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C U P R I N S / C O N T E N T S

A r t i c o l e / P a p e r s

L. STAMATOPOULOS & N. EVELPIDOU – *River-bed evolution during the Holocene in Kalavrita region (Northern Peloponnese, Greece)*... 5

Mihai IELENICZ, Smaranda SIMONI (TOMA) – *The Valley System Evolution in Romania* 9

Maria RĂDOANE, Ionuţ CRISTEA, Nicolae RĂDOANE – *Geomorphological Mapping. Evolution and Trends*.. 19

Virgil SURDEANU, Olimpiu POP, Marius DULGHERU, Titu ANGHEL, Mioara CHIABURU – *Relationship between trees colonization*.. 41

Karel KIRCHNER, Lucie KUBALÍKOVÁ – *landslide and debris-flow activity in the sulphur mining area of Calimani Mountains (Romania). Evaluation of geoheritage in the western part of National Park Podyjí, Czech Republic*........... 51

Florina GRECU, Cristina GHIŢĂ, Emil CÎRCIUMARU – *Land Vulnerability to Geomorphological Hazard Induced By Pluviometric Criteria (Romanian Plain)*.. 59

Gabriel MINEA, Liliana ZAHARIA – *Geomorphological impact of floods in the Bâsca Catchment (Romania)*... 67

Sandu BOENGIU, Cristiana VÎLCEA, Mihaela LICURICI – *Landslides in the Plain Sector of the Jiu Valley*.. 75

Alexandru NEDELEA, Anca MUNTEANU, Răzvan OPREA, Laura COMĂNESCU, Robert DOBRE – *Cryo-nival modeling system. Case study: Făgăraş and Piatra Craiului Mountains* 83

Iulian SĂNDULACHE – *Planation surfaces in the Bistricioara catchment (Eastern Carpathians)* 91

Dinu OPREA GANCEVICI, Ionuţ CRISTEA – *On periglacial processes and landforms in the Brodina River Basin (Obcinele Bucovinei)* 99

Smaranda SIMONI (TOMA) – *The Role of the Periglacial Processes in the Present Morphodynamics of the Doamnei River Basin (the Făgăraş Mountains)* 109

Maria ALBU DINU – *Călmăţui (Teleorman) Hydrographic Basin – Morphometric Analysis Elements*... 123

Robert DOBRE – *Use a GIS techniques to identify areas to consider when designing the Comarnic – Sinaia motorway sector so as to meet sustainable development requirements*.. 131

On periglacial processes and landforms in the Brodina River Basin (Obcinele Bucovinei)

Dinu OPREA GANCEVICI, Ionuţ CRISTEA

Abstract. Situated in the north-eastern part of the Eastern Carpathians, Obcinele Bucovinei are characterised by a strong parallelism of the main ridges, following a NW-SE direction, with altitudes decreasing from 1400-1500 m in the west to 800-900 in the east. Due to their altitude and localisation in the Romanian Northern Carpathians, the moulding of Obcinele Bucovinei started with the installation of glaciations by processes characteristic to permafrost. While dividing the periglacial units in the Pleistocene, Posea & coll. (1974) include the most part of the Mountains Obcinele Bucovinei in the north-central periglacial province, the Carpathian region, the detritic perigacial layer and the crionival sublayer (between 700 and 1500 metres), while the high segment of the mountain Obcina Mestecăniş (up to 1500 metres) belongs to the nivo-cryogenic sublayer. Dividing among regional morphogenetic periglacial ***Würmian*** units Ichim (1983) situates the same mountains in the *Carpathian periglacial domain*, where he identifies two altitudinal levels: the level of cryoplanation and intense weathering (above 1000 metres) and the level of solifluctions (600-1000 metres). Morphogenetically speaking, the periglacial area is characterised by a series if specific phenomena and processes determined by various agents such as gravitation, surface runoff water and groundwater, snow and wind. These are closely related to the characteristics of the thermal regime. The main processes typical to the periglacial morphology are: freeze-thaw cycles, nivation, eolisation, and, subsequently, gelifluviation. Thus, the alternation between glacial stadial and interstadial periods alternately placed the mountains Obcinele Bucovinei in the zone of either the continuous or discontinuous permafrost. In the cold stadial periods, the dominant processes gelifraction and nivation generated large debris slopes, residual peaks and wind generated microforms. The transition to the interstadial periods is morphologically marked by the intensification of solifluidal processes and torrent erosion. The specific landforms resulted from such processes are: residual forms (ridges, cliffs), debris deposits, rhythmically stratified slope waste deposits, altiplanation terraces, solifluctions, nival niches, eologlyptolites etc**.**

The Brodina River is the main right-side tributary of the superior segment of the Suceava river. It is 31 kilometres long and its basin is 153 km². Geostructurally speaking, the catchment completely covers the external flysh, in the west ,the Audia Thrust Sheet for about 48 km², and the central and eastern part the Tarcău Thrust Sheet, for about 103 km². The lithologic variety characteristic to the flysh is reflected in the different reaction to the action of periglacial processes. Therefore, petrographic areas rich in marlstone and clay were mainly affected by eluvial and solifluidal processes while gelifraction was a process specific to areas dominated by limestone, sandstones and conglomerates. Periglacial processes and phenomena generated in the morphology of the river catchment both periglacial deposits – debris deposits, some of them still active (on the Vejul Mare – Hrebeni Ridge), solifluidal deposits (the periglacial deposit identified upstream from the Brodina-Ehreşte junction), involutions, and erosive landforms – residual ridges (Vejul Mare), slopes and terraces of cryoplanation, eologlyptolites.

Key words: periglacial, frost-heaving, involution, cryoplanation, eologlyptolite

Rezumat. Asupra unor procese şi forme periglaciare în bazinul hidrografic Brodina (Obcinele Bucovinei). Situate în nord-estul Carpaţilor Orientali, Obcinele Bucovinei se caracterizează printr-un accentuat paralelism al culmilor principale, orientate NV-SE, cu altitudini ce scad de la vest (1400-1500 m) la est (800-900m). Prin altitudinile sale şi localizarea în nordul Carpaţilor româneşti Obcinile au fost modelate odată cu instalarea glaciaţiunilor prin procese caracteristice permafrostului. În regionarea unităţilor periglaciare Pleistocene Posea şi colab. (1974) situează aproape integral Obcinile Bucovinei în *provincia periglaciară central-nordică, regiunea carpatică, etajul periglaciar detritic, subetajul crionival* (700-1500m), doar partea înaltă din Obcina Mestecăniş fiind încadrată *subetajului nivo-criogen* (>1500m). Ichim (1983) într-o regionare a unităţilor morfogenetice periglaciare wurmiene din România, situiază aceleaşi Obcine în *domeniul periglaciar carpatic,* în care identifică altitudinal două etaje: etajul crioplanaţiei şi al dezagregărilor intense (peste 1000 m alt.) şi etajul solifluxiunilor (600-1000 m). Din punct de vedere morfogenetic periglaciarul este caracterizat de o serie de procese şi fenomene specifice, determinate de diverşi agenţi – gravitaţia, apa de şiroire şi infiltraţie, zăpadă, vânt. Aceştia evoluiază strâns dependent de caracteristicile regimului termic. Principalele procese ce ce caracterizează morfologia periglaciară sunt: ciclurile gelive, nivaţia, eolizaţia şi secundar gelifluviaţia. Astfel alternanţa stadialelor şi intestadialelor glaciare plasau periodic Obcinele Bucovinei când în zona permafrostului continuu când în cea a celui discontinuu. În răcirile stadiale procesele dominante, gelifracţia şi nivaţia, au generat marile pânze de grohotişuri care acoperă versanţii, martori şi microforme eoliene. Trecerea către interstadiale este marcată morfologic de intensificarea proceselor solifluidale şi a celor de eroziune torenţială. Formele specifice sunt: formele reziduale (creste, ţancuri etc.), grohotişurile, depozitele de versant ritmic stratificate, terasele de altiplanaţie, solifluxiunile, nişele nivale, eologliptoliţii etc.

Râul Brodina este principalul afluent de dreapta al Sucevei superioare. Are o lungime de circa 31 km şi se dezvoltă pe o suprafata bazinală de peste 153 km². Geostructural, bazinul se suprapune în întregime flişului extern, la vest pe Pânza de Audia (cca 48 kmp), iar partea centrală şi estică pe Pânza de Tarcău (cca 103 kmp). Varietatea litologică specifică flişului se reflectă în comportamentul diferit al acestora la acţiunea proceselor periglaciare. Astfel arilor petrografice preponderent marnoase şi argiloase le-au fost specifice procesele eluviale şi solifluidale, iar celor dominate de gresii, calcare şi conglomerate procesele de gelifracţie. Procesele şi fenomenele periglaciare au generat în morfologia bazinului atât depozite periglaciare – grohotişuri, unele chiar active (Culmea Veju Mare – Hrebeni), depozite solifluidale (depozitul periglaciar identificat amonte de confluenţa Brodina-Ehreşte), involuţii, cât şi forme destructiv-erozive – creste reziduale (Veju Mare), versanţi şi terase de crioplanaţie, marmite de eolizaţie (eologliptoliţi).

Cuvinte cheie: periglaciar, elevaţie periglaciară, involuţie, crioplanaţie, eologliptoliţi

Introduction

Situated in the north-eastern part of the Eastern Carpathians the mountains Obcinele Bucovinei are characterised by a strong parallelism of the main ridges, following a NW-SE direction, with altitudes decreasing from 1400-1500 m in the west to 800-900, in the east. The glaciations determined by the Quaternary temperature decrease resulted in the extension of the ice sheet towards lower latitudes. In the Carpathians, mountain glaciers appear and grow above 1800 m. Practically, above the snowline and the limit of frost action phenomena and under the altitude of 1800 metres can be identified the conditions of periglacial moulding, mainly by processes related to gelivation and also, especially under the snow line, by processes of nivation, solifluction and eolisation. These work on a permanently frozen layer, the permafrost. The term was introduced by Muller in 1943 and it is an abbreviation of the expression *permanently frozen*.

By their altitude and localisation in the Romanian Northern Carpathians, the moulding of Obcinele Bucovinei started with the installation of glaciations by processes characteristic to permafrost.

While dividing the periglacial units in the Pleistocene, Posea & coll. (1974) included the most part of the Mountains Obcinele Bucovinei in the north-central periglacial province, the Carpathian region, the detritic perigacial layer and the crionival sublayer (between 700 and 1500 metres), while the high segment of the mountain Obcina Mestecăniş (up to 1500 metres) was included to the nivo-cryogenic sublayer. The authors consider gelifraction as the dominant process in the moulding of landforms. As a consequence, especially in the case of frost shattering rocks (sandstone, limestone and magmatic rocks), downslope and at the bottom of the mountains will be found large debris deposits and important eluvial materials covers on horizontal and sub-horizontal surfaces. The other processes are also present but they are of secondary importance.

Dividing among regional morphogenetic periglacial ***Würmian*** units, Ichim (1983) placed the same mountains in the *Carpathian periglacial domain*, where he identifies two altitudinal levels: the level of cryoplanation and intense weathering (above 1000 metres) and the level of solifluctions (600-1000 metres).

Morphogenetically speaking, the periglacial area is characterised by a series of specific phenomena and processes determined by various agents such as gravitation, surface runoff water, groundwater, snow and wind. These are closely related to the characteristics of the thermal regime. The main processes typical to the periglacial morphology are: freeze-thaw cycles, nivation, eolisation, and, secondarily, gelifluviation. The specific land forms resulted from such processes are: residual forms (ridges, cliffs), debris, rhythmically stratified slope waste deposits, altiplanation terraces, solifluctions, nival niches, eologlyptolites, etc.

The identification of landforms that can be attributed to to the periglacial morphogenesis in the Brodina hydrographic river catchment completes the image of the complex pleistocene moulding of the Obcine. The eolisation and the erosion, the elevation and the vertical separation of gelifracts, the cryoplanation and the results of its action, periglacial deposits and structures are all proofs of a morphology that has been poorly exemplified in the geomorphological literature attributed to this mountain unity.

Aspects of the periglacial morphogenesis and morphology in the north-eastern part of the Eastern Carpathians

The identification and characterisation of the various periglacial landforms is made by Donisă, 1968 (Bistrita Valley), Barbu, 1976 (Obcinele Bucovinei), Ichim, 1979 (The Stânişoara Mountains) and Rusu, 2002 (The Rarău Massif).

According to his research, Ichim asserted that in the Eastern Carpathians the periglacial morphology is represented by deposits, structures and landforms resulted from the dynamics of various specific processes. He also identified the main periglaciar processes that moulded the lower mountains in the Pleistocene, gelifraction and solifluctions, but he does not dismiss the effects of nivation and cryoplanation. He classified the discovered periglaciar deposits according to J. Dylik's opinion, in either erosive or weathering, the first type including debris, solifluction deposits and rhythmically stratified deposits while the second category includes periglacial eluvial deposits.

Debris deposits cover the slopes to altitudes lower than 1000 metres, their formation depending on the structure and extension of flyschoid gelive rocks as sandstones, limestones and conglomerates under the impact of freeze-thaw cycles. These are now fossilized and fixed by vegetation. There are also forms of moving debris deposits determined by the morphometrical features of the relief (slope, energy etc.) and lack of vegetation.

Solifluidal deposits are frequent on slopes, below the 1000 metres level. These are difficult to identify in the landscape and are sometimes revealed by lateral erosive fluvial processes that bring to daylight soil slip mounds 10-15 metres in length and up to four metres thick. Some were described by Ichim in the proluvial cones and the terraces of the hydrographic network of Stânişoara Mountains and by Donisă in the terraces of the river Bistriţa, in the mountain area.

Rhythmically stratified slope deposits are successions of alternate structures that point out different conditions of the periglacial morphogenesis. These deposits are made of bigger gelifracts separated by horizons of smaller gelifracts and horizons of sand and clay. Such deposits are identified on the Bistriţa Valley at Roseni (Donisă, 1968) and on the valleys of the streams Negrileasa, Voroneţ and Sălătruc in the Stânişoara Mountains.

Periglacial eluvial deposits were formed in interfluvial areas but also appear on gentler slopes. Are constituted of fine deposits but also sometimes by coarse deposits, strictly dependent on lithology. I. Ichim (1979) notes in Stânişoara Mountains the dependence of the granulometric structure by the slope and by the petrografic typology.

Periglacial structures include cryostatic structures and periglacial ice wedges.

Cryoturbations or periglacial involutions are isolated deformed structures occuring in the deposit layers as a result of thermal changes. These are present both in terrace deposits and in solifluidal slope deposits. I. Ichim exemplifies these microforms for the mentioned deposits on the Largu, Cucalea, Cracău Vallies in Stânişoara Mountains.

Ice wedges are less mentioned, slightly atypical structures that could be the consequence of a deformation of superior layers rather than the result of ice intrusion into the bedrock or into other deposits. The author signals such a possible structure in the influx point of the Rotaru creek in the Izvorul Muntelui lake.

The landforms resulted from the action of periglacial processes are among the most important topics in geomorphological research. *Gelifraction* is mainly revealed by sedimentary deposits, like debris, but above 1000 metres residual landforms can also occur (Barbu N., 1976) – sharp ridges (narrow peaks), tower or needle-like shaped peaks, pyramidal peaks etc.

Solifluctions generated various landforms, like solifluction glacises, valleys and slopes. This process was facilitated by certain slope gradients and by the thickness of the layer exposed to the cyclic action of a thermal fluctuating regime. The most frequent forms of patterned ground are circles and solifluction lobes; sheets are less frequent, the only form of this kind being identified by Ichim (1970) on the Sălătruc valley.

Nivation occured secondarily in the North-Eastern Carpathians above 1000-1200 metres, altitudes that marked the lower limit of perennial snows (Péwé, cited by Ichim, 1979). The result of nivation are nival hollows with their lower limit is represented by stripes resulted by debris accumulation. I. Ichim identified such landforms on the Ţiflea Mountain, in the Fărcaşa riverbasin (The Stânişoara Mountains), above 1500 metres. Rusu considers that *nival hollows* are not representative for the Rarău Mountain but he doesn't reject the possibility that some smaller sinks in the eastern part of the plateau and north-east of Piatra Zimbrului, should have periglacial origin.

Cryoplanation or altiplanation is a complex process that combines gelifraction, nivation and frost creep and generates the terraces of altiplanation. These are gently inclined surfaces that occur on mountain tops or on the upper part of

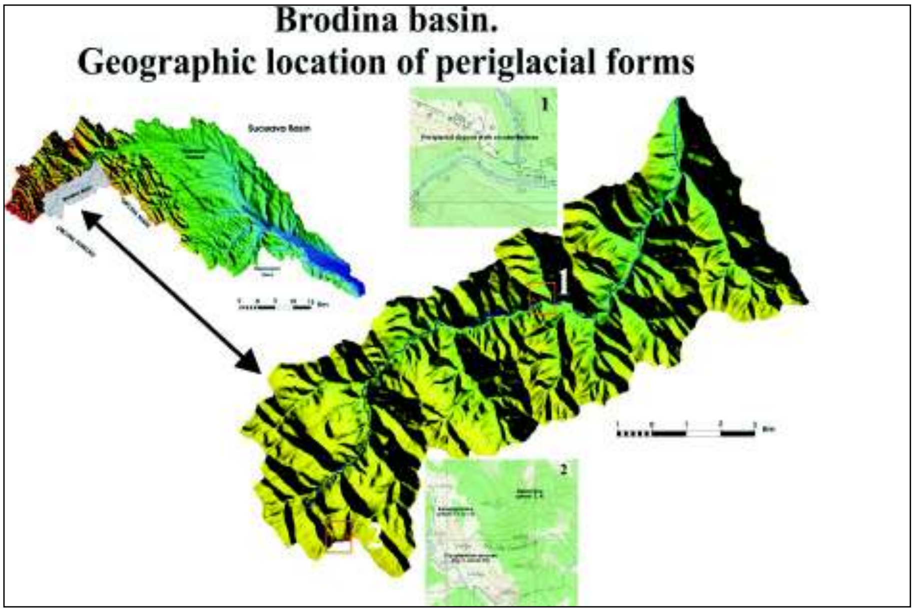

Fig. 1. **The geographic position of the Brodina river basin and location of periglacial forms**

mountain slopes as a result of the above mentioned processes. Such forms were also identified and described by Ichim (1973) in the Stânişoara Mountains (Ostra, Hăcigosu, Migovan) at about 1400-1500 metres, after they had previously been mapped and described in the Rodna Mountains (Morariu, 1940) and in the Călimani Mountains (Ichim, 1972).

Eolization or wind erosion, created microforms such as small wind hollows in rock, named by I. Ichim – eologlyptolites. In the Stânişoara Mountains he identified a series of such forms that can have up to 80-90 centimetres in diameter. Hollows that are less than 10-15 centimetres wide and up to 5-8 centimetres deep are the most frequent. He also indicates the presence of some rills, considered to be the result of both eolization and surface runoff.

Presentation of the studied area and of the work method

The Brodina River is the main right-side tributary of the superior segment of the Suceava river. It is 31 kilometres long and its catchment is 153 km². Geostructurally speaking, the catchment completely covers the external flysh, in the west, the Audia Thrust Sheet for about 48 km², and the central and eastern part the Tarcău Thrust Sheet, for another 103 km². The characteristic lithology for the flysch is made of a rhythmic alternance of conglomerates, sandstones, clay and marl arranged in a structure whose complexity grows towards east. From a structural point of view, the Audia Thrust Sheet transgresses the Tarcău Thrust Sheet in a large overthrust.

The structural and lithologic details give a special note to the landform. One can see an obvious parallelism of the peaks oriented prevailingly towards NW-SE. This feature determines in Brodina valley a succession of narrowing and depression sectors grafted on hard and erosive rocks. The minimal altitude is located at the junction with Suceava, almost 580 m, and the maximal altitudes are located in SW of the superior basin on the hard horizons of the quartz-feldspatic stone of Tomnatic-Prisaca: Vejul Mare (1494 m), Vejul Mic (1421 m), Feredeu (1429 m), Hrebeni (1406 m)

In what climate is concerned, the studied area belongs to the continental moderate climate of medium and low mountains having east influences of the excessive continental climate west influences of the humid continental climate and north-west Baltic influences. The thermic values decrease according to altitude from about 6º on the bottom of the valleys to 2º on the hights of over 1300 m. The rain fall increase according to altitude. The empirically determined values according to an algorithm made by Apostol L. and his co-workers (1985) vary between 800 mm on the bottom of the valley and 1100 mm / year at over 1400 m. I the warm season occur 70 – 75% of rain, a fact reflected in water run-off. The river flow stands at an average value of about 1,85 mc/s, that indicates a liquid flow of about 13 l/s/kmp. The turbidity stands at low values explained by the lithologic characteristics and by the structure of the land use. According to the data offered by the Corine Land Cover 2000 European programme, the hydrographic basin is covered about 79% by natural vagetation (coniferous, mixt woods, bush areas, secundary pastures). About 20% are agriculture lands, spontaneous vegetation and only 1 % boult area and complex cultures. The forest prevalence in Brodina hydrographic basin (71%) covering even the highest peaks makes somehow difficult the identification and the observation of the periglacial landform features mainly fossilized by the vegetation emerged at the beginning of Holocene.

The recognized forms attributed to the periglacial morphology appear on maps and are expeditively measured. Fix landmarks are placed on the debris deposits for the purpose of the actual dynamics display.

Periglacial elements in the Brodina River Basin

In a study regarding the mountains Obcinele Bucovinei, Barbu (1976) discussed the morphogenetic conditions of the Pleistocene periglacial period, considered to have an important role for the actual morphology. He considers gelifraction and solifluction as the most important of the dominant slope shaping processes. According to him, mountain slopes evoluted towards a decrease in altitude (a process similar to the mechanism of peneplanation) and disagrees with the regressive and parallel retreat of the slopes theory (the mechanism of pedimentation). The periods with periglacial conditions were dominated by slope processes, while the interperiglacial was characterised by an increased hydrologic competence of rivers that evacuated the sediments accumulated on the valley floors. Taking into consideration the idea of alternative processes, Barbu believes it is highly unlikely that the deposits of the first periglacial morphogenesis should have remained unaltered, with the possible exception of some accumulations in some Prewürmian terrace deposits. In consequence, considers that slope deposits and debris belong to the transition period from the Würm to the Holocene.

He admits the existence of different types of periglacial deposits and, for the residual landforms, he exemplifies the gelifraction moulded peaks – Creasta Vejului, Creasta Hrebenilor, Creasta Huţanului, Obcina Mare, cone-shaped or pyramidal peaks (Lucina, Tatarca, Tâmpa, Feredeul etc.). He also admits the existence of ruiniform elements – Piatra Fuscului, Piatra Vânătă, does not locate other periglacial landforms, but he does not exclude that they may exist.

Same author admits the existance various types of periglacial deposits and gives examples of residual ridges moulded by gelifraction: Vejului Ridge, Hrebenilor Ridge, Huţanului Ridge, Obcina Mare Ridge and also mentioned some exemples of residual peaks such as Piatra Fuscului and Piatra Vînătă. He does not identify other periglacial landforms but he does not exclude the possibility that such forms should exist.The lithologic variety characteristic to the flysh is reflected in the different reaction to the action of periglacial processes. Therefore areas rich in marls and clay were mainly affected by eluvial and solifluidal processes while gelifraction was a process specific to areas dominated by limestone, sandstone and conglomerates.

Periglaciar deposits. In the Brodina River catchment debris deposits are to a large extent fossilised and fixed by vegetation.

These can consist either of large blocks as can be seen above Poiana Solovan, at the upper part of the Hepa Mountain or of smaller size gelifracts (10-20 centimetres), similar to those from the northern side of the Veju Mare Ridge. (Photo 1, 2).

Photo 1, 2. **Debris flow and terraces in the body of gelifracts**

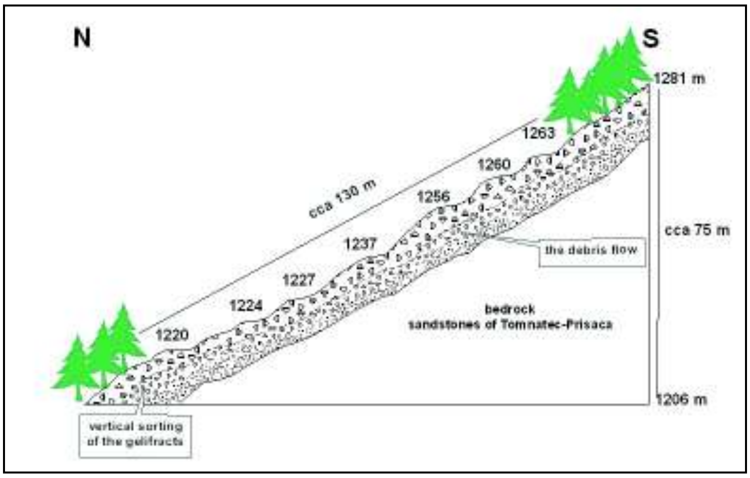

Fig. 2 **Cross-section. The debris flow on the northern slope of the Vehu Mare Ridge**

Morphometric and morphological observations on the debris flow that covers the northern slopes of the Vejul Mare Ridge revealed a succession of small terraces up to 0.6-0.8 metres wide (fig. 2), that were about 130 metres long at a level difference of about 75 metres. The analysed debris surface is at an altitude mainly between 1200-1290 metres.

The succession of these small terraces seems interesting. Genetically speaking, they could be associated with the rock creep, a process similar to the river flow that generates a succession of riffles and pools along the riverbed. We can't also exclude the biogenic origin of such terraces, given their similarity to the more frequent *pied du vache.* The terraces were marked with the purpose of periodic survey in order to identify the genetic process.

If we consider the position of the gelifracts on a vertical profile (photo 3, 4), their vertical sorting becomes evident, consequence of frost-heaving. Bigger size gelifracts are thus pushed upwards due to the larger area exposed to the action of interstitial ice formed during numerous annual or even daily cycles. It is possible that these periglacial processes, frost – heaving and frost – thrusting, should also be active today.

Upstream from the junction of the rivers Brodina and Ehreşte, at an altitude of about 750 metres, in the sediments of the 6-8 metres high terrace was identified a periglacial deposit that might cover an area of about 35 metres. This structure could not be observed on its entire length; an area of only 2 metres wide on the entire height of the profile was accessible for analysis (photo 5, 6).

Photo 3, 4.
Vertical sorting of the gelifracts

Photo 5, 6.
The identification of the terrace profile and its uncovering

We could thus notice a series of layers of sand and clay whose color and content suggest their sedimentation occurred in different morphogenetical conditions. (Photo 7).

Some layers contain centimetric angular rock elements that are indicative of slope transport. These are, most probably, colluvial solifluidal deposits subjected further to cryoturbation processes.

In the successive structure of the layers one can observe small folds that can be associated with some cryostructures – involutions, and also small lenticular structures (Photo 8, 9).

Despite the few available profiles, the presence of the periglacial deposits in Obcinele Bucovinei is obvious. By comparison, residual forms are less evident, barely identifiable.

The process of cryoplanation is a debatable subject among the authors that studied the periglacial landforms in the Eastern Carpathians. In a study on the periglacial in the Călimani Massif, Ichim (1972) identified such landforms in the area of the Reţiţiş, Negoiul Unguresc – Pietrosul Peaks and in the area of the Drăguş Plateau. Morphologically speaking the terraces of altiplanation are small plateaus delimited by escarpments or small screes of 2-8 metres. The presence of debris both on the top and at the bottom of the scarps suggests a parallel retreat of the slope due to gelifraction processes. In Călimani this process was favoured by lithologic and structural characteristics – the alternation of andesitic lava with volcanic agglomerates.

Towards the Brodina River's springs, on the right (Western) side of the Bursucul stream (the western end of the Vejul Mare, 1493m – Obcina Feredeu 1429 m Ridge), a series of residual peaks – and small terraces can be interpreted as results of the process of cryoplanation (Fig. 3, Photo 10). In the profile curvature of the slope one can identify two steps marked by two residual heights delimited by 3-4 metre scarps at the bottom of which occur grass-covered gelifracts.

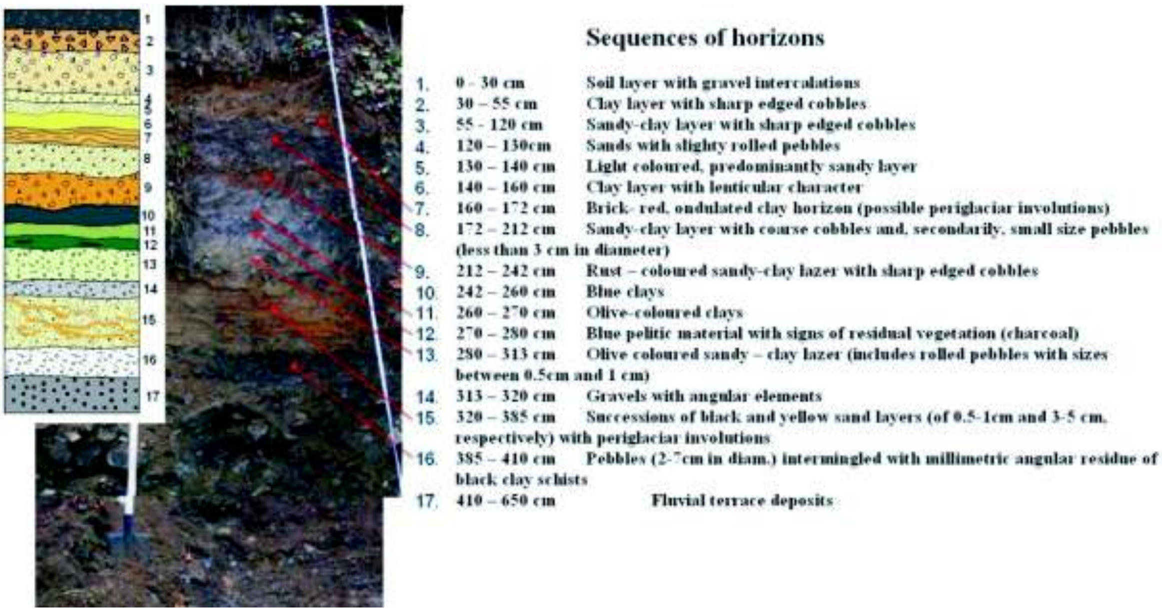

Photo 7. **Display and petrographic characteristics of the periglacial structure**

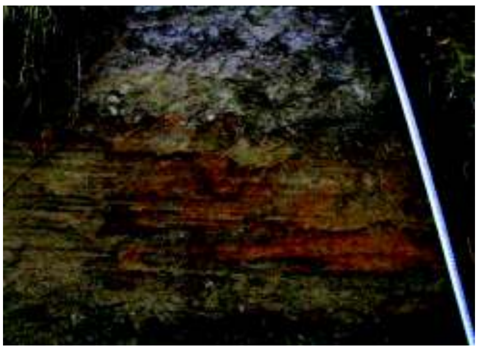


Photo 8, 9 **Cryoturbations and lenticular structures**

Their altitude is about 1343m and 1349 m respectively. From a structural point of view, the peaks are made of silicate sandstones and look like small cuestas, the scarp retraction occurring at the end of the rock bed. The length of the horizontal surfaces varies between 30 - 40 metres at the lower step and 80-100 m at the upper one. The height of the escarpments is of about 10-20 meters and it decreases towards the extremities.

Eolisation is a periglacial process during which the wind, charged with ice crystals, polishes rocks and isolated cliffs, creating erosion microforms named deflation hollows or eologlyptolites (term used by Ichim, 1972). Such microforms were identified on the western sides of some gelifraction affected residual peaks, situated at about 1300 m altitude.

Our identified deflation hollows are 20-25 cm in diameter and 4-8 cm deep (Photo 11, 12, 13), some of them being slightly asymmetrical possibly as a result of turbionary air movement. Asymmetry might also be explained by the different gradients of the surfaces subjected to wind erosion.

Their place of formation may be most likely the expression of the dominant winds during periglacial moulding and this confirms the general opinion according to which winds had mainly a westward movement.

Conclusions

Placed during the Quaternary glaciations in the periglacial morphogenetic domain, the Obcinele Bucovinei Mountains preserve various forms of this morphology. The specificity of spatial distribution of periglacial processes is determined by structural and lithologic characteristics of the flysch deposits. The dominant processes such as gelifraction and solifluctions are distributed according to the rock characteristics. Gelifraction and its correspondent landforms such as debris covered slopes, residual ridges and peaks, terraces of altiplanation, occur mainly on sandstones, limestones and conglomerates. Solifluidal processes affected mostly areas with marls and clays, morphologically resulting in periglacial deposits. Nivation, eolisation and gelifluviation played a secondary part but the presence of their corresponding landforms confirms the diversity of the periglacial morphology in these mountains. We hereby consider that the Brodina River's hydrographic basin offers suggestive and conclusive examples.

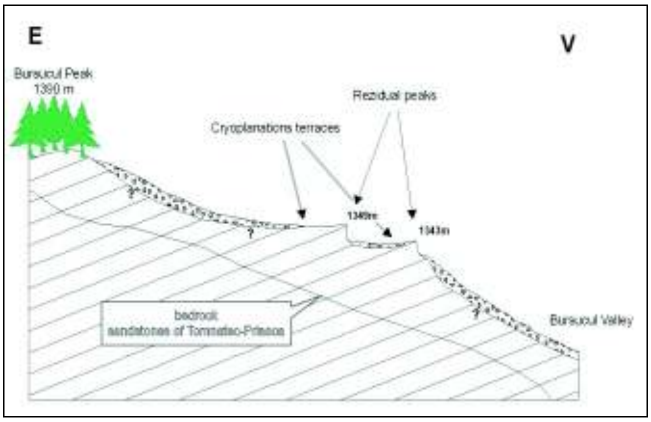

Fig. 3, Photo 10 **Cryoplanation terraces**



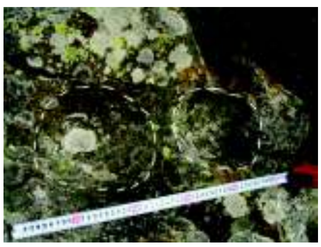

Foto 11,12,13 **Eologlyptolite**

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