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Glacial and periglacial relief in the Făgăraş Mountain, with special focus on the Vâlsan river basin

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Abstract

The glacial modeling has created two well individualized geomorphologic landscapes in the Transylvanian Alpes: Borăscu, characterized by the large extension of the platform and high peaks, and Făgăraş, where cirques were multiplied and have developed until they reduced the platform to a very sharp ridge (gipfelflur). The layout of the main ridge on the West-East direction and the overall morphography of the two slopes, the northern one short and steep and the southern long, with gentle slopes, were also reflected in the way of development of glaciers in the Quaternary. In the Vâlsan basin there are distinguished some particularities of the glacial landform. Thus, the glacial landform of this sector of the Făgăraş Mountains is characterized by a small steep (200-300m) which favored the development of a long glacial valley with gentle slopes and led to the forming of the moraines at the glacial valley floor. The Vâlsan glacial cirque is at 2300m altitude, is small and has small lakes. The bottom of the cirque is flat and is predominantly grafted on mica-schist and gneisses. The Vâlsan *glacial valley* is North-South oriented and has several glacial thresholds. The slopes surrounding the Vâslan valley are symmetrical, being affected by torrents and avalanches. Other characteristic landforms are: *narrow glacial crests, glacial replats ridges, nunataks and moraines*. The frost wedging caused the residual relief represented by *sharp ridges, peaks, landforms of accumulation, debris cones, glacis, stone arches, protalus ramparts*. Overall, the Vâlsan glacial valley is a typical valley where the intensive post-glacial processes have hidden most of the features resulting from the glaciers action, which kept the characteristic „U" shape and the glacial replats appear from place to place under glacises and rock debris.

Key words: *the Vâlsan, gipfelflur, narrow glacial crest, glacis*.

Rezumat. Relieful glaciar şi periglaciar din Munţii Făgăraş, cu privire specială la bazinul Râului Vâlsan.

Modelarea glaciară a creat în Alpii Transilvaniei două tipuri de peisaje geomorfologice bine individualizate: *Borăscu*, caracterizat prin larga extensiune a platformei şi a vârfurilor înalte şi *Făgăraş*, unde circurile s-au înmulţit şi s-au dezvoltat până au redus platforma la o creastă foarte ascuţită, (*gipfelflur*). Dispunerea culmii principale pe direcţie V-E şi morfografia de ansamblu a celor doi versanţi, cel nordic scurt şi abrupt, iar cel sudic prelung, cu pante mai domoale, s-au răsfrânt şi în modul de dezvoltare al gheţarilor în Cuaternar. În cadrul bazinului Vâlsan se disting anumite particulariăţi ale reliefului glaciar. Astfel, relieful glaciar din acest sector al munţilor Făgăraş se caracterizează prin prezenţa unui abrupt de mici dimensiuni (200-300m) ce a favorizat dezvoltarea în lungime a văii glaciare, cu pante domoale şi a determinat depunerea morenelor la baza văii glaciare. Căldarea glaciară a Vâlsanului se găseşte la altitudinea de 2300 m, are dimensiuni reduse şi cantonează mici lăculeţe. Fundul circului este plat fiind grefat predominant pe micaşisturi şi gnaise. *Valea glaciară* a Vâlsanului este orientată pe direcţia N – S şi prezintă mai multe praguri glaciare. Versanţii care încadrează valea Vâlsanului sunt simetrici fiind afectaţi de torenţialitate şi avalanşe. Alte forme de relief caracteristice sunt: *custurile, umerii glaciari, striurile, rocile mutonate şi morenele.* Gelivaţia a determinat apariţia reliefului rezidual reprezentat de *creste ascuţite, vârfuri*, forme de relief de acumulare, *conuri de grohotiş, glacisuri, ghirlande de pietre, potcoave nivale*. În ansamblu, valea glaciară a Vâlsanului este o vale tipică în care procesele postglaciare intense au ascuns în cea mai mare parte elementele caracteristice rezultate în urma acţiunii gheţarilor, se păstrează forma caracteristică de " U", iar umerii glaciari apar din loc în loc de sub glacisurile şi poalele de grohotiş.

Cuvinte-cheie: *Vâlsan, gipfelflur, custură, glacis.*

INTRODUCTION

The study of the glacial landforms of the Romanian Carpathians started with *Beobachtungen über Tektonik und Gletscherspuren im Fogaraschen Gebirge*" in 1881, work in which P.W. Lehmann makes references to the tectonics and glacial traces from Făgăraş Mountains. Here there are described

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for the first time a few glacial cirques and glacial lakes on the north slope of these mountains, between the peaks Negoiu and Gălăşescu. The moraine sediments are not so visible in the relief because of the advanced decay which makes them so hard to identify; moraines are hard to recognize from the point of view of the shape and of the structure of the material; striated rocks are rare, and the erratic nature of many blocks is hard to recognize as well.

For this reason Lehmann does not succeed to identify moraines and cannot establish the maximal expansion of the ice age. Demonstrating the law of Partsch, he establishes the altitude of 1700 m as the limit for the permanent snow during the ice age, he insists over the independence of the cirques related to the structure and the lithology, emphasising their dependence on the altitude and the exposition. Among the researchers who showed interest for the study of the glacial landforms in the Carpathians were the Romanian geologysts L. Mrazec, Gh. Munteanu-Murgoci and Popovici-Haţeg. L. Mrazec notices the predominant exposure of the glacial cirques from the Alps of Transylvania towards north and east.

Their dimension is bigger in comparison to the southern slope. He identifies roches moutonnees, glacial thresholds and lakes in the cirques. Starting with 1898, Emmanuel de Martonne starts his field campaigns in the Alps of Transylvania, giving a special importance to the glacial landform (Fig. 1).

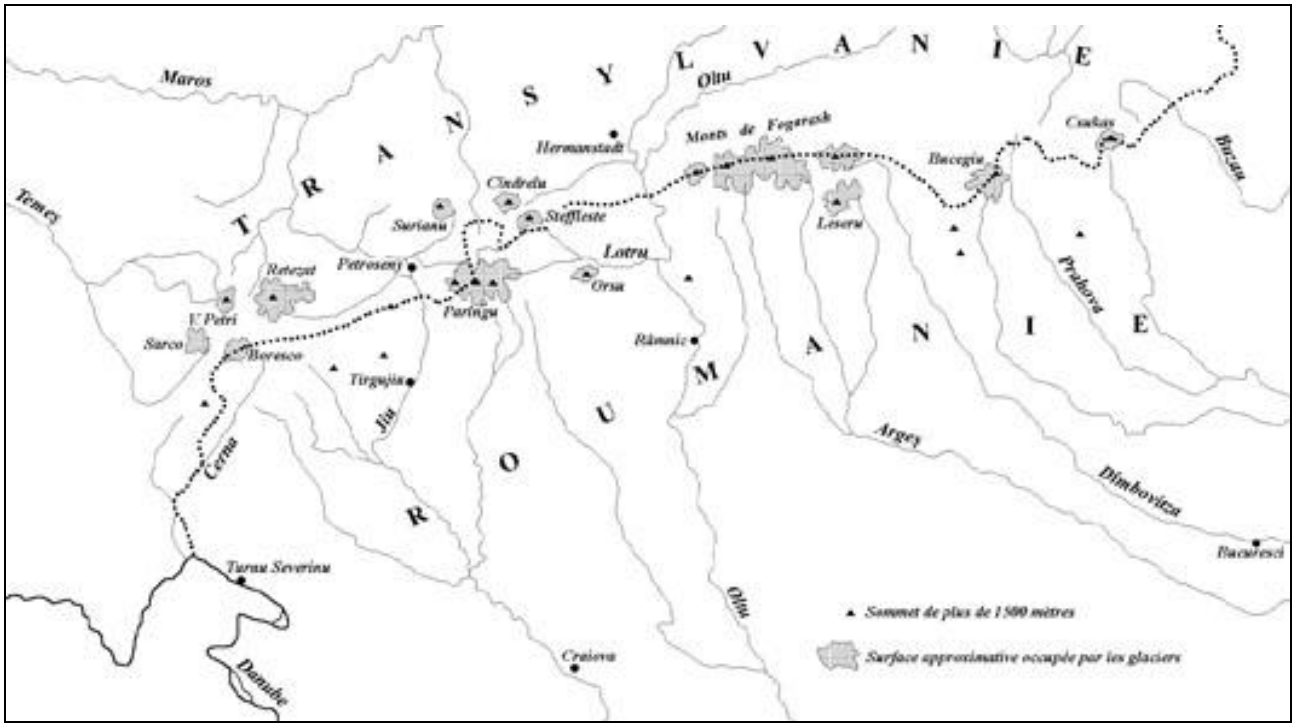

Fig. 1 Glacial extension in the Alps of Transylvania. Emmanuel de Martonne (1900)

In his opinion, the glacial shaping of the landform left in the Alps of Transylvania two very characteristic types of geomorphological landscapes well individualised:

- Borăscu type, present in Godeanu, Ţarcu, Şureanu, Cindrel, Lotru, a part of Retezat and Parâng and the eastern branch of Făgăraş, characterized by a large extension of the platform of the high peaks, spotted with glacial cirques.
- Făgăraş type, present in Parâng, Retezat and Făgăraş, where the cirques propagated and developed till they reduced the platform to a very sharp crest, while the glacial valleys which were descending on the mountain's slopes were themselves separated by sharp crests (gipfelflur).

DATA AND METHODS

The study of the glacial relief from the valley of Vâlsan river started with bureau methods, by this meaning the study of the scientific literature (Urdea, 1994,1998) but which referes especially to others areas from the Făgăraş mountains, the basin of Vâlsan being less known. The numerous field trips consisted in observations, measurements, photographs while studying the existing maps (sc. 1:25000), satellite images LANDSAT ETM +, aerials images. The obtained results were processed with the help of the programs: GLOBAL MAPPER and ARCVIEW 3.2. There were made measurements and map drawings of the glacial

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cirques, of the thresholds and identified the moraines that were under big amounts of detritus, a result of the postglacial cryonival processes.

The Făgăraş Mountains

Until now, there were carried out many studies on the field about the glacial morphology from the Făgăraş mountains. The most well-known are those carried out by **Emm. de Martonne** (1907), **R. Luzerna** (1908), **E. Nedelcu** (1959) (Fig. 2), **I. Sârcu** (1958), **Gr. Posea** (1982) and **M. Florea** (1986, 1989, 1998). Several studies on the morphological and hydrological features of the glacial lakes from the mountains were published by **O. Phleps** (1914), **A. Năstase** (1960a, 1960b) and **I. Pişota** (1956, 1957, 1958). Information about the ice age from the Făgăraş Mountains can be found in the works of **Th. Kräutner** (1930) or **St. Pawlowski** (1936). The Făgăraş Mountains have over 175 glacial cirques (Posea et al., 1974), grouped in glacial complexes, at the source of the hydrographic thoroughfare. On the north slope, between Moaşa (2034m) and Luţele (2176m), a cirque or a group of several cirques may be found at the source of every valley. All the rivers here flow into the Olt: Jibra, Avrig, Şerbota, Sărata, Laiţa, Valea Doamnei, Bâlea, Arpăşel, Arpaşu, Podragu, Ucea Mare, Ucişoara, Viştea Mare, Viştişoara, Sâmbăta, Brezcioara, Urlea, Valea Dejanilor, Berivoiu and Sebeşu. On the southern slope, the cirques form big glacial complexes due to the presence of several hydrographic thoroughfares that are more developed than the northern ones. Here, the glacial landform groups itself at the sources of the rivers Boia, Topolog, Capra, Buda, Vâlsan, Valea Rea, Zârna and Dâmboviţa.The W-E direction of the main crest and the landform ensemble of the two slopes, the northern one –short and steep-, towards the Făgăraş Hollow, and the southern one – long, with gentle slopes, towards the Subcarpathians basins, influenced the manner in which the glaciers developed in the Quaternary. In this way, even if the exposure is not favourable, the longest valley glaciers formed in the south, reaching in numerous cases 7 km in length (Florea, 1998), while on the northern slope the valleys are shorter, at most 5 km, but they are very deep. The glacial cirques are well developed on the northern slope Suru (2283 m) and Luţele (2176 m), having steep walls and deep floor. In some situations, their morphology is complicated by the presence of many horizontal lobes and vertical stairs, as it happens on Laiţa, Arpaş, Sâmbăta or Valea Dejanilor. On the southern slope, there are present suspended cirques at the source of the valleys whose glaciers were coming out onto big glacial valleys as Capra, Buda or Valea Rea.

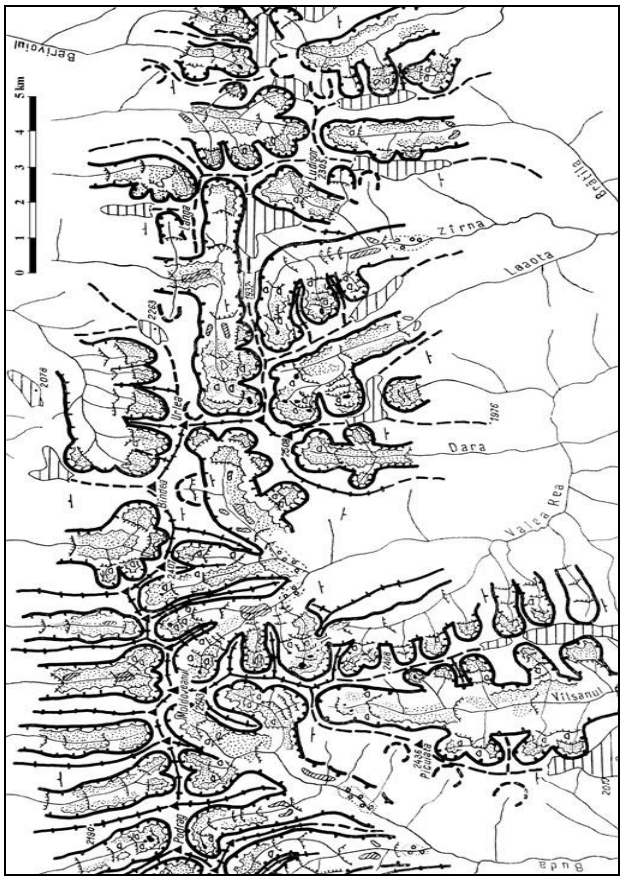

Fig. 2 The glacial morphology of the Făgăraş Mountains. E. Nedelcu (1960)

There occur cirques complexes with many floors, sideway lobes and lacustrian hollows and glacial channels. The glacial valleys of Făgăraş, especially those on the northern slope, have a unique morphology for our country. Because of the local base level, near and very low, represented by the Făgăraş Basin, the preglacial hydrographic thoroughfare became deeper in the slope of the mountain, delimitating the alignment of the secondary crests, perpendicular on the main one (gipfelflur).

The valley glaciers start the glacial modelling from the inferior side of the slopes and from the fluviatile beds. Coarse rock as the crystal schist of the Getic Nappe maintains the secondary crests sharp and high, with steep slopes, while the former fluvial valleys get an U - shape and in the longitudinal profile they have steps. The great relief difference between the surrounding peaks and the former floor of the valley glacier can be found only in the glacial valleys from the Făgăraş Mountains, due to the strong vertical erosion by the preglacial rivers from Făgăraş. For example, we can mention

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the Bâlea, Ucea Mare, Ucişoara, Viştea Mare and Sâmbăta glacial valleys, on the northern slope, or Capra, on the southern one.

The landscape of the glacial valleys is completed by the presence of a system of narrow glacial crests and pyramidal peaks from our country, developed on the both sides of the main crest, between the peaks Şerbota (2331 m) and Urlea (2473 m). These were formed by glacial and periglacial processes and it separates today a good part of the glacial cirques and the valleys. The detailed morphology of the cirques and the valleys is completed by the presence of numerous micro and meso-scale forms, glacial and sculptural forms as the hollows from the erosion of the surface under the glacier filled with lakes, the transfluence saddles, nunataks, roches moutonnées, thresholds and polished surfaces or glacial grooves.

The glacial lakes are on the both sides of the main crest, at an average altitude of over 2000m. Most of them occupy a central position in the glacial cirques; a few are installed on the steps of the glacial valleys, behind the thresholds. 26 lakes have a permanent character, and in the years with more humidity, there can be formed temporary lakes–(Pişota, 1971). The frontal and lateral glacial moraines are better kept on the southern wing than on the northern one, where they have been strongly washed by the postglacial erosion, because of the high potential of erosion of the landform, due to the inclined slope of the valley. Concerning the ice ages, the majority of the studies (de Martonne, 1907; Phleps, 1914; Niculescu et al. 1960) bring arguments in favour of the two glacial ages, Riss, when the maximal expansion is reached, and Würm, of less intensity. In 1982, Gr. Posea launches and provides arguments with paleoclimatic and morphological arguments regarding the manifestation of the quaternary ice age in one Würm period, with more levels of evolution.

For the limit of the permanent snows in the Făgăraş Mountains, during the glacial ages, there were obtained different values, depending on the author and on the used method. Lehmann (1885) establishes a value between 1500 m - 2000 m, de Martonne (1907) appreciates it at 1900 m, during the first ice age, and 2100 during the second one, and Lucerna estimates it at 1700 m (Florin, 2005).

The glacial landform of the Vâlsan river basin

The Vâlsan river basin is located between the Doamnei and Argeş rivers, from east to west, on the soutern side of the Făgăraş Mountains. In the Vâlsan basin, we can distinguish certain particularities of the glacial landform. So, the glacial landform of this branch of the Făgăraş mountains is characterized by the presence of a small steep (200-300m), which favoured the development of a long glacial valley with gentle slopes and entailed the moraines sediments at the foot of the valley. During the pre-Quaternary age, through a faster deepening, the valleys pushed their springs towards north, forming several levels of erosion. In a transversal profile, the valleys have a U shape, with periglacial glacises (Nedelea, 2005).

The main glacial forms on the Vâlsan valley

The Vâlsan glacial cirque (Fig. 3) or the Corrie of Vâslan is located at the altitude of 2300 m, it has small dimensions and small lakes, having its springs here.

Fig. 3 The Vâlsan Glacial cirque

The bottom of the cirque is flat, being grafted on mica-schists and gneiss which developed in small hollows made by glacial erosion. The glacial threshold situated at 2000m, with a height of 100 m, is grafted on amphiboles (Fig. 4).

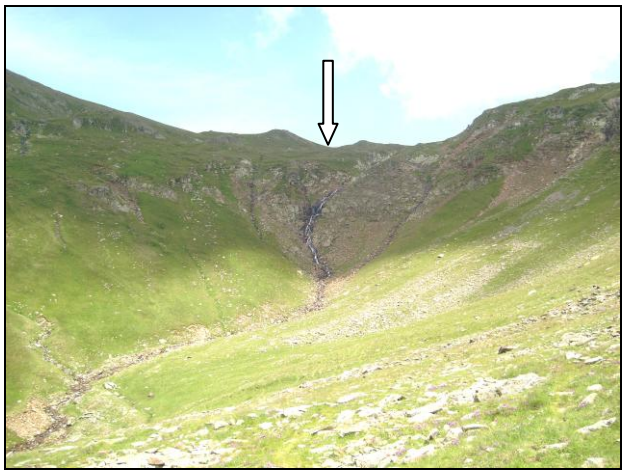

Fig. 4 The Vâlsan glacial threshold

The glacial micro-landform of erosion within the glacial cirques and valleys can be identified with

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difficulty because of the big amount of disintegrated sediments from the slopes (the glacial striations – forms that resulted from the friction between the glacier and the lithological level) (Fig. 5,6).

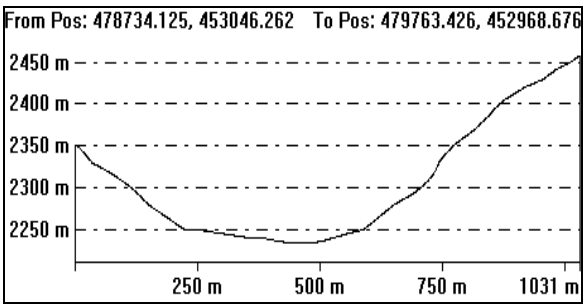

Fig. 5 The Vâlsan glacial cirque, cross section

Fig. 6 The Vâlsan glacial valley

Other landforms that are characteristic to this glacial branch of the Vâlsan valley are: the pyramidal peaks, which can be found on the both sides of the valley, especially on the ridge between Vâslan and Argeş; ***glacis*** and ***roche moutonnées.***

The accumulation landforms are represented by detritus resulted from the erosion manifested on the riverbed and the lateral walls by the glaciers, adding the efects of the weathering from the nearby regions, and which is transported by the glaciers, forming **moraines** (Fig. 7, 8).

The periglacial landform

The periglacial domain had an extended development over the Făgăraş Mountains during the Upper Pleistocene. The cryonival processes affected the region situated in the neighbouring of permanent snow (Fig. 9). The results of the periglacial processes can be found in the studied area, in the high mountains region, in the alpine and subalpine areas and at the timberline.

The old periglacial sediments are mostly found in the soils and vegetation. The postglacial evolution took place on the background of a transition to a softer climat which induced the modification of the types of processes.

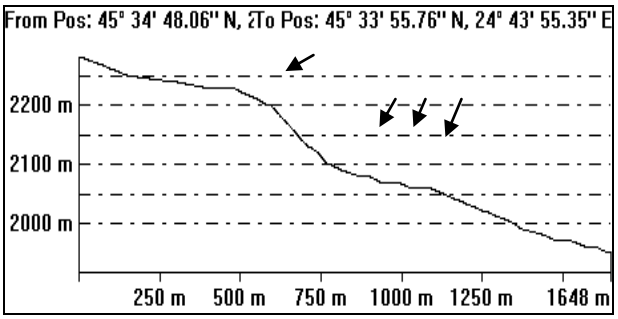

Fig. 4 Longitudinal profile of the valley, with emphasis on structural thresholds grafted onto amphibolites

Fig. 5 Accumulation of debris from the slopes

Fig. 96 The glacial debris in the Vâlsan cirque (west slope exhibition)

For the southern branch of the Făgăraş mountains, a change of the timberline with almost 1000 m can be observed, so a part of the old preglacial sediments were covered (Nedelea, 2005). The cryonival processes imposed themselves and they are in progress in various ways, depending on the local conditions (altitude, the exposure of the slopes, the massivity, and the angle of the slopes, rocks, but

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also temperature, wind and precipitation amount). Mean temperatures are -2; – 0º C, while the average precipitation amount is 1000 – 1400 mm per year. The snow lasts for 150 – 200 days per year, while the frost days are very numerous.

Micro cryogenic -landform

The gelifraction manifests itself accordingly to the lythological structure on mica-schists, paragneiss, gneiss and dolostones. The result is a ruiniform landform, represented by pyramidal crests: Picuiata, Piatra Tăiată, Scărişoara, etc. (Fig. 10)

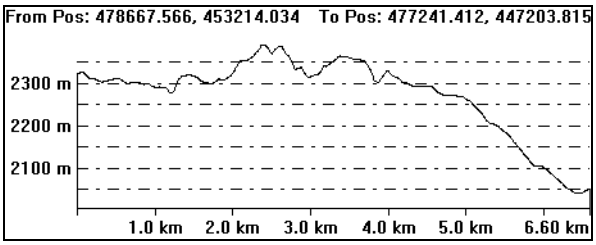

Fig. 10 Profile interfluve where ruiniform apparent appearance, the result of gelifraction (Peak Picuiata)

Periglacial sediments and structures

The screes formed as a result of the gelification. They can be encountered at altitudes of over 1800m and they are widely spread in the Vâlsan valley. The avalanches and the downfalls created the screes that often end up in the bed of the rivers. They formed during the Pleistocene (big masses of scree, fastened by the soil and vegetation), but also during the Holocene (Fig. 11).

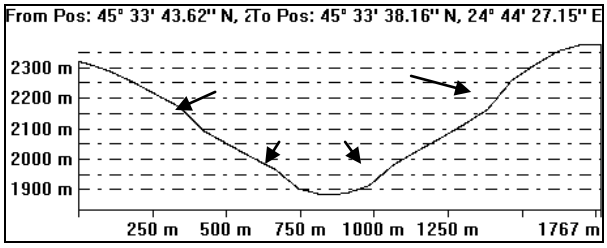

Fig. 11 Cross section highlighting the valley glacial replate (2150-2250 m) and scree cones (1950-2000 m)

Rock glaciers

Rock glaciers are important accumulations of desintegrated material that took the shape of lobes which can move, taking the form of scree flows (Haeberli, 1985). On the Vâlsan valley they are inactive, being covered by the alpine meadow. Judging by relief's aspect, the hillocks' succesion, waves, micro-hollows, some moraines which can be found at over 1800m is possible to have functioned as rock glacier in postglacial era. Nowdays these forms can be met on the eastern and western slope of the valley, at altitudes of 1700-1900m, with a deplyoment of 200-300m lenght, being covered with vegetation and recent gelifracts. They oriented on the deployment direction of the glacial valley, north – south. In spring the temperatures in this sector are 5-6^{0}C, indicating the lack of ice and confirming the fossil character.

Solifluction

Solifluction implies a displacement of the superficial bed, oversaturated with water that produces in general on a waterproof or permeable substratum. The solifluction lobes produce the slopes with slopes of over 25º, being particular especially during spring, and it can be met on alpine meadows above 1500m. This process is accentuated by streaming and surface erosion. The solifluction process is also favoured by the anthropic intervention (sheep paths). They can be met on the both slopes of the glacial valley, but it is more spread on the western slope (the Scărişoara Peak)

Hillocks

They are at over 1800 m altitude (very rarely beyond), on flat surfaces or with slopes of 10 – 15 degrees, on Borăscu surface or in the cirque glacier (fig. 12). Its diameter measures 0.5 – 1m and they don't get over 0.5m in height. Next to solifluctions, they are very widely spread. The hillocks have an ice core that doesn't melt till late spring. The hillocks are formed from fine materials, from clay and sandy clay with a few stones. They can be encountered on the western slope of the Scărişoara Peak and on the eastern slope of the Piatra Tăiată Peak. Their shaping is due to the gelifluction processes, in humid conditions and to seasonal ice which favours cryoturbation.

Fig. 7 Hillocks

Nival micro-landform

Avalanche corridors present a higher frequency in the superior branch of Vâlsan, being at over 1900 m. These corridors have a higher frequency on the

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left side of Vâlsan's valley. The avalanche corridors from here are large, and at their basis we can see important amounts of screes (Fig. 13).

Fig. 8 Avalanche corridors - Scărişoara Mare 2489m

Nival micro-hollows develop themselves on the slopes, at their basis in the deposits of scree or on the ridge surfaces with a reduced slope. They can be located on the Borăscu platform and on the Ţuica Peak. Other landforms which can be found in the nival micro-landform are: nival niches on the western slopes of the Vâlsan's valley and the protalus ramparts (accumulation forms found at the basis of the nival niches) (Fig. 14).

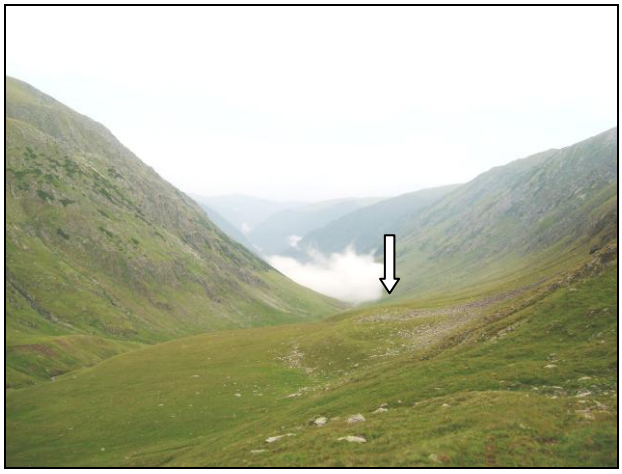

Fig. 9 The protalus ramparts on the right side of the glacial valley

CONCLUSION

The Vâlsan glacial valley is a typical valley, where the intense postglacial processes have hidden the most of the characteristic elements resulted from the action of the ice. The reduced slope determined the modelling of a prolonged glacial valley, which keeps the characteristic U – shape, and the glacises show up from place to place under the foothill scree. The manifestation of the postglacial cryonival processes determined the covering of the bottom of the valley with scree on wide areas, the water of the river getting deeper until the basis level, uncovering the old thresholds imposed by the structure or, on certain zones, it created meanders imposed by avalanches and scree cones. The advancement of the timberline in the postglacial area makes difficult the field reasearch, often being necessary that the studies and the estimations to be made on the basis of the information from the topographical and geological maps (Fig. 15).

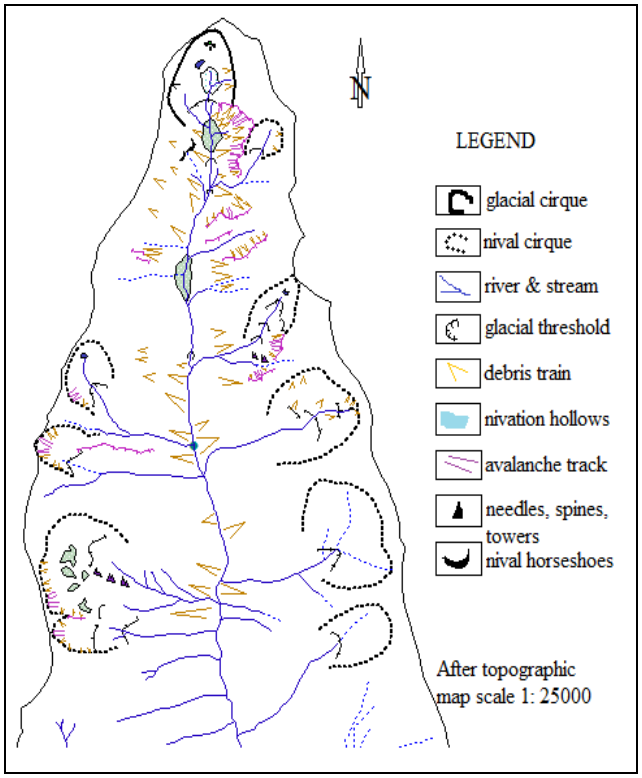

Fig. 10 The glacial landforms in the Vâlsan river basin (drawn by the author, after the topographic map, scale 1:25000)

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