosswise to valley axes into two parts: with cirques and without them.
4. There are two types of the montane belt (the landscape of mid- and low mountains) structure: one under the influence of the subsystem of high-mountain landscape, and the other one, where the entire catena is located below the upper timberline.
5. The slope systems are the important factor controlling structure and functioning of the landscape. They constitute a functional connection between the types of landscape.
6. The landscape of the Polish Tatra Mts. can be divided into three landscape horizontal belts: the typical high-mountain landscape, the transitional landscape, and the typical landscape of mid- and low mountains.

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