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Scientific significance of visualisation methods for expression of selected attributes of landscape character of the High Tatra Mountains

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Abstract: The contribution deals with scientific interpretation of visual characteristics of the landscape, which was not very discussed theme until today. Our study concerns the landscape of the High Tatra Mountains. Emphasis is put on anthropogenically influenced settlement areas, with markedly displayed objects of travel movement with downhill courses. We assess visual characteristics of the landscape as landform configuration and land-cover structure composition, in order to express basic visual characteristics of the studied area. Research works in the field were important element of our research, being followed by a phase of data processing. We selected one of exposed localities with high anthropogenic influence in the High Tatras. It is a locality situated between settlement of Tatranská Lomnica and slopes below and above the Skalnaté pleso Lake. We identified visual fields (visual sectors and zones), from where are characteristic views on the mountains. We visualised landforms in their context to geological structure in a 3D model. The results obtained in this case study may be applied as a basis for environmental impact assessment (EIA) and can lead to eventual propositions of new design of downhill courses in visual exposed areas.

Key words: visual exposed areas, visual characteristics of landscape, relief's forms, 3D model, land-cover structure

Introduction

In humanities, there is still topical the research of semiotics, as of language as of visual forms of signs. Application of this knowledge to the research of landscape brings series of new stimuli, findings and procedures. This text is dealing with selected aspects of the landscape visualization, 3D models creation and their importance for research methodology, with optometric properties of landscape and their application in praxis as well as with animation and dynamic 4D environs marginally.

The aim of this contribution is definition and visual transformation of visual characteristics of the High Tatra Mountains. The object of research is anthropogenic influence and human activities which cause visible impact in CHAL (characteristic landscape appearance) of the National Park. The results concern one of exposed localities with the mentioned attributes of CHAL. We demonstrate the relationships between landforms and geological structure in a 3D model, and underline the significance of the context of landform configuration and land-cover structure composition using the method of CHAL identification, DMI (Jančura, 2000).

Problem statement and terminology

The landscape is represented by signs, the combination of which is unrepeatable for every landscape. "Landscape" is a holder of determining visually por-

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table information on characteristic features of the landscape. We define the visible landscape by predominant combination of parts of the landscape's spatial structure: (a) relief shapes (configuration), and (b) arrangement of the land-cover parts (composition) (Jančura, 2000). Landscape types are components of the landscape's "readability". The landscape type represents a combination of landscape properties differentiated according to identifiable signs that enable us to recognize and classify "landscapes" (Jančura *et al*., 2006). The characteristic[1] appearance[2] of landscape[3] (CHAL) represents selected, characteristic properties of the landscape feature. Association of the three words that are used by the NC SR Act No. 543/2002 Coll. on Nature and Landscape Protection, is representing one term (concept). It creates particular succession of conceptual words:

1 – *characteristic* (*distinctive, indicative, symptomatic, typical*),
2 – *appearance* (*feature, aspect, look, picture*),
3 – *of landscape* (*circumscribed area, space*).

The "character" is a set of properties, and "characteristics" is description of determining signs. The term "characteristic" (symptomatic) means that there are some signs in the landscape that express some representative or individual properties of the landscape. The term "feature" is close to the term "sign". The sense of the term CHAL expresses position of visual identification of the characteristic set of – signs, features – properties – of visible landscape. "Feature" is specific term of more general one "landscape sign". The related term in the sense of European Landscape Convention is "characteristic features of landscape" that express presence of some representative signs and their sets in the landscape.

How can we express the value of visible landscape? The term "landscape character" expresses natural, cultural and historical values of the landscape. Landscape character represents regional and local specifics, unique landscape characteristics. Visual "impact" is a term adopted from English and denotes negative phenomena, which appear in the landscape character. It means "incidence, impingement, fall, collision, shock, stroke, hit and blow". Some disorders in the landscape (pathological symptoms) appear as "impact" symptoms.

Visual semiotics. The ability to express and denote visual landscape attributes resulted from our vocabulary style of scientific works of known semiotics' authors (Sonesson, 2000). Man speaks by words, landscape by pictures. The landscape is mainly a landscape seen. The landscape appears as a set of characteristic signs. Visible sign can be interpreted as graphical icon, pictogram or as its denomination by a word. Signs, their semiotic expression, enable one to characterize the landscape properties. The (finite) number of signs exist that precisely characterise the landscape, non-interchangeable with other landscapes. The landscape has to be seen both in horizontal and in vertical projection and 3D by sideward (e.g. aerial) views. Transcription of the set of signs is represented in the research of visual landscape features by photo-documentation (Jančura & Slámová, 2009) Photo-panorama, in natural optical view-port of 3:1, that responds to the visual ellipse of human eye optics, matches best our view into the landscape (Smardon *et al*., 1986). Very often are use segmental pictures having the aspect ratio generally 1.5:1 to 1.3:1 (so called postcard size, or PC-screen). Thanks to the development of optometric methods it is possible to determine also in panorama large-scale landscape (width, height, depth, distances), its dimensions and visually-optical presentation in 3D-environs. These are connected with the possibility of determination of visual fields composed of visual sectors and ranges. We have to identify standpoints, wherefrom the appropriate number of representing landscape signs can be seen. By this, we gain information on non-interchangeable combination of signs and of non-interchange ability of landscapes, up to axiological attributes of landscape character value and originality.

Methodology

The results of visual attributes and CHAL identification are elaborated according to the differential method of identification (Jančura, 2000), modified for the study area. The sequence of the result processing includes five steps. Methodology results from research, identification and interpretation of selected representative (significant) attributes of relief (geomorphology) and of land-cover structures (LCS). The procedure integrates a set of visual and landscape-ecological features of the landscape: horizontal projection of selected LCS attributes chiefly by ortho-photomap analysis, vertical projection of selected relief attributes through photo-panoramas, up to 3D model of the landscape (Jančura, 2003). Important part is field research. Detail mapping of landforms took place in the summer of 2004 under the Lomnický štít Peak. Location of individual landforms was made by GPS, type SporTrak (Magellan), with correctness of position's location in space coordinates x,y about 3 m (in the field 5–7 m) and 1 m of height, using the coordinate system WGS 84.

1. Generation of a 3D relief 's model

The 3D model presented in this paper by a manually drawn picture is based on the digitalised contour plan. The manually drawn picture was the first requested by investor and the second reason was more detailed relief as we can achieve using GIS with original scale of 1: 25,000 maps (in 2004 we have no more detailed maps). The first step includes model's generating by digitalisation of contour plan in the vector program CorelDRAW Graphics Suite 11. This software we used also in the second step and the in the process of picture's adjusting. The second step includes creation of a 3D model using projection of "false" perspective. We describe this process in the following points: digitalised contour plan is transformed to plane of projection at an angle of 30° (so the projection reflects top view), then contour lines are projected as 1.5 vertical exaggeration. Contour lines are elevated in constant steps, not with regular reduction, and that is the reason why it is only imitation of the perspective. The third step includes imitation of space dimensions, using a graphic method of shade lining. Shade lining more highlights steep slopes and concave landforms. The exaggerated model represents landforms in more detail compared to that one without exaggeration. The manually drawn model represents also those landforms, which are not readable from original map and with comparison of GIS medium, landforms we can drawn on model elsewhere we need, without landform modification, which is caused by digital data's processing by a GIS software. By data's modification in GIS medium, we understand the average value between contour lines.

2. Land-cover structure (structural differentiation of the landscape)

The method stems from differentiation of land-cover structure (LCS) components, interpreted from maps, ortho-photomaps (original source GEODIS s.r.o., 2003, provided by SAŽP, Banská Bystrica), and aerial photographs (summer 2004). Detailed botanical mapping in 100 m wide sections of terrain transects (Pavlík, in Jančura *et al*., 2004) at the presented locality helped to verify the LCS. The LCS were classified according to Jančura (2000) and were mapped in the field from May to September 2004. This method was described by Jančura *et al*. (2004).

3. Geological and geomorphic attributes of the landscape character

The relief is inherently linked with geological structure of the area. Together with climatic relations, it is geology that influences the shaping of landforms most remarkably. The landforms were mapped in the field and located in detail using also the existing literature data (Lukniš, 1973) (cf. also Table 1).

4. Optometric landscape parameters

Visual fields represent those areas in the landscape, wherefrom we can see the equal sector of landscape space. Visual fields are composed of visual ranges and visual sectors. The visual ranges are distances of vista sites from the object (landscape segment). The visual sectors are angles and directions of view on the object in the landscape, e.g. according to the cardinal points.

Results

We present the results on two basic spatial levels; the first level is that of the mountain region at the scales of 1:50,000 and 1:100,000), the next one is the selected locality with markedly visual anthroppgenic influence of CHAL at the scale of 1:25,000.

Visual characteristics of the High Tatra Mountains study area

The High Tatra Mountains, as part of the Carpathian Mountain Range, have specific position in the European mountain system. These are the high-mountains' representative of that mountain system. When we visually percept any landscape space, we can identify several factors. The first one is configuration – form of the landscape space (relief) and land-cover's composition, which compose the surface structure of the relief.

Relief – configuration of landscape space (landform differentiation of the landscape)

Visual position of the High Tatras results from proportion of convex relief of asymmetric horst of the Tatra's block and a concave hollow basin landscape of the Podtatranská kotlina basin. The proportion of high-mountains convex relief of the Tatras makes contrast to plane and upland landscape of the Popradská kotlina basin, what is the substance of their monumentality, high visual exposedness, and visibility.

We percept this relationship by classifying landforms as:

- Convex landforms of the High Tatra Mountains and Kozie chrbty Mountains
- Transition from the mountain massif to the hollow basin of Tatranské podhorie
- Concave landforms of the Podtatranská kotlina basin
- Planar, undulate and upland landforms of the Popradská kotlina basin.

The size of the Podtatranská kotlina basin is approximately from 17.1 to 25.7 km what makes wide visual foreground, exposing the steeply rising massif of the High Tatras. The relief energy (difference between the base of the hollow basin and the main ridge) is approximately 1,500 to 2,000 m.

The position of the continental drainage divide of the Vah River basin between the Baltic and Black Sea provides a significant shape context. This divide creates specific visibility of the studied landscape space and its visual exposedness.

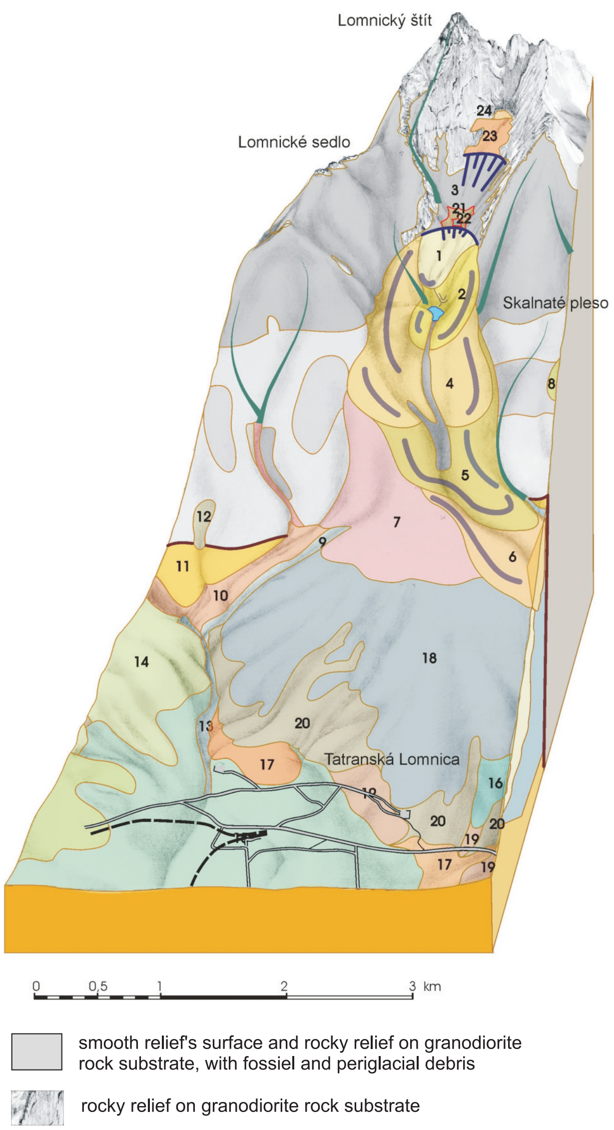

Fig. 1. Model of landforms and geological structure in the area of Tatranská Lomnica – Lomnické sedlo (based on Lukniš, 1973; modified)

1 – moraine – late Würm, stadial E, oscillation E3; 2 – moraine – late Würm, stadial E, oscillation E2; 3 – rocky fault slope ("zlomiská"); 4 – moraine – late Würm, stadial E, oscillation E1; 5 – moraine – Würm, stadial D; 6 – moraine – Würm, stadial B; 7 – moraine – Würm, stadial A; 8 – walls of snow shallow holes ("snežné hniezda") – the Holocene; 9 – alluvial fans and terraces; 10 – periglacial slope landforms and cones; 11 – debris; 12 – dellen 13 – alluvial plain – the Holocene; 14 – moraine -Würm, stadial C; 15 – glaciofluvial cone; 16 – denuded glaciofluvial cone; 17 – periglacial cone; 18 – polygenetic debris; 19 – thrust slides on underlying rocks of the Podtatranská Formation unit; 20 – smooth relief surface on the Podtatranská Formation unit; 21 – firn moraine; 22 – moraine lake basin; 23 – roche moutonnée; 24 – firn fields

Structure of land-cover (structural differentiation of landscape)

The landscape of the High Tatras is typified by high diversity of landforms and surface structures. There is a contrast between abiotic landscape represented by cliffy relief and water areas and life forms of dwarf-pines, compact forests and mountain meadows. Settlement structures, individual buildings and architectural style form significant components of each landscape. Just the architecture creates phenomena of producing characteristic signs of such an environs' type.

The secondary structure of the landscape is formed by such components, as: cliffy relief, dwarf-pine, forests, meadows and settlements. Contemporary landscape structure and landscape type formed recreation-urban and forest high-mountains landscape, with corresponding sports-recreation and spa functions. Their constituent is a specific mountain architecture, the presence of transport technologies (ski tows, cable-ways) and related seasonally used tourist walk-ways, downhill courses and ski traces.

Visual landscape, landscape character, characteristic landscape appearance (CHLA)

Visual position of the High Tatra Mountains results from vertical gradient of the central, hig-mountains' glacial highland and upland relief of the Tatras with cliffy relief of ridges, and concave hollow basin of Podtatranská kotlina. High visual exposedness rises from combination of relief types and vertical exaggeration, with elevation differences between the base of the hollow basin and main ridge being approximately 1,500–2,000 m. There occurs a typical combination of prevailing forest landscape on highlands and uplands with cliffy relief in the visual landscape (Fig. 2).

The High Tatras are great mountains with the highest peaks in the entire Carpathians and their glacial relief contributes to their individuality. This is connected with ice-spruce-limb forests, and the high number of endemic species of fauna and flora. CHLA appears as high level of diversity of land-cover structure, composition of forms, shape and texture differences between the components: cliffs, dwarf-pine, forests, meadows and settlements. There is specific mountain architecture of recreation and spa buildings, presence of transport's technologies (ski tows, cableways) and tourist walkways, downhill courses and ski traces with seasonal use. Symbiosis of human and high-mountain nature represents the bio-climatic zone of settlements of the town Vysoké Tatry with spa-therapeutic functional use.

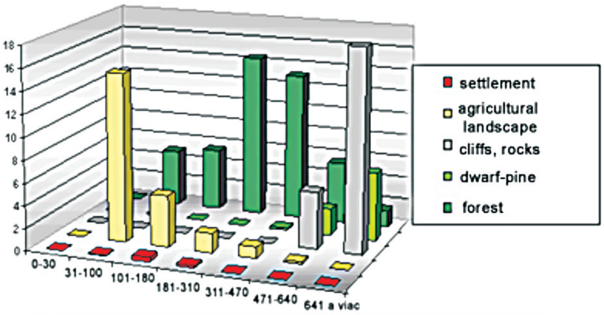

Fig. 2. Classes' abundance of the present landscape structures on relief types (according to vertical dissection of relief)

Visual-optic attributes of landscape space

View on the Tatras' panorama is possible from several points. Some of them provide a possibility of having a view on the majority of complex characteristic signs of the landscape. Changing of geographic position of view site, which means in our case whole visual field, causes change in our visual perception of CHLA in selected mountain's part.

In respect to the form and position of the High Tatra Mountains above a vast area of the Popradská kotlina hollow basin and its uplands, providing many possibilities of views. The whole space was divided into several parts. Their identification is controlled by:

- range
- vertical gradient of High Tatra Mountains above Popradská kotlina hollow basin
- largeness of mountain's space area
- lightness and aspect in relation to the movement of the sun.

Visual fields are those areas, where the shape and distance from the mountains is not changed and which have the same attributes and type's characteristics. Visual field are bounded by: (a) visual zones – distance from the main ridge, (b) visual sector – view axis, which in term of optics divide individual positions in relation to the location versus the main ridge.

Summary overview of visual zones and their characteristics

I. Visual zone from 0 to 4.5–5 km – intra-mountain zone.
II. Visual zone from 5 km to 8 km – under-mountain zone.
III. Visual zone from 8 km to 11 km – foothill hollow basin zone.
IV Visual zone from 11 km to 14 km – hollow basin zone.
V. Visual zone from 14 to 20–25 km – far-distance views.
VI. Visual zone over 20–25 km – far-distance views.

Summary overview of visual sectors

Generally, it means delimitation of view's angle on the mountain massif in relation to the view axis and base courses related to the cardinals: SW–SSW–S–SSE–SE.

Discussion and conclusion

A specific case in terms of landscape-aesthetical and landscape-ecological approaches is landscape's identification as a complex of signs. This is characterised by selection of chosen attributes of the landscape (character) and landscape's visualisation, making three-dimensional models and defining optometric attributes of the landscape. The method provides selection of representative (significant) signs and their symptoms.

Application of knowledge in practice. Interpretation of representative signs and symptoms appearance from the aspect of their visual impact on the characteristic landscape appearance is useable in spatial planning, assessment of effects on the environment, and generally through landscaping documentation. The results are applied as recommendations and regulatives in practice. They are used in assessment of characteristic landscape appearance as separate part of EIA documentation.

There are very well developed methods used in foreign countries for landscape's semiotic and visual impact identification, and further are known symptomatic methods, and their application is very successful. Since the 1960s, the "National Environmental Policy Act" has been emphasizing the requirement of visual sources, which are monitored and assessed through visual control points (Bogdanowski, 1999). Publications exist on visual impact analyses of visual landscape attributes (Smardon *et al*., 1986) in relation to the visual impact assessment in the USA. For instance, Swanwick *et al*. (2002) considered visual landscape's characteristic between the landscape character and visual impact, in connection with identification of visual sensitivity and visual capacity, in terms of landscape's visual points preservation. A method of photo-panoramas is comparative to that of the visual impact assessment (Jančura, 2003), which has a bearing on implementation of methods used in nature and landscape preservation also in terms of their legislative preservation.

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