LOCAL CONDITIONS AND IMPACTS OF THE AVALANCHES. CASE STUDIES IN REPRESENTATIVE SECTORS WITHIN

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ABSTRACT. - **Genesis conditions and effects of avalanches. Case studies in representative sectors within Piatra Craiului and Fagars mountains.**
The present paper aims at investigating the avalanches and their impact on the environment components. Snow avalanches are natural phenomena, which are controlled by the specific features of the mountain realm. They start suddenly due to the combination of meteorological and non-meteorological factors, which make the loose materials (snow, ice, detritus, vegetation or soil) collapse or slide down along the slope. In consequence, erosion is increased or facilitated because of the impact they have on the other components of the environment (thalwegs deepening, forest destruction). The distribution of avalanches is hard to be highlighted, because of the inaccessible lands and the adverse meteorological conditions. From this reason, one needs to know their complex features, namely the morphology, vegetation and spatial dynamics of the areas prone to such phenomena. The effects on the environment can be easily identified in the mountain realm, inasmuch as they create typical corridors along the streams crossing the forests. At the same time, however, they have certain effects on the slope deposits, too. These will be further presented with examples for the eastern slope of the Piatra Craiului Mts. and the Suru – Negoiu section in the Făgăraş Mts. These areas are deemed representative for each of the mentioned mountain massifs.

Keywords: snow avalanches, morphological genesis conditions, impact, Piatra Craiului Mts., Făgăraş Mts., Carpathian .

1. Introduction

The topic of this study is to present the genesis conditions and the effects generated by that avalanches occurring in two mountain ranges within Southern Carpathians, namely in Piatra Craiului and Fagaras Mountains. Avalanches are

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complex processes triggered by gravity, which consist in the sliding of snow andice down the slopes. During this motion, these materials increase their volume, weight and speed, while exerting an unexpected, but spectacular, mechanical erosion (Iancu, 1978). Snow avalanches, which occur on rather steep slopes (20^0 – 50^0), impact the environment components (Voiculescu, 2002) and the society, affecting directly or indirectly the human beings (McClung and Schweizer, 2006).

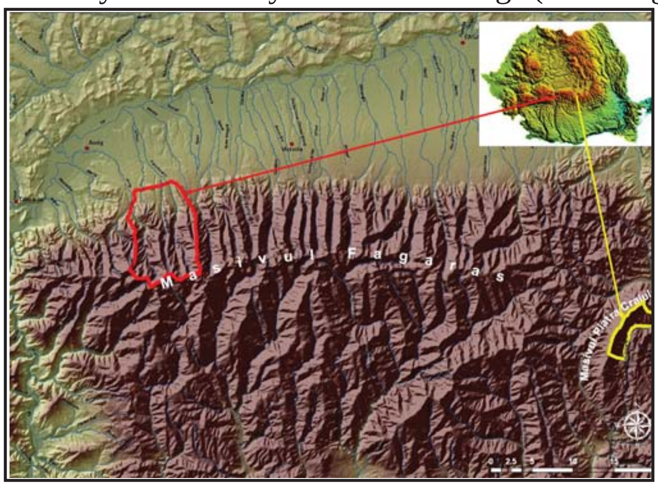

Figure 1. The location of the study areas within Romania and within the Făgăraş and Piatra Craiului massifs

The aim of this study is to bring to front the morphological genesis conditions, the significant effects that the avalanches occurring in the two mountain massifs can have on the environment components. These extremely violent processes are encouraged by a number of factors that are specific for the Piatra Craiului and Făgăraş mountains. We are referring here to the preexisting morphology, typical for the high mountains, with ridges shaped by glacial or periglacial processes, rising to 2238 m and 2535 m, as well as to the slope aspect, bio-climatic altitudinal zones, the presence of snow layer, and so on. Some of these features have already been analyzed in a general manner in a number of works dedicated to these massifs (Constantinescu, 2009; Gheorghe, 2009; Moțoiu, 2008; Munteanu, 2009; Munteanu et. al. 2011, 2013; Voiculescu, 2002).

This paper is going to present in detail the conditions of vulnerability to snow avalanches, based on examples taken from each mountain massif.

In order to analyze the general context that encourages avalanche formation we chose the most representative areas in the two investigated mountain massifs, i.e. the eastern slope of the Piatra Craiului Mts. and the Suru – Negoiu section belonging to the central – northwestern part of the Făgăraş Range (Fig. 1, 2 and 3). Both areas exhibit streams originating from the main ridges or from the alpine, sub-alpine and forest altitudinal zones, typical for these massifs. The features imposed by these local factors are responsible for an array of effects on the various components of the natural or anthropogenic environment.

This material, is a preliminary study conducted in Romanian Carpathians, as in this mountain chain, detail issues related to avalanches have not been approached yet. The investigation carried out is meant to complete the already existing detailed analyses regarding the avalanches and their catastrophic effects in the two areas (Câmpean, Câmpean, 2010; Constantinescu, 2006, 2009; Gheorghe, 2009; Mititeanu, 2014; Moțoiu, Munteanu, 2006; Moțoiu, 2008; Munteanu, 2009; Munteanu et. al. 2011, 2012, 2013; Voiculescu, 2002, 2004, 2009; Voiculescu et. al., 2010, 2012). All previous works are important, because they focused on the Romanian mountain realm, and especially on the complex environment elements of the two massifs, of which many are important resources that need to be protected. Because of that, the Piatra Craiului Mts. have already been declared a national park, while the Făgăraş Mts. are still waiting to become one, inasmuch as there is a proposal in this respect. Consequently, getting to know in detail all the systemic connections between these two mountain massifs has become a necessity.

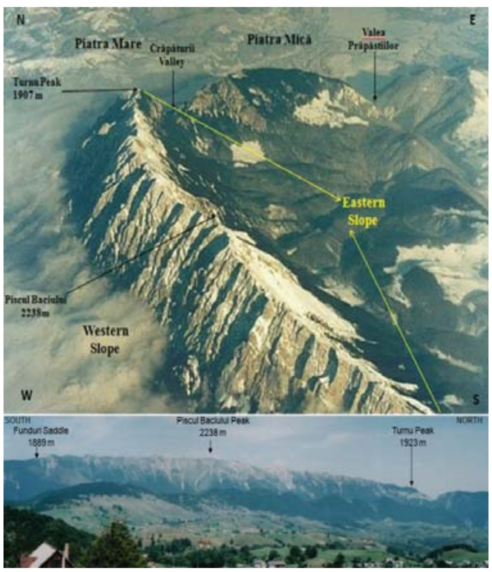

Fig. 2. The eastern slope of the Piatra Craiului massif seen from above and from the east (Photo by: upper www.alpinet.org, bottom Munteanu A.)

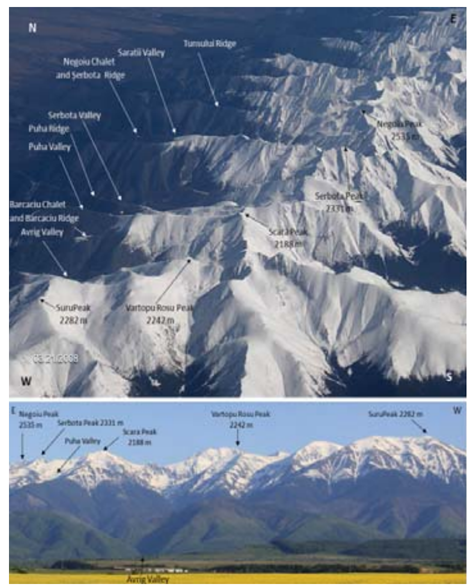

Fig. 3. The Suru – Negoiu section, seen from above and from the north (Photo by: upper Gheorghe, bottom Ovidiu Sopa)

2. Methodology

In order to accomplish this paper we have turned to the literature dealing with on the one hand with the avalanches occurring in these mountain areas (Bădescu, 1972; McClung, 2002; McClung and Schaerer, 2006; Voiculescu, 2002) and on the other hand with the various effects they have on the environment components (Alexa, 2005; Decaulne, 1999; Decaulne, Saemundsson, 2007; Deline, et al., 2011; Smith et. al., 1994; Viglietti et al., 2010; Weir, 2002) or on the human activities (Brundl, et. al., 2004; Habermann et. al., 2008; Voiculescu et al., 2010, 2012). Some other studies we have taken into account deal with avalanches seen as complex risk phenomena (Keiler et al., 2006; Jonasson et. al., 1999; Voiculescu, 2002).

The study begins with the identification and overall presentation of the avalanche prone areas of the two investigated territories, followed by the accomplishment of longitudinal profiles. The analysis has taken into account the factors that trigger the avalanches and the effects they have on the environment. By developing vulnerability maps to contemporary geomorphological processes, we have been able to establish the characteristics of each area affected by avalanches. The reconstitution of avalanche trails was based on dendrogeomorphological analyzes of traces preserved by the affected vegetation.. At the same time, we have investigated a number of elements that suffer the impact of such processes: pastures, forests, tourist tracks, sheepfolds and exploitation roads. Thus, we have been able to find out the links that exist between the manner in which avalanches develop and the effects they have on the environment. The most evident cases, were exemplified through photos (Fig. 9-16).

The study relies on field measurements, mappings and observations undertaken in various periods of the year, on the analysis of cartographic documents (the existing topographic maps of various scales and other thematic maps), as well as on aerial photographs, satellite imagery, ortophotoplans, pictures and GPS surveys. For some important avalanches, we have done substratum analyses, measured the size and of trails of the tracks and assessed the effects they have on vegetation and other environment components. Data processing has been accomplished digitally, according to the methods presented in the literature (Barbolini et. al., 2011; Givry and Perfettini, 2004; Margreth and Romang, 2010; Simenhois and Birkeland, 2010; Voiculescu, 2004, 2009; Weir, 2002).

The maps for the eastern slope of the Piatra Craiului Mts. (Fig. 4, 6) have been prepared by processing the Ikonos 2004 satellite imagery (provided by the Administration of the Piatra Craiului National Park) by using the ArcView 3.2. software. In this way, we have been able to establish the avalanche prone areas, to compute various morphometric values and to identify the contemporary geomorphological processes and the various types of vegetal formations (Pop and Vezeanu, 2006).

The analysis of land vulnerability to geomorphological processes for the Făgăraş Mts. (Fig. 5) has been accomplished by GIS techniques, based on the combinationof the representative thematic layers.

These have been assigned different importance values, depending on the weight they have in the determination of susceptibility class. The five thematic layers (slope map, vegetation map, soil map, slope aspect map and the map of contemporary geomorphological processes) have been developed after a thorough

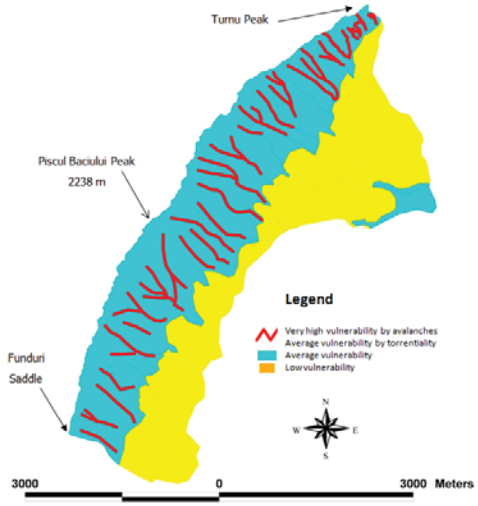

Figure 4. The eastern slope of the Piatra Craiului massif - vunerability map to current geomorphological processes

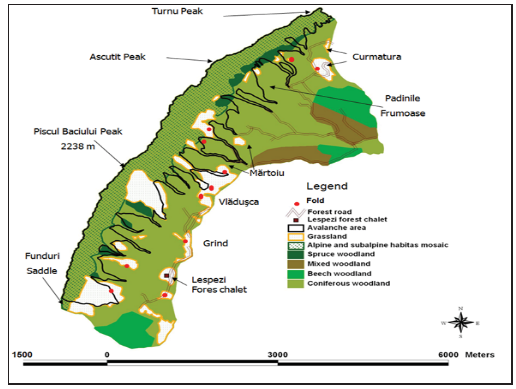

Figure 6. Area on the eastern slope of the Piatra Craiului massif, with vegetal formations, sheepfolds and forest roads impacted by avalanches (Munteanu, Moțoiu, 2006, with modifications)

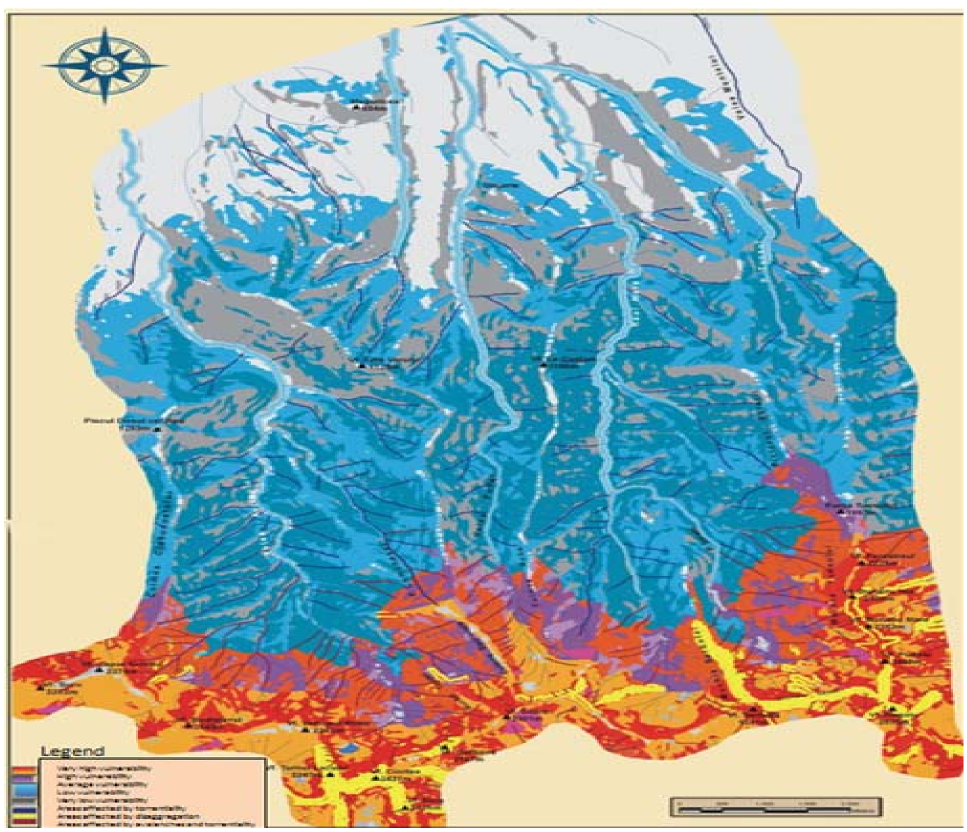

Figure 5. The Suru – Negoiu section – vulnerability map to current geomorphological processes).

examination of the physico-geographical features of the study areas. They have been reclassified based on the observations made in the field and the information taken from the specialty literature. After reclassification, they have been put together by means of the following equation:

$$S = \Sigma(P,Ut,S,E,Pga),$$

where: *P – slope gradient; Ut – land use; S – soils; E – slope aspect; Pga – contemporary geomorphological processes.*

The result of this equation (Single Output Map Algebra) has been an intermediary product that has been reclassified based on the information gathered in the field in order to obtain the final map showing the classes of susceptibility to contemporary geomorphological processes (Gheorghe, 2009).The maps produced mirror the distribution of the types of geomorphological processes, which has been imposed by the vertical variation of morphogenetic factors.

At the same time, we have made use of other data and information provided by the Administration of the Piatra Craiului National Park, the members of the Mountain Rescue Teams, the forest offices, the chalet-keepers and the members of the NGOs that carry out specific activities in the mountain realm.

3. Results

Avalanches are regular phenomena for the regions with similar morphological and climatic conditions. They are capable of moving downstream millions of cubic meters of snow in just a few seconds, which explains their avulsion force and transport capacity. For this reason, not only they actively shape the topography, but are also responsible for the destruction of facilities, roads, buildings, settlements or anything else that comes in their way (Bădescu, 1972, Weir, 2002). The most serious damage is caused to forest industry, because the avalanches block the forest roads and destroy the wood material by plucking up the trees and carrying them downstream. It has been estimated (in all the Carpathians) that an avalanche can destroy as much as 10000 – 20000 m^3 of wood (Alexa, 2005). The Piatra Craiului and the Făgăraş Mts. share the same characteristics, with some diferencefs imposed by the local conditions.

3.1. General conditions and potential factors for avalanche occurrence

The areas prone to avalanches belonging to the two massifs are controlled by an array of factors, which derive from the specific environment conditions.

Those discussed in this paper show the following regional characteristics:

- the eastern slope of the Piatra Craiului Mts. starts from the main ridge (with mean altitudes of 2000 m and a maximum elevation of 2238 in the Piscul Baciului peak) and stretches from the Funduri Saddle (1889 m) in the south to the Turnu peak (1923 m) in the north (Fig. 2). It is delimited by the Funduri valleys in the south and the Curmătura valleys in the north, the slope advancing as low as 1300 – 1400 m.

- the Suru – Negoiu section, with mean altitudes of 2200 m and a maximum elevation of 2535 m in the Negoiu peak (Fig. 3), stretches between the two peaks bearing the same name, which tower over the northern main ridge of the Făgăraş Mts. To the west, it is bordered by the Clăbucet crests, to the east by the Tunsului ridge, while to the north it descends as low as 600 – 700 m at the contact with the Făgăraş Depression.

The general morphology is imposed by geological conditions, which favor the surface erosion and the occurrence of avalanches. The geology of the two investigated areas is different, as follows:

- the Piatra Craiului massif is made up of sedimentary rocks (the Kimmeridgian – Tithonic limestones), which on the main ridge are exposed, while on the western flank of the synclinorium bearing the same name are covered by conglomerates (Upper Aptian) oriented along the bedding planes. At the contact between these formations, one can see structural cliffs. Avalanches usually slide down along the stream channels developing on the limestones. More often than not, these are dry, inasmuch as meteoric waters easily percolate the fissured bedrock (Constantinescu, 2006, 2009). Sometimes, however, the valleys continue on conglomerates. Here, because of the frequent avalanches, they look like corridors flanked by vegetal elements.
- the Făgăraş Mts. are formed by crystalline schists belonging to the Getic Nappe (Upper Proterozoic). They are several thousand meters thick and include other cristaline rocks, such as amphibolites, gneisses, micaschists, amphibolite-paragneisses, limestones and crystalline dolomites. The sedimentary cover is found on small areas. It has a low thickness and many unconformities (Mutihac, 1990).

The lithological and structural influences are mostly mirrored by the glacial morphology, by the thresholds, dip slopes and cuestas, by the asymmetric structural shoulders, by the development of river system, and last but not least by the contemporary geomorphological processes, of which the avalanches are the most important (Gheorghe, 2009). One should note the presence of faults in both massifs, which conditions from a tectonic point of view the valley location and implicitly the associated avalanche tracks. On the surface there are Quaternary deposits, to be found in different stages of fixing, by the vegetation which is destroyed periodically by avalanches.

The eastern slope of the Piatra Craiului massif is more uniform and less dissected in comparison with that lying in the Făgăraş Mts. (Fig. 2 and 3), which shows a sequence of secondary sharp ridges and valleys. This is due to the fact that the two mountain ranges met different conditions of glacial and periglacial modelling. Under the circumstances, the two massifs display landforms specific to the respective conditions. For instance, in the Piatra Craiului Mts. one can see narrow nivo-torrential valleys on limestones and wider ones on the conglomerates, while in the Făgăraş Mts. the valleys are large and show corries, thresholds or even moraines. The bedrock is covered by surface deposits formed by the avalanches. The gradients are controlled by topography: they are steeper on the upper parts and on the glacial thresholds (often more than 45^0) and lower inside the cirques (less than 30^0) or in different deepening levels of valleys.. In between these values, there are areas favorable for avalanche occurrence.

Slope aspect is extremely important for the starting of avalanches. On the east-facing slopes avalanches may occur throughout the winter, as it happens in the Piatra Craiului massif, while in the Făgăraş Mts., where the slopes have a northerly aspect, spring avalanches prevail (except for the east-facing edges of the secondary ridges).

The meteorological factors are imposed by the parameters that also control avalanche occurrence. Thus, at such altitudes, the amount of fallen snow is high enough to allow the accumulation of a consistent snow cover. When its structure, size, and qualities are adequate, it collapses and slides down the slopes, generating avalanches (Moțoiu, 2008; Voiculescu, 2002).

The vegetal cover, distributed on altitudinal zones, has a double function. On the one hand, it encourages the starting of avalanches (in the alpine and sub-alpine zones) and on the other hand, it can diminish their effects (in the case of the forest lying at lower altitudes). Both massifs experience similar conditions, but at different scales. In the sub-alpine and alpine realms, as well as along the streams and inside the catchment areas lying above the tree line, where aspect and gradients are favorable, avalanches occur. These can penetrate the forest area, sometimes climbing down as far as the foot of the slopes or the valley junctions (Voiculescu, 2002; fig. 6, 9, 10, 11, 12 left, 13, 14, 15, and 16 right). Some of the tracks affecting the forest vegetation are also mapped on forest management plans.

4. Discussion

The reviewed factors explain how the avalanches operate as a system. Depending on the existing relationships among all the elements of the system, one can identify some features of manifestation and implicitly some effects.

4.1. Local aspects and the impact on the environment

The local morphologic conditions determine particular characteristics in the manifestation of current processes. When analyzing the vulnerability maps to current geomorphological processes (Fig. 4 and 5) one can note that both investigated areas experience high intensity avalanches. In summer, along the polygenetic corridors torrential processes are extremely active. This aspect is specific especially for the Făgăraș massif, because of its lithological features. The avalanches are present as well in the upper part of valleys and slopes which have been modeled by glaciers in Fagaras, beyond the upper limit of forest, due to great altitudes and massiveness.

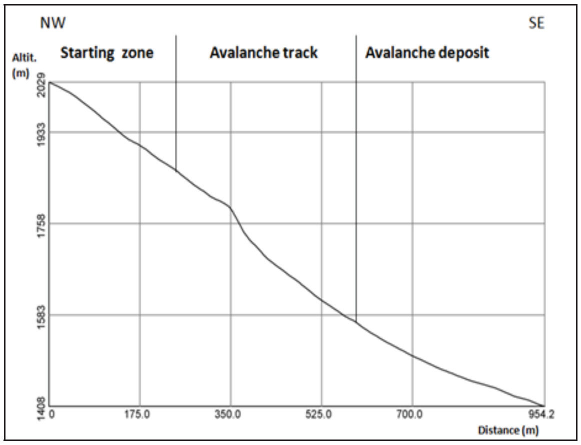

Figure 7. Long profile with the functional zones of a valley from the Padinile Frumoase area, which is representative for the northern section of the eastern slope of the Piatra Craiului massif (Munteanu, 2009)

The pre-existing relief is shaped by the avalanches both along the tracks and in the deposition areas, where typical micro-landforms come into existence (Smith et. al., 1994). For instance, the two investigated areas preserve corridors (overlapping the streams) and mounds (in the runout zone), which are the result of avalanche erosion and accumulation. These are in a continuous transformation, inasmuch as the avalanches occur on a cyclical basis.

Likewise, by analyzing the existing situation shown on the two maps (Fig. 4 and 5), one can note some specific aspects for each investigated area, which will be further discussed in order to get a clearer picture of the situation for a better understanding of the local morphologic conditions.

4.1.1. The eastern slope of the Piatra Craiului massif

The torrential valleys that scar the eastern slope of the Piatra Craiului massif are shallower and straight. They start from the ridge and orient themselves towards the synclinorium axis, being separated by sharp calcareous interfluves, which get rounded to the base where conglomerates prevail. The micro-slopes of these secondary interfluves are very steep, often vertical, which encourages the sliding of snow packs. The avalanche chutes are essentially divided into three functional zones: *the starting zone*, consisting of one or more tributaries, and developing mostly on limestones, *the avalanche path*, which resembles a corridor cut through the forest (Fig. 7 and 10), and *the runout zone*, with accumulation mounds at the base. The thalwegs are filled with scree, partly stabilized by grassy vegetation or shrubs. The carried materials usually reach the forest zone and sometimes they are deposited as low as 1300 – 1400 m altitude, affecting forest (Munteanu, 2009; Munteanu and Moțoiu, 2006; Munteanu et. al., 2013).

On the eastern slope of the Piatra Craiului massif, where avalanche prone area is 9 km^2, the studies have highlighted the existence of 34 avalanche chutes, 9 in the southern catchment and 25 in the northern one. Of this area, 4 km^2 are forests and 1.6 km^2 are pastures, the rest being represented by assemblages of bare rocks and alpine and sub-alpine habitats (Munteanu, 2009; Munteanu and Moțoiu, 2006, Fig. 6). The tracks are rather evenly distributed along the entire length of the slope, but they show local differences especially in terms of their size. Usually, they advance far into the forest realm (Fig. 12, left) thus preventing the forest from advancing to higher altitudes, although it has a natural rising tendency. This can also be ascertained by looking at Fig. 11, which makes a comparison between the appearances of the Padinile Frumoase Valley prior and after the avalanche of March 2005 (Moțoiu and Munteanu, 2006). Consequently, depending on tracks location the slopes can be divided into three sections (Munteanu, 2009):

- between the corridor climbing down from the Funduri Saddle, on the south, and the Grind Valley originating below the Piscul Baciului peak, on the north, avalanches differ in size. Their length gradually increases from the south, where they have 1000 m, to the north, where they reach 1200 m in the central part and even 1500 m along the main corridor of the Grind Valley.
- in the central-northern part of the slope, between the Grind Valley on the south and the Padinile Frumoase on the north, avalanches can travel along the valleys more than 1500 m (but their length gradually decreases to the north). It is the case of the Vlădușca and Mărtoiu valleys (Fig. 9), where the sliding snow goes lower than the upper tree line and frequently reaches the synclinorium axis.
- to the north, in the Curmătura catchment, avalanches occur on most valleys, despite the presence of forest vegetation as far as the ridge. However, the tracks are shorter, of only 100-300 m (Fig. 10). Despite the less significant lengths, they still display clearly the three functional zones mentioned previously. These zones can easily be observed along the accomplished profiles (Fig. 7).

Depending on their dimensions, the avalanches impact the various components of the environment, as follows:

- the pastures lying in the headwaters and transport areas, which stretch along the streams that cross the forests, are mostly the result of avalanches. Usually, the sheepfolds lie in their immediate vicinity or exactly within the vulnerable areas (Fig. 6; Moțoiu and Munteanu, 2006; Pop and Vezeanu, 2006).
- there are 11 sheepfolds, of which 5 are close by, most of them with temporary character, while the rest is spread in the glades developing on the synclinorium axis, near the runout zone. The grazing is often carried out inside the vulnerable areas. This activity may have a positive role in diminishing the avalanche risk, as long as the grass is cut short, and consequently the sliding of snow above it is hindered (Moțoiu and Munteanu, 2006).
- likewise, inside the area vulnerable to avalanches there are 6 tourist tracks (totaling 17200 m) and one tourist shelter (Grind), which was affected by a

large avalanche in 2005, in the vicinity of which was placed the Radu Negru chalet, destroyed by an avalanche in 1953 (Moțoiu and Munteanu, 2006) (Fig.12, right). Another chalet that used to exist in the Vlăduşca glade was also destroyed by avalanches (Constantinescu, 2006).

- in this area, there are five forest roads totaling 300 m. These stretch along the valleys, as far as the deposition zone. Some of them were created on purpose in order to allow the evacuation of the materials deposited by avalanches (Munteanu, 2009).

4.1.2. The Suru – Negoiu section

In the Suru – Negoiu section one can see a number of landforms that are controlled by the higher complexity of the Făgăraş Mts. The avalanche chutes are more difficult to identify. This happens because there are areas where avalanches may start as sheets that slide down on the longer slopes of the alpine zone, on long distances, where forest vegetation is missing, without necessarily creating a track. One can count approximately 130 avalanche paths, which are unevenly spread on the river catchments. Most of them, more than 50, are found in the Avrig watershed, followed by the Sărata watershed with 40 corridors and the Puha and Şerbota catchments, with only 20. Here, the area vulnerable to avalanches amounts to 20 km^2. The areas most affected by such processes are the pastures and the forests. In addition, there is a significant impact on tourist activities too, inasmuch as tourist tracks cross the vulnerable areas, but also on the pastoral activities, because the sheepfolds are located along the glacial valleys, within the avalanche tracks or on the evacuation cone deposits.

We will further present the detailed analysis of the existing situations depending on the catchments they are in.

All the valleys in the Făgăraş Mts. are more complex and have different features in comparison with those lying in the Piatra Craiului massif, because they suffered the effects of an intense glaciation.

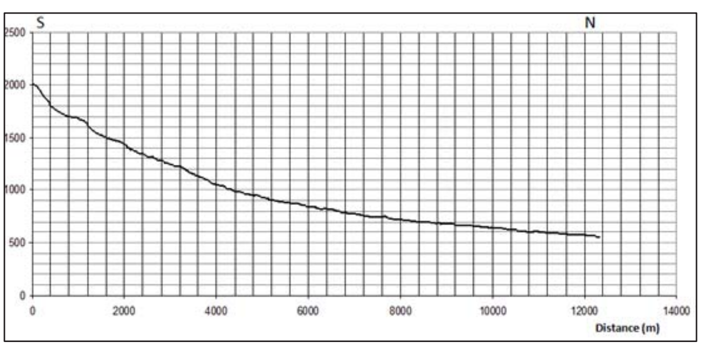

Figure 8. Long profile on the Avrig valley, which is representative for the Suru – Negoiu section on the northern slope of the Făgăraş Mts.

The Avrig Valley is the most complex of all the investigated territories. The valley long profile (Fig. 8) begins at 2000 m, near the Avrig glacial lake, from where it originates. The lake is nested on the upper step of a glacial cirque, where seven corridors with lengths of 300 to 500 m converge. Downstream the lake there is a first glacial threshold, with two steep slopes (at 1900 and 1800 m), at the base of which there is an intermediate cirque (1750 – 1850 m), in which a number of corridors that scar the adjacent slopes come together. A series of avalanche tracks start below the Ciortea peak. They are 650 m long and are crossed by a tourist track (from the main tourist trail on the ridge), that is at the origin of many human casualties. On the same level with the cirque step, there is another corrie that collects the avalanche tracks (which are about 400 m long) coming from the main ridge of the Făgăraş Mts. stretching between the Gârbova (2188 m) and the Scara (2306 m) peaks. As far as the glacial cirque that can be seen at the base is concerned, this lies at 1660 – 1710 m altitude and gathers the avalanche deposits from the neighboring slopes . Downstream its glacial threshold lying at 1550 – 1650 m follows the glacial valley stretch, displaying a series of lateral and bottom moraines, which are buried by the deposits laid down by avalanches. At 1400 m altitude, there is the junction with a corridor climbing down from the Vârtopul Roşu peak, 1400 m long, whose debris cone has pushed eastwards the thalweg of the main valley. Another track descends from the Stănişoara sharp ridge. It is 2000 m long and gathers all the streams originating below this crest. The same ridge is also scared by six valleys (with lengths between 700 and 1200 m), the headwaters of which have a high potential for avalanche occurrence. The tourist track starting from the Bârcaciu chalet and heading to Lake Avrig crosses all these corridors. Downstream, on the trunk valley, the deposition zone reaches 1250 m. Here are piled up all the materials coming down in the corridors excavated in the adjacent slopes crossing the forest area (Fig. 13, left). At 1050 m altitude, the main valley receives a tributary coming from the west, more exactly from the Budislavu peak, which is 2500 m long. Near the junction, at 1100 m altitude lies the terminal deposit of the avalanches that occur along this corridor. On the right, the Avrig valley receives the Comăneasa, which has two avalanche tracks (Fig. 13, right), 1200 m long, in the headwaters, and deposits lying at 1330 m. Throughout the entire catchment the impact on forest environment is significant, because, many corridors/rivers cross forest areas.

The Puha Valley has the smallest watershed in this area. This has a gentle appearance and is void of the sharp ridges and steep slopes so typical for the adjacent valleys. It follows that the avalanche tracks that scar the valley sides are also smaller. Thus, on the upper part, those coming from the northern ridge or from the side are 100 to 400 m long. On the lower stretch, in the perimeter of the moraine lying beneath the glacial threshold (which is situated at 1700 m, the highest altitude of a terminal threshold in the investigated area), there are several tracks, about 750 m long, which start from the Scărişoara sharp ridge and climb down to 1350 – 1450 m altitude. Along this valley, the damage suffered by the forest is the lowest.

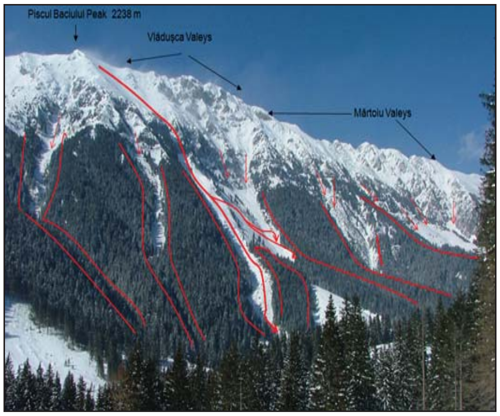

Figure. 9. The valleys and the avalanche tracks in the central northern part of the eastern slope of the Piatra Craiului massif (the Vlăduşca and Mărtoiu areas).

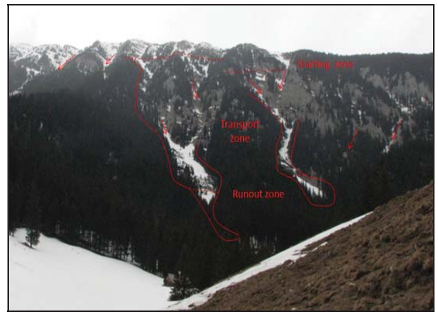

Figure.10. The valleys and the avalanche tracks with their functional zones in the northern part of the eastern slope of the Piatra Craiului massif (Photo by Munteanu A.)

Figure 11. The comparative evolution of avalanche track number 10 in the Padinile Frumoase in the years 2004 and 2005 (summer), after the large avalanche that occurred in March 2005 (Photo by Munteanu A.)

Figure 12. Avalanche effects: avalanche deposit on a track in the Padinile Frumoase (left) and the location of the former Radu Negru chalet built in the Grind area in 1932 and destroyed by an avalanche in 1953 (right) (Photo by Munteanu A.)

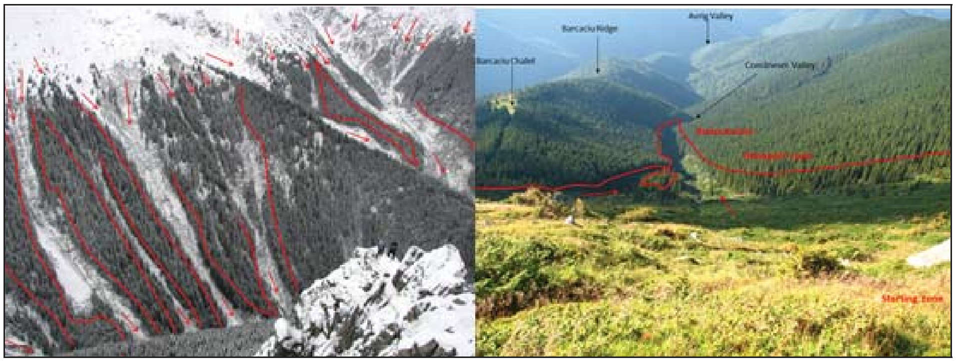

Figure 13. Avalanche paths on the western slope of the Avrig valley (left) and on the Comăneasa valley (right). Both valleys penetrate the forest zone playing havoc on vegetation (Photo by Munteanu A.)

The Şerbota Valley has a larger watershed, is asymmetric and on the west it shows a number of tributaries and implicitly of large avalanche chutes. These descend from the Puha ridge and are between 700 and 1500 m long. To the west, however, the tracks are shorter, between 300 and 800 m. As far as the runout zone is concerned it is as low as 1200 m. On this valley, there are two upper glacial steps and a fluvio-glacial one, as well as a glacial threshold, which is situated at lower altitudes (1400 – 1500 m) in comparison with the adjacent valleys. Here, too, the impact on forest vegetation is low, because downstream the threshold there are only four avalanche tracks.

The Sărata Valley has a complex watershed , the morphology of which is given by the intense glacial shaping that affected this area. Consequently, the northern ridge is knife-edged, the slopes are very steep and often vertical, and transfluence saddles, castellated relief and moraines are common. The asymmetry of the valley is given by the contrast between the Şerbota knife-edged ridge, which is rather smooth, and the Tunsului crest, one of the most massive sharp ridges, which is dissected by numerous torrential streams acting as avalanche tracks. This massiveness is given by the fact that it stems from the main northern ridge of the Făgăraş Mts., more exactly from the area of Negoiu peak (2535 m, the second highest summit in the Romanian Carpathians). The tracks carved in the slope of the Şerbota ridge are 300 – 600 m long, those found near the crest are 400 m long, and those lying towards the Tunsului ridge have lengths between 2000 and 900 m. The main valley has three levels of cirques, which gather all the avalanche chutes coming from the northern ridge. The median cirque receives a tributary coming from the Negoiu Mic peak. The glacial threshold lies between 1500 and 1600 m. Downstream of it there are several smaller tracks, the largest and the longest of them being shown in Fig. 16 (right). Slightly below, there is another avalanche chute, with five tributary tracks, the deposit of reaches 1100 m altitude. On the Şerbota knife-edged ridge, the tracks descend only to 1400 m. Here, the impact on the forest vegetation is much lower in comparison with what happens on the Tunsului ridge.

The avalanche path lying on the western slope of the Tunsului ridge starts from the area where altitudes are higher than 2100 – 2200 m . Its starting zone is above 2000 m, the track advances as low as 1500 m, while the runout zone reaches 1400 m (sometimes having a relative height of 800 m). The path, which is 1500 m long, develops along a torrential stream, which is a tributary on the right-hand side of the Sărata valley, on the fluvio-glacial stretch of the valley. Here, too, as it happens on the entire slope of the Tunsului ridge, avalanches hinder the forest from advancing to higher altitudes.

The analysis of vulnerability maps shows the territorial distribution of avalanches, which reflects their natural genesis conditions. The two studied areas are both affected, even if to different extents, by avalanches, this being reflected by the local morphologic characteristics. All the detailed examples highlight the way in which nival shaping systems operate. Each (of them) has a certain impact and particular effects on the environment components. They are especially felt by forestry vegetation which is most affected when there are penetrating water runs. Effects vary being conditioned by subsoil morphology and vegetation levels.

Conclusions

The avalanches occurring in the investigated massifs are very complex natural phenomena, with different features imposed by local conditions. Due to the pre-existing geological context and the potential triggers, avalanches are very likely to occur in these areas.

The most impressive impact is suffered by forest vegetation, which in both mountain massifs is hindered to develop in altitude. The damage inflicted upon vegetation is more significant in the Făgăraş Mts., while that inflicted upon anthropogenic component is higher in the Piatra Craiului massif.

The study areas presented so far are representative for the way in which the avalanches operate on the eastern side of the Piatra Craiului massif and on the northern slope of the Făgăraş Mts. What happens in the two investigated areas could be generalized for other mountain massifs, too. Therefore, the present study completes the detailed analyses of the avalanches occurring in the two mountain units. It may serve in the future as an important database for the management of local resources.

Acknowledgements

This work was supported by the project: ”Evaluation and Monitoring of Avalanche Risk in the Context of Mountain Environment Organising and Planning. Case Study – Fagaras and Piatra Craiului Mountains”, financed by CNSIS, category IDEI. We wish to express our appreciation to all those who supported us in the documentary and field investigations: the Administration of the Piatra Craiului National Park, the Rescue Service, the chalets keepers from Curmătura, Bârcaciu, Negoiu, and the members of the Liliecii Brasov NGO.

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