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Identifying current morphological processes and their impact on mountain landscape (Tatry Mts. area)

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Abstract High mountain area as a specific landscape phenomenon of West Carpathians is characteristic of high degree dynamics of georelief with number of prevailing morphological processes. Monitoring of dynamics and changes of relief as a result of geomorphological processes is one of the important part of geomorphological research. We've tried to identify contemporary morphodynamic processes in high mountain landscape and consequently assign impacts and effects of processes in alpine and subalpine part of Tatras. Presented results are based on method of repeated observations over extended time period including ground-based photography and acquisition of spatial data with typical frequency of three times a year.

Key words High mountain landscape, morphological process, the Tatras, landscape dynamics

1. INTRODUCTION

High degree of dynamic changes of georelief is influenced by many morphodynamic processes. Their results are outcome of complex interaction among climate change, geological characteristics of landscape, geomorphological specifics of the area and indirect human actions. Interaction of these factors causes the alpine area to become vulnerable and it generally leads to its gradual and subsequent deterioration.

As stated by Raczkowska (2006) geomorphic hazards are understood as the phenomena, which are rapid, trigger and transport a great amount of material for relatively long distance. The events are short lasting and time-limited. Most often they cause distinct changes in relief as well damage the vegetation. Assessment of the vulnerability of the monitored area must be based on the vulnerability of individual systems against the destructive processes. According Midriaka (2003) to mitigate or prevent adverse effects it is need to know the alpine environment itself, objectively derive its natural potential and ecological carrying capacity and then ensure that none of the limits are exceeded. The aim of this paper is therefore a) to identify contemporary morphodynamic processes of alpine landscapes and b) to highlight the impact and effects of processes in alpine and sup-alpine zone of Tatras.

2. MATERIAL AND METHODS

2.1 Study area

As the study area we‘ve selected location (hiking trail, Fig. 1) in subalpine and alpine levels of Belianske Tatry. It is a relatively small mountain range of northern Slovakia with particularly exceptional natural conditions. Even though this particular geosystem is unique in Slovakia, occurring only in the High Tatras, the geological structure of the area is rather variable. It is characterized by the units of Triassic, Jurassic and Cretaceous (fatricum, taricum) together with Palaeogene units in the northern part of the territory.

As claimed by Varšavová (2002) the least vulnerable are the stratigraphic units of Lower Triassic. They are represented by conglomerates, quartzite and siliceous sandstone (tatricum - verfen) and quartzite unit babossky (fatricum - sinemur). Whatsoever the largest group represented in the study area are moderately vulnerable stratigraphic rock sections.

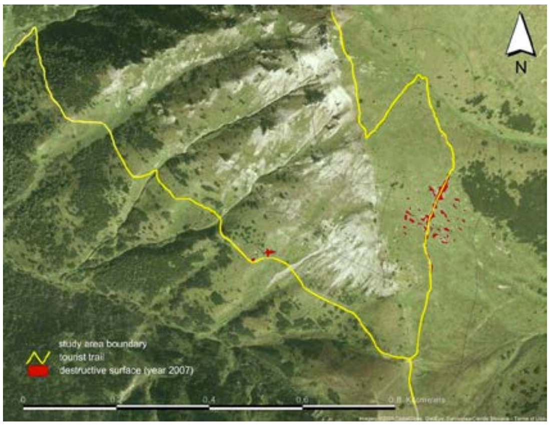

Fig.1 Studied area - the destructive zones around hiking trail at Kopské saddle, Belianske Tatras (2007)

Study area is the alpine part of catchment of the river Dunajec river, more specific the subcatchment of rives Bialka and Biela voda. A hydrological recipient of the territory is stream Javorinka on the north side and Biela Voda on the south side. The study area is a temporary snow type in alpine hydrological conditions with the maximum flow in May and minimum flow in January and February. Area is characterized as a cold climate zone with the July average air temperature below 12 ˚C. According to the soil classification system of Slovakia soils of Belianske Tatras are divided into three groups: the brown forest soil, humus-carbonate soil (rendzis) and nival soils (fluvisols, arenosols, leptosols).

2.2 Methodology

Monitoring the dynamics and changes in topography caused by geomorphic processes is one of the important domain of geomorphological research since the morphodynamic processes represent the most dynamic component of the landscape. Geomorphic hazards have been subjected to relatively intensive studies for the last 25 years. During this period the frequency of occurrence of summer storms of high precipitation totals and intensities in the Tatra Mts has been observed thus generating an additional impulse for such detailed studies.

According to Raczkowska (2006) the studies of geomorphic hazards concentrated on two main groups of problems:

1. current activity of geomorphic hazards – their magnitude, spatial and temporal variability, rainfall thresholds of geomorphic events and resulting effects in morphology;
2. extent and magnitude of geomorphic hazards during last few hundreds years until the Little Ice Age.

The analytical part focuses on a) the spatial identification of various forms of destruction of soil and vegetation b) identification of processes and measuring their intensity in the alpine zone of the Tatras‘ covering areas from the peaks over the ridge and the crest position, down to saddle and slope zones. The main research method to study selected is repeated observations and spatial identifications of both horizontal and vertical changes in landscape as the result of all geomorphic processes. Its main purpose is to determine the occurrence and effects of morphodynamic processes at different time periods. To obtain accurate spatial data with the desired cycle time (usually 2 to 3 times per year) we‘ve used the method of repeated ground photography. As a most appropriate period to observe the processes (Hoeller, 2001) is the beginning of winter season when the soil temperature is around 5˚C (positively inducing most of the processes) and the end of February to April (higher snow temperatures).

3. MORPHOLOGICAL PROCESSES AND THEIR IMPACT ON MOUNTAIN LANDSCAPE

Climatic conditions (rainfall, wind and air temperature) have the important role among the all morphodynamic processes that take place in alpine levels. As shown on Fig. 2, the temperature variation over three years period follows regular seasonal pattern with extremes that trigger the morphodynamically active phenomena. Precipitation is on the other hand the most variable meteorological elements with particularly large variations. Average numbers of days with precipitation cover 30 to 60% of the year. The wind direction and speed are of great importance since they induce and initiate erosion, transportation and material accumulation.

In the study area, we identified a group of processes, attacking the area around the tourist trail unpredictably. In this case the starting zone of morphodynamic processes occur in the upper parts of slopes in the fan-shaped troughs and valleys. In particular, these are the processes of debris flows and avalanches. Second group of processes consists of those activated in close proximity of hiking trail. In this case we are talking about the effects of nivation processes associated with melting snow fields. In the saddle and ridge positions it is eolithic deflationary processes dominating over the others.

Fig 2. Daytime temperatures in the study area in the time interval (2008 - 2010) with marked temperature extremes in winter.

Fresh as well as inactive debris flows gullies accompanied by levees are very common landforms on all types of slopes in the Tatras. Debris flows are the most important geomorphic agents modelling slopes even in the cryogenic domain above the timberline (Midriak, 1984). Most often debris flows affect talus slopes as coarse, granite debris and such slopes favour fast infiltration of water during intensive rainfalls, leading to increasing pore pressure and tiggering of waste movement (Kotarba, 2004). On 30 - 35˚ inclined debris – mantled slopes the present-day debris flows are tiggered by overloading the waste material with rainwater or meltwater (Hreško, 2005). The occurrence of debris flows and avalanche chutes in the examined area was recorded again after more than the decade. As an example is the avalanche chute below the Žiarska vidla (Fig. 3), with the highest activity recorded in winter 2008. As a consequence debris flow has been observed the following summer.

Fig. 3 Avalanche chute below the Žiarska vidla at different time periods.

Continuously active debris flow occurs in the studied area (in the trough under the Hlúpy vrch) with the fragments of material attacking the tourist trail. For large avalanche chutes with relatively long transportation trajectory only a small percentage of fragmented material reaches the trail and the erosion grooves are formed in their vicinity.

Avalanches and avalanche chutes are most often presented with a significant destruction of vegetation cover and soil-transmitted hypergenous layers. In the study area the occurrence of avalanches is recorded since 2000. Extremely large avalanches were monitored in 2010 where dominated by soil cover and vegetation destruction in the tensile zone and destruction mountain pine stands in the transport parts of avalanche paths. Gliding avalanche processes lead to a massive mass transport of snow and mixed soil material. Snow mass acts on the subsoil with tremendous pressure and force, resulting in the formation of deformed surfaces. The effects of melting snowfields trigger consequently the nivation processes (Fig. 4). Snowfields effects on the landscape are the results of frost weathering, nival processes and melting water.

Fig.4 Navation effects of snow fields - material is transferred by melting snow water; on steeper slopes it is running down due its own weight (Belianske Tatry)

According to Clarke, McClung (1999), there are three conditions for initiation of these processes a) the smooth surface (bare rock or homogeneous vegetation cover), b) snow temperature around 0 ˚C and c) at least 15˚ slope pitch.

4. CONCLUSION

A detailed geomorphological research in alpine zone of High Tatras is to identify and verify a basic understanding of morphodynamic changes taking place over the upper timberline.

Alpine mountain areas of Slovakia are characterized by their high sensitivity towards diversity and intensity of environmental changes. It allows us to follow even small changes induced by effects of geomorphologic processes on soil and vegetation cover. Knowledge of morphodynamic changes in alpine zones forming the relief requires long-term observations and measurements that leads to the gradual foundation of complex models for quantitative assessment of environmental vulnerability. Previous works focused on the hiking trails assigned destruction as a result of the significant impact of tourism and related other activities. Our intention is to highlight the interaction of geomorphological processes that are causing disruption in soil and vegetation cover and reduce the overall stability of slopes in the alpine environment.

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