Geogr. Fis. Dinam. Quat.
32 (2009), 57-66, 8 figg.

ADRIAN CIOACĂ (*) & MIHAELA DINU (**)

RECENT EVOLUTION OF THE GEOMORPHIC PROCESS IN THE MOUNTAIN SPACE IN BRAŞOV COUNTY (Central Romania) (***)

ABSTRACT: CIOACĂ A. & DINU M., *Recent evolution of the Geomorphic process in the Mountain space in Braşov County (Central Romania).* (IT ISSN 0391-9838, 2009).

The relief of Braşov County includes two basin units, drained by the river Olt and its tributaries. One is bordered by piedmonts (Bârsa Country and Făgăraş Country), being a wide hilly habitat (the southeastern part of the Transylvania Plateau) and the other is a mountain area with a great morphogenetic and altitudinal diversity (Făgăraş, Piatra Craiului, Bucegi, Bârsei, Ciucaş, Întorsurii, Perşani and Baraolt Mountains). The main ecosystems of Braşov county are well balanced, corresponding to the relief steps: mountain (over 700 m represent 40% of the county surface), hills and basins (around 400 and 700 m, extending on around 60% of the county surface). Territorial units of the county overlap on two morphostructural units: the Carpathians mountains and the Transylvanian Depression.

This disposal favors specific ecosystems diversification: The mountain area of the county belongs to the two mountain building structures: crystalline - Mesozoic unit belonging to the Oriental and Southern Carpathians and the Cretaceous flysch unit of the Curvature Carpathians. Their characteristics define the environment conditions, differentiated in their turn according to the petrographic formation, detailed relief, bio-climate range.

Based on a sequential series of observations undertaken by the authors during the last 40 years, there has been discovered a series of changes, both in the rhythmical nature and amplitude of the geomorphic processes as well as in their typology. In the alpine and sub-alpine floor of the Făgăraş, Bucegi and Piatra Craiului Mountains there has been observed an intensification of the debris flow rhythmicity, on the avalanche lanes, as well as an increase in the quantity of materials transferred by the low basins floods. As an exemplification, there have been offered several case studies made in the Făgăraş Mountains (Sâmbăta glacial cirque). On the low and medium mountains level of the Braşov county (Întorsurii, Perşani, Baraolt Mountains), in addition to the debris flow processes, there have also many gravitational processes have also occurred, affecting the forests (Perşani, Vârghiş, Găunoasa and Vulcăniţa basins), analyzed by the authors during the years 1968, 1977, 2003, and 2005. The studies of the geomorphological processes are accompanied by in analyses of the environmental factors that favored their evolution.

KEY WORDS: Geomorphological processes, Mountain relief, Braşov County, Romania.

(*) *«Spiru Haret» University, Faculty of Geography, Bucarest.*
(**) *Romanian American University, Faculty of Economy of Domestic and International Tourism, Bucarest.*
(***) *12th Belgium-France-Italy-Romania Geomorphological Meeting - IAG «Climatic change and related landscapes» (Savona, 26-29 September 2007).*

INTRODUCTION

For over half a century, increasingly severe climate phenomena, and particularly their impact on other environmental factors, in our case on the relief, has encouraged research on current geomorphic process. Thus we could speak of both a methodological and space revival for these investigations, resulting in a diversification of concepts regarding current morphodynamics. Moreover, following optimization of the use of the territory several issues have been brought to the attention of geomorphologists, as a side effect of enhanced and repeatable geomorphic processes over the same area or even their expansion. Focusing studies on catastrophic geomorphic risks has only been a step away that most of us have no hesitated to take. Taking into account the fact that their increasingly aggressive media coverage hasn't always complied with scientific facts. Geomorphologists have a duty to develop this research and to become socially involved.

The issue of climate change, a concept that tends to replace that of cyclic (periodic and non-periodic) climate oscillations, has had a significant echo both in the scientific world and in political, economic and cultural circles, as well as decision-makers in our country and all over the world.

The present study (inside the CEEX/22/2006 Romanian Project) provides a scientific support for the management of natural and human resources in rural communities in the mountain area of Braşov County (fig. 1). In order to assess the status of environmental factors and the limits of areas affected by various geomorphic risks, researches into current morphodynamics, primarily geomorphic processes, has relied on our expertise during the past 4 decades into other Romanian Carpathian and Subcarpathian areas (Dinu & Cioacă, 1997). This has allowed us o assess not only geomorphic risks in the area but also their impact on land use (Cioacă & Dinu, 2003). Thus we answer the call of *The International Association of Geomorphologists* (Zaragoza,

2005) stating that: Geomorphologists should contribute to decision-making, at all levels, to prevent and mitigate geomorphic hazards and encourage decision-makers to place higher priority on prevention and mitigation of risks associated with natural hazards.

RESEARCH METHODS

The action of climate factors on the relief occurs on the entire planet surface but especially there where basic geomorphic areas lack the protective or mitigating vegetation layer (Waugh, D., 1990; Humlum, 1998). It is called for in the mountains through geologic structure exploitation by climate factors, respectively differential erosion. If the part played by geological factors, respectively rock and structure behavior in various environments, is already known, our research has focused on the parallel assessment of topo-climate parameters and their relation to the amount of materials dislodged and set into motion on the slopes.

Temperature and rainfalls are essential because they have a decisive influence on erosion, and geomorphic process differentiation takes place function of their layering in the mountain area. The first attempt at quantifying has consequently been an East-West topo-climate profile in the Făgăraş mountains, which relied on stationary measurements carried out at mountain lodges in Sâmbăta, Podragu, Bâlea, Negoiu, Suru, a series of observations covering more than 15 years. Subsequently, these data have been recalculated by means of the statistical series method function of the measurements carried out at weather stations comprising a long line of observations (Sibiu and Omul Peak in Bucegi). Along this series of data, we've also called on chronicled empirical observations in order to complete information on extreme weather phenomena throughout the past 200 years (Binder, 1998).

Along with field survey observations and expeditively mapping, in our study we have relied on a comparative interpretation of topographic maps at a scale of 1:200 000 edited in 1968 and 1:50 000 edited in 1987/1989, as well as on aerial photographs taken in 1990 for the areas in Perşani Mountains. The method of correlative deposits has been employed solely in the analyses of the current morphodynamics in Postăvaru and Perşani Mountains.

For the morpho-structural analysis we used geological maps at a scale of 1:200 000 (the Braşov map sheet 1968, coord. Dessila-Codarcea, Dimitrescu, Patrulius) and at a scale of 1:50.000 (Făgăraş, Hoghiz, map sheets 1987, coord., Dimitrescu, Patrulius, Popescu; Codlea and Zărneşti map sheets 1989, coord. Patrulius, Dumitrescu, Gherasi) so that field assessment for case studies have been constantly reported to previous mappings that have noted down the main formations and structural lines. Detailing has nonetheless been the outcome of personal observations: slopes matching rifts outlined by tectonic movements; sloped modeled through differential erosion between the two sides of rifts made up of different formations; asymmetrical valleys established on axes of asymmetrical synclinals or per lines or fits separating compartments of different height.

We finally estimated the magnitude of large scale vertical movement of the ground surface during the Pleistocene. For their intensity, we resorted to the map of recent crustal vertical movements in Romania, scale 1:1000000 (Cornea & *alii*, 1977).

THE ROMANIAN CARPATHIAN AREA

The Carpathians represent the second largest mountain chain in Europe, located in the central part of the continent and covering a narrow, but extremely arched area going from the Vienna Basin (Bratislava, Slovakia) and the Timok Valley (Niš, Serbia).

This orographic axis is more than 1,600 km long and it covers a 170,000 km^2 area. Out of this, 910 km, respectively 66, 303 km^2 are situated on the Romanian territory (27.8% of the country surface). This is where the Carpathians reach the peak of their arch and where, due to the sinking of the median area of their fundament (Transylvania Depression), the Carpathian arch (the Oriental and the Meridional Carpathian) is separated and underlain by a circle section (the Occidental Carpathians). Practically, the general image of the Romanian Carpathians is that of a quasi- ellipsoidal ring made up of the long arch and of the underlying arch section.

That is why, ever since the Roman Antiquity the Romanian Carpathians bear the name of «Corona Montium», which encloses, just as the walls of a circular castle, another sunk-in Carpathian section, the Transylvania Depression. In fact the central location of the Romanian Carpathians has also determined the radius-concentric arrangement of the other relief levels (units), both within and outside the Carpathian circle, which it dominates. By extrapolating the «castle» image of the Romanian Carpathians, the Transylvania Depression appears as an *intramural* area, whereas the *extramural* area seems to be made up of the buttresses which support on the outer side the castle fortifications (the Subcarpathian and Peri-Carpathic hills) the «foundations» of which are laid into the surrounding marginal plains.

The Carpathian chain, as a geologic unit, formed together with the Alps, the Balkans, the Caucasus, and the Himalaya, through the closure of the ocean basin (the Thetis Sea), during the Late Cretaceous (Alpine orogenesis). The Romanian Carpathians, located at the crossroads of three large tectonic plates, the East-European, the Central-European and the Moesian, have the most complex tectonic structure. This is also underlined by the fact that at the borders of these plates there appeared three depression areas as well: the Sarmatian (East), the Getic (South) and the Pannonic (West), which also counted as the base level, setting the rhythm and intensity of fluvial erosion.

From the point of view of their geologic structure, the individualization of the mountains occurred in the orogenetic stages during the Neozoic and the Quaternary, when the old crystalline rocks (Pre-Hercynian and Hercynian), covered in Mesozoic deposits (Alpine), reached their current heights. Through this complicated process consisting of mountain uplift and the development of a series of depression areas (inside and between the Carpathians), with each main rising stage followed by intense erosion processes, the Carpathian area was leveled cyclically. The evolution of the climate left its traces through the planation that occurred during the Palaeogene, through the leveling that took place in the Neogene and through the glacial or peri-glacial modeling, simultaneous with intense fluvial erosion, in the Quaternary (fig. 1).

This brief characterization of the Romanian Carpathian area would not be complete without pointing out that aside from playing a role in the architecture of the Romanian territory, the Carpathians were also «an integral part of the core around which the Romanian people formed». This area, a true «Dacian nucleus», provided shelter and a variety of conditions that favored agricultural and cattle raising activities, which allowed the appearance and the development of permanent human settlements. That is why the resources that the Carpathians so generously offered have defined their functional physiognomy, consisting of a unitary and varied landscape. Located in depressions and in valleys, or on leveled peaks, these settlements were the target of the Roman operations during the conquest of Dacia. Later on, as the Carpathians were almost equally distributed among the three historical provinces (Moldavia, Walachia and Transylvania), the mountain area represented a point of convergence of all of the Romanian territories from a social and an economic point of view.

THE BRAŞOV COUNTY

Through its central position in Romania (fig. 1), Braşov County supersedes the maximum curvature area of the Carpathians. The mountain area of the county belongs to the two mountain building structures: a crystalline - Mesozoic unit belonging to the Oriental and Southern Carpathians and the Cretaceous flysch unit of the Curvature Carpathians. At the same time, Braşov county also includes the greatest part of two depression units, Ţara Bârsei and Ţara Făgăraşului (or Ţara Oltului), both drained by the river Olt and its tributaries. Their alluvial plains are bordered by terraced piedmonts and piedmont hills, intensely populated, that provide the passage either towards the south-eastern part of the Transylvania Plateau, or to the actual mountain are. It is a mountain area displaying great morphogenetic and height diversity (Făgăraş, Piatra Craiului, Bucegi, Bârsei, Ciucaş, Întorsurii, Perşani and Baraolt Mountains).

Mountain geosystems. In Braşov County, in relation to the mountain relief height and fragmentation and taking into account the climate parameters, there are specific geosystems for high mountains, as well as for small and medium-high mountains. Naturally the concepts of «high» and «small and medium high» are related to the height distribution of Romanian relief, and the typology and intensity of recent and current geomorphic processes varies function of these geosystems. Based on sequential series of observations undertaken by the authors during the last 40 years, there has been discovered a series of changes, both in the rhythmical nature and amplitude of the geomorphic processes as well as in their typology. In the alpine and sub-

FIG. 1 - Pleistocene cryostructure layout on Romanian territory (after Coteţ, with modifications): 1, Congelifractions; 2, periglaciar splits and drifts; 3, splitting polygons; 4, periglaciar involutions and folds; 5, stone circles; 6, mixed cryostructures; 7, unpublished data; 8, loess plains; 9, relief units: a, plains; b, hills and plateaus; c, mountains; 10, heigh mountains; 11, inter-mountain depressions; 12, research area.

alpine floor of the Făgăraş, Bucegi and Piatra Craiului Mountains there has been observed an intensification of the debris flow rhythmicity, on the avalanche lanes, as well as an increase in the quantity of materials absorbed by the low basins floods. On the low and medium mountains level of the Braşov county (Întorsurii, Perşani, Baraolt Mountains), besides the debris flow processes, there have also appeared ample gravitational processes, affecting the county forests.

The small and medium-height mountain geosystems are made up of the shorter ends of the Eastern Carpathians and the actual Curvature area (Cioacă, 1978). Taking into account the presence of the great inter-mountain Braşov depression, there are landscape differentiations that take into account the fact that the Curvature Mountains are a climate barrier between ocean and continental influences. In the first case, the Inner Curvature Mountains are outlined: Perşani Mountains and the south of Baraolt Mountains (under 1,200 m, average annual temperatures of 4-6ºC, rainfalls of 700-900 mm/year), lacking in natural sub-alpine meadows but also with birch and fir-tree woods. In the second case, continental and layering influences imposed by average heights are obvious: Outer Curvature Mountains, respectively Timiş Mountains (Piatra Mare, Postăvarul), the Întorsurii Mountains and Ciucaş Mountains (the northern slope), have a layered landscape with a cooler climate (an average annual temperature of 2-4 ºC, rainfalls of 800-1,000 mm/year), sub-alpine meadows, spruce or mixed woods. Both mountain lines suffer, on the inside, from the influence of temperature reversals in Braşov Depression.

The high mountain geosystem in Braşov County comprises the eastern part of the Southern Carpathians. These are either crystalline massifs covered by Jurassic calcareous formations and Cretaceous conglomerates (Bucegi, Piatra Craiului) or made up of crystalline only (Făgăraş). Yet, all are heavily raised and designated by sheer drops per tectonic movements, heaving of over 1,000 m. Peak heights often exceed 2,000 m, so that the relief bears strong traces of its Quaternary evolution (traces of extensive glacial and periglaciar shaping). Nowadays, the temperature regime records negative annual averages at over 2,000 m: –2ºC, and under 2000 m and up to 1,500 m, between 0 and 2-3ºC. Average annual rainfalls, although lower than those in the western part of the Southern Carpathians at the same heights, exceed 1,000-1,200 mm/year.

The following are part of the high mountain geosystem in Braşov County:

– the Bucegi Mountains (the orographic knot at Omu Peak, 2,505 m and the calcareous and conglomerate cuestas of the suspended synclinal displaying cut-throughs of valley origins with glacial traces Ţigăneşti, Mălăieşti and Gaura);
– The Piatra Craiului massif (its taller northern half), representing a repositioned, asymmetrical synclinal slope: a large cuesta to the west (calcareous drops, detritus) and an opposing slope, with smaller slopes fragments by snow torrent tracks among which meadows and wood clusters are featured;
– The Făgărăşului Mountains (the eastern part of their peak, with an east-westward orientation, whose northern slope lies in Braşov County). Their original glacial morphology emerges with complex glacial cirques and valleys, secondary glacial trougs, micro-cirques, a detailed relief referred to as rocky cauldrons (e.g. Arpaşului, Doamnei river valley or Sâmbetei). The latter has been the focus of our repeated research. Extending the main peak, a lower massif (Mount Ţagla 1,641 m), thickly forested, providing a passage towards Perşani Mountains.

We cannot assess the climate particulars of these mountains without referring to the two depression areas, since vertical rainfall and temperature distribution and especially the frequent temperature reversals condition the modeling systems of surrounding mountains. It is enough to mention two climate studies approaching either the mountain area in the country (Stoenescu, 1951) or the most representative depression (Mihai-Niculescu, 1975), in order to have a clear overview of the causes triggering extreme weather phenomena. Moreover, extending the array of data recorded by weather stations and used by these authors, they are confirmed nowadays as well, as recorded in recent study (Cioacă & Niculescu, 1995) on assessing geomorphic processes in Perşani Mountains.

The mountain framework around Braşov Depression, through its geosystem factors, influences both the diversity of active surfaces entailing depression weather phenomena, and the evolution of the hydrographic network, the layered and structural distribution of vegetation. We stress on these points since they are accountable for the diversity of current geomorphic phenomena and for their intense, temporal and territorial evolution. As underlined on several occasions by the above-mentioned, massifs are in fact huge generators of cold air masses descending into the depression. Under these circumstances, the relief configuration is prevalent as compared to the classical weather layering, since altitude channels have always favored intense ventilation as compared with the weather stillness in the depression itself.

Another issue we have taken into account in analyzing extreme cases of exceptional rainfall was their occurrence particularly in small hydrographic basins. Even if for their most part, these basins develop on forested slopes, there are differences in their origin as to the protective role of the vegetation layer. Function of the altitude of massifs and origins, they can lack vegetation (Făgăraş, Piatra Craiului or Bucegi), can be covered by alpine meadows (Ciucaş, Piatra Mare, Postăvarul), by fir tree forests (Întorsurii, Ţagla) or deciduous trees (Perşani, Baraolt).

RECENT GEOMORPHIC PROCESSES

Due to the diverse mountain geosystems in Braşov county, we have selected several specific cases whose morphodynamics evolution has been monitored for several years. Among the most recent cases we have studied: the debris flow at Sâmbăta cirque (year 1968), the floods at Măieruş, Apaţa, Augustin and Hoghiz (year 1975), at Dumbrăviţa (year 2000), the mud flows at Crizbav (year 1970), Veneţia and Comana (year 1975), the flows associated to landslides at Poiana Mărului (year 1997), Jimbor (year 1978), Lueta (year 1981) and Vulcan (year 2002), (Personal, unpublished observations).

Case studies in Perşani Mountains

Because these small mountains are almost completely covered in deciduous forests, all human settlements lie at their outer side, both towards Olt Country and towards Bârsei Country. We would have expected that fast geomorphic processes triggered within the mountains would not affect the human communities due precisely to their positioning. Reality has proved we were wrong: because torrent-generated shapes undertook a fast evolution and have reached considerable size, the effects of inner local processes has soon spread to the outside, affecting outer communities. Here follows a few cases characteristic for smaller, completely woodland mountains.

The hydrometeorological phenomenon on May 20th-21st 1998

In the southern area of Perşani Mountains, the petrographic homogeneity of crystalline schist, where a dense network of narrow valleys became dominant, has called for a relief displaying rounder or smooth peaks, connected to the erosion surface of 950-1000 m (Cioacă, 2002). The small hydrographic basins are collected by the Şinca valley, a river Olt tributary in the depression bearing the same name. Although these mountains have been initially completely covered by forests, the population in neighboring depressions has found shelter here against successive migrating hordes, as well as the precarious social and economic conditions during early and medium Middle Ages. Avoiding valleys that were quite traveled through at those times, the population sought isolation climbing up the inter-river areas. In order to provide for themselves under these new circumstances, the upper level forests were cleared to make room for crops and grazing grounds. Although during the past century the population in Poiana Mărului village climbed down into the valley into a compact hearth, several hundred isolated households (fig. 2) are still hidden away on the forested slopes.

We have presented these antropogenetic landscape changes in order to outline the fact that in the Southern Perşani Mountains hydrographic basins have deforested origins, and thus flow, ravine and quick torrent phenomena are widely spread. Under these circumstances, torrent flows fuel a vast network of ravines crisscrossing the inter-river areas, and thus large amounts of drift is transported downhill to Şinca and onwards to the river Olt (Cioacă & *alii*, 1993).

A «spectacular» case occurred here on May 20th-21st 1998 (a year with no excessive rainfalls). Heavy rainfalls occurred for 36 hours in such amounts as to justify their labeling as extreme weather phenomena. The largest multi-annual average monthly rainfalls recorded here in July amount to 80.7 mm, whereas in this short period of time

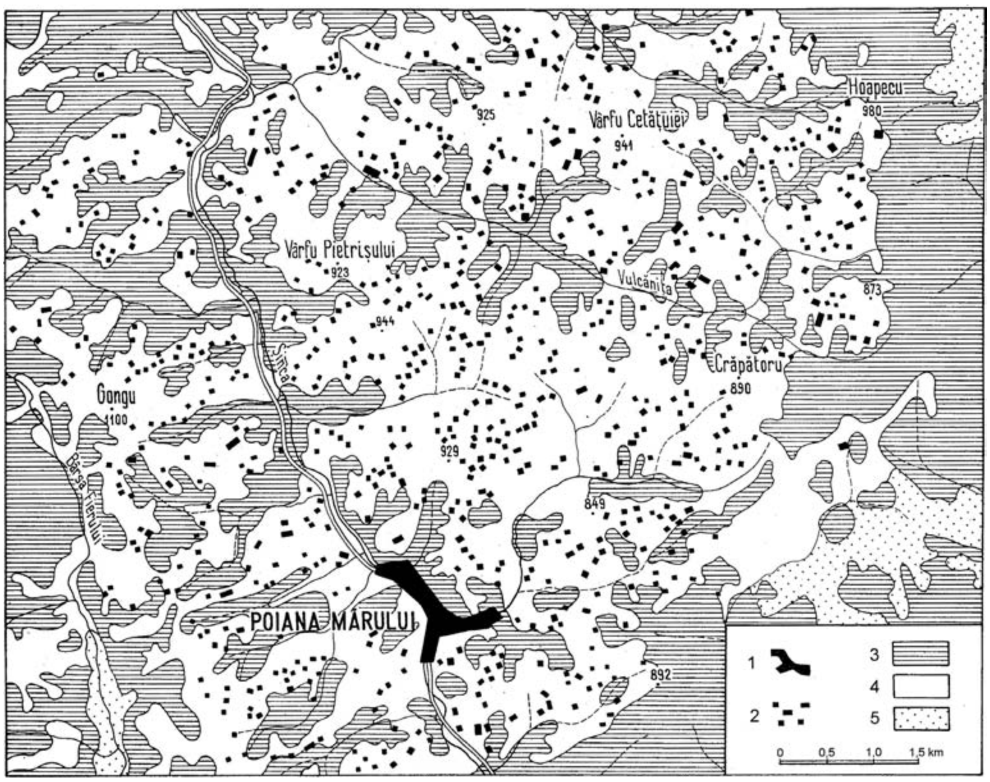

FIG. 2 - The households of Poiana Mărului, spread-out on the slopes of the Southern Perşani Mountains: 1, The recently established hearth on the Şinca valley: 2, isolated households spread out on deforested slopes; 3, forests covering the slopes and surrounding the massif; 4, secondary meadows and crop plots on the peaks; 5, intensive crop lands in the depressions.

(May, 1998) the rainfalls represented more than double of this average, respectively 177.9 mm. From the information obtained during interviews with villagers from Holbav, Paltin and Poiana Mărului, we have outlined an area of exceptional rainfalls superseding several small hydrographic basins (Feriga, Strâmbaru, Găunoasa and Vulcăniţa) making up the Holbav basin, a tributary in Şinca valley. As compared to previous measurements carried out in 1986 on the length of all torrent formations in the small Vulcăniţa basin (32.550 m), in 1998, based on aerial photography completed by field mapping, we have outlined an increase of almost 8.000 m, reaching an overall value of 40.180 m. The damage suffered by lands due to slope and basin processes brought on by the rainfalls in this basin in May 1998 alone has been assessed to over 1.800 m^3, representing the calculated amount of broken banks, crashes in reception basins and transport along talwegs.

The flood on August 17th 2002, formed once again in the south of Perşani Mountains yet this time on the slope facing Braşov Depression, in the small Helbuş basin, was accompanied by quick mudslides affecting 37 households in Colonia 1 Mai, part of Vulcan, lying in the depression plain on the left bank of Vulcăniţa (from Bârsa).

In this hydrographic basin, the slide amounted to 0.5 liters, very large if we are to take into account the fact that over 80% of the basin area lies on the slope and is fully covered by forests. As opposed to the previous case, the protective part played by the forest was obvious.

The significant value needs to be explained by the exceptional rainfall density: over 100 l/m^2 in just 22 hours (fig. 3). This adds to the fact that, although the rains occurred in August, the thick drift layer accumulated in the upper and middle areas of the basin did not allow infiltration, and rainfalls almost totally ran downhill towards the village. Here, water torrents were channeled on the lands belonging to households on the forest eaves, which had just been cleared of the early vegetable crops. Associated to access roads to the crop plots, they have carried through the superficial soil layer and have turned into mudslides affecting the village. Ravines are almost entirely absent and the only sections of the forested slope where they could settle down were the clearings, where the drift layer is thin and easily removable.

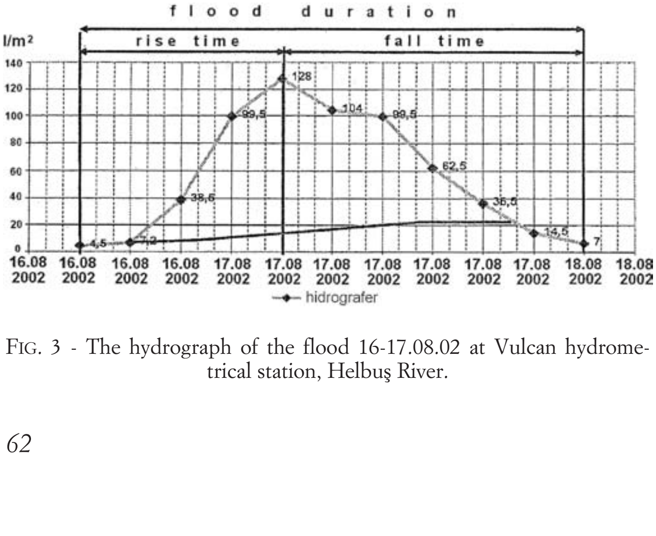

FIG. 3 - The hydrograph of the flood 16-17.08.02 at Vulcan hydrometrical station, Helbuş River.

Unfortunately, this last example is not singular, since settlements on the outer areas of Perşani Mountains have been often affected by quick geomorphic phenomena triggered inside the mountains. Among the most recent cases we've studied: the floods at Măieruş, Apaţa, Augustin and Hoghiz (year 1975), at Dumbrăviţa (year 2000), the mud flows at Crizbav (year 1970), Veneţia and Comana (year 1975), the flows associated to landslides at Poiana Mărului (1997), Jimbor (year 1978) and Lueta (year 1981).

Case studies in Făgăraş Mountains

The hydro-weather phenomena in the northern Făgăraş Mountains are tightly related to the orographic rainfall pattern imposed on and by the type of Southern Carpathian hydro-pattern. Here river flows are correlated to heavy rainfalls as well as to snow melting. The highest values are recorded in July-August, and exceptional rainfalls complete thus sub-type of lower alpine hydro-pattern at over 1,600 m high (floods have a 30-40% occurrence in August). It is worth remembering that due to the higher altitude of Făgăraş Mountains, super-imposing heavy rainfalls over a very reach snow-originating feed also carries on drift deposits in the reception basin of these rivers. Thus, although this area displays the lowest river turbidity values in the country (on the Făgăraş northern line made up of crystalline, erosion-proof rocks, the average value of turbidity is under 100g/m^3), when it comes to floods originating in heavy rainfalls occurring on the alpine and sub-alpine river origins, exceptional increases in drift flow are often recorded.

The correlation between water flows and the alluvial flows transported along large rivers, in our case (Zăvoianu & *alii*, 1983 in vol. Geografia României, p. 335) the river Olt (fig. 4), is expressed through the equation: $\log R = 1.25 \cdot \log Q$

This indicates an increased variation gradient for alluvial flows in suspension with water flows at the passage area from the mountains to the hill or depression areas. In the case of small hydrographic basins, such as those making up

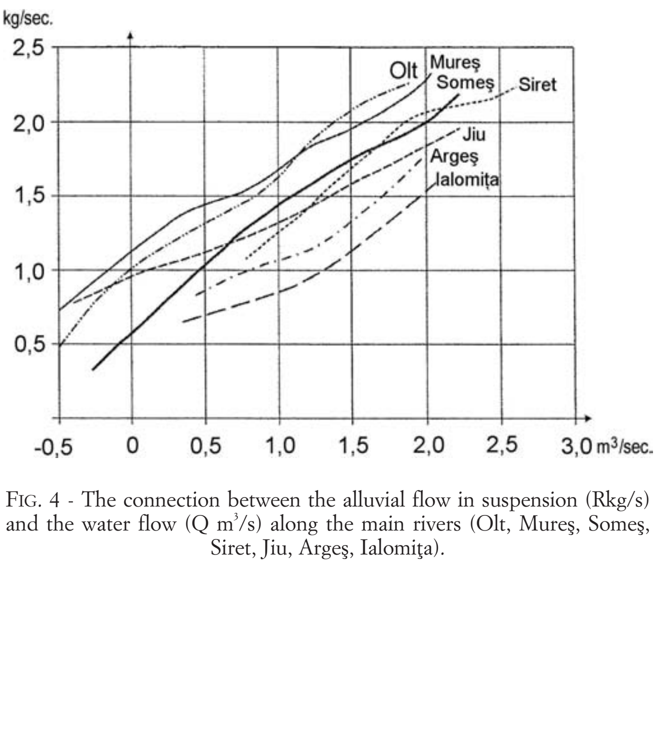

FIG. 4 - The connection between the alluvial flow in suspension (Rkg/s) and the water flow (Q m^3/s) along the main rivers (Olt, Mureş, Someş, Siret, Jiu, Argeş, Ialomiţa).

the subject of our cases studies, there is a tight correlation between water flows and suspended alluvial flows, especially since lithologic conditions are homogeneous here, whereas the physical-geographical conditions are differentiated and established by altitude differentiation

The debris flow on August 20th-21st 1968

The sector where the debris flow was triggered lies in the central and eastern part of Făgăraş, the Sâmbăta river basin being representative in this case (Cioacă, 1970). It starts from altitudes of over 1,900 m, where the glacial cirque lies, which is drained down to 460 m till its confluence with river Olt. In the upper area, the basin lies on crystalline rocks (fig. 5): paragnaise and mica-schist with biotite and granite, then the series of crystalline chlorite-sericitous schists, interrupted in some places by crystalline calcareous and gnaise lenses. We have stressed on this detailed structure in order to underline the fact that rocks have a homogeneous behaviour to erosion, that

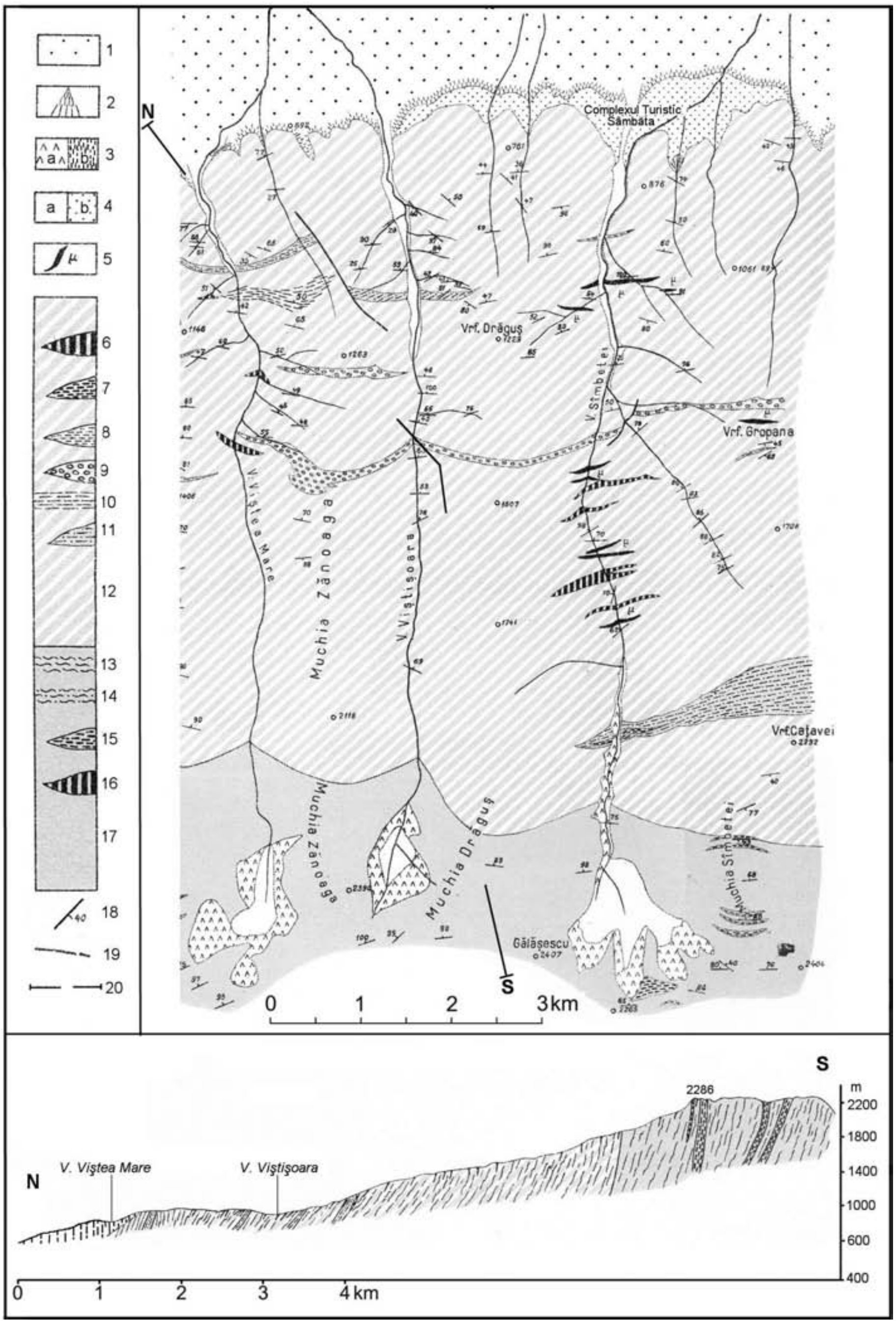

FIG. 5 - The geological sketch of the eastern side of the Făgăraş Mountains –Sâmbata valley: 1, Alluvial deposits; 2, alluvial fans; 3, active detritus (a) and piedmont drifts (b); 4, glacial deposits (a) and terrace pebbles (b); 5, diabases; 6, crystalline calcareous rocks; 7, amphibolites and amphibolite schists; 8, porphiroides, psamitic gnaise; 9, lenticular gnaise; 10, sericitous-chlorite schists; 11, chlorite mica-schists; 12, micro blast, chlorite and biotite mica-schists; 13, chlorite paragnaise; 14, granate paragnaise; 15, amphibolite gnaise; 16, tectonic crystalline calcareous rocks; 17, micaceous paragnaise; 18, crystalline schist declivity; 19, rift lines; 20, profile orientation (Dimitrescu, 1974).

morphic resistance is the same all throughout the valley longitudinal profile to the contact with the piedmont glacies.

From a morphological point of view, the Sâmbata valley is flanked by two ridges from the main Făgăraş peaks (Muchea Drăguşului and Muchea Sâmbetei), and its origin supersedes the complex glacial cirques under the karling type peaks: Gălăşescu 2,471 m and Urlea 2,475 m. Between them, the two saddle (Fereastra Mare and Fereastra Mică of Sâmbata), evoke the sliding ice mass over the main peaks. Nowadays, following gelifraction occurring extensively more than 9 months a year, crystalline rocks are intensely fragmented, and the resulting drift is directed along a series of torrent bodies and avalanche trails. They crisscross the walls of the glacial cirque, and debris cones are extended along the slopes. On the other hand, thick detritus layers, partly fixed by vegetation, cover the floor of the cirque, where the slope is significantly reduced due to successive drift deposits.. The original material in-between detritus layers has even allowed for the fir tree forest to settle in, whose upper limit reaches over 1,980 m (fig. 6). This is why mobile detritus accumulations are shaped either as «rivers of rocks» on the slopes or as «seas of rocks» or mounds under the slope. The exceptional mobility of these debris flows is well known, and such areas in the southern part of the Sâmbata cirque, where there is a high hazard of triggering accelerated slides, are usually avoided by tourist trails and farming-grazing activity in the summer.

The debris flow that has made the object of this case study occurred much lower, under the glacial threshold towards the glacial valley, on its left slope. The Sâmbăta lodge, located at the forest eaves on a fixed detritus mound was the one mostly affected. Disintegration phenomena are frequent on the ridges and slopes around the glacial cirque. In our case, the uncovered slope under Muchea Drăguşului, where snow-settling niches abound, continuing with small gullies and avalanche trails and ending in detritus cones, suggest the possibility of repeated detritus movements.

Several snow niches lying at over 2,100 m provide the conditions for stones and broken rocks from under the ridge to be temporarily stored, right above the forest and

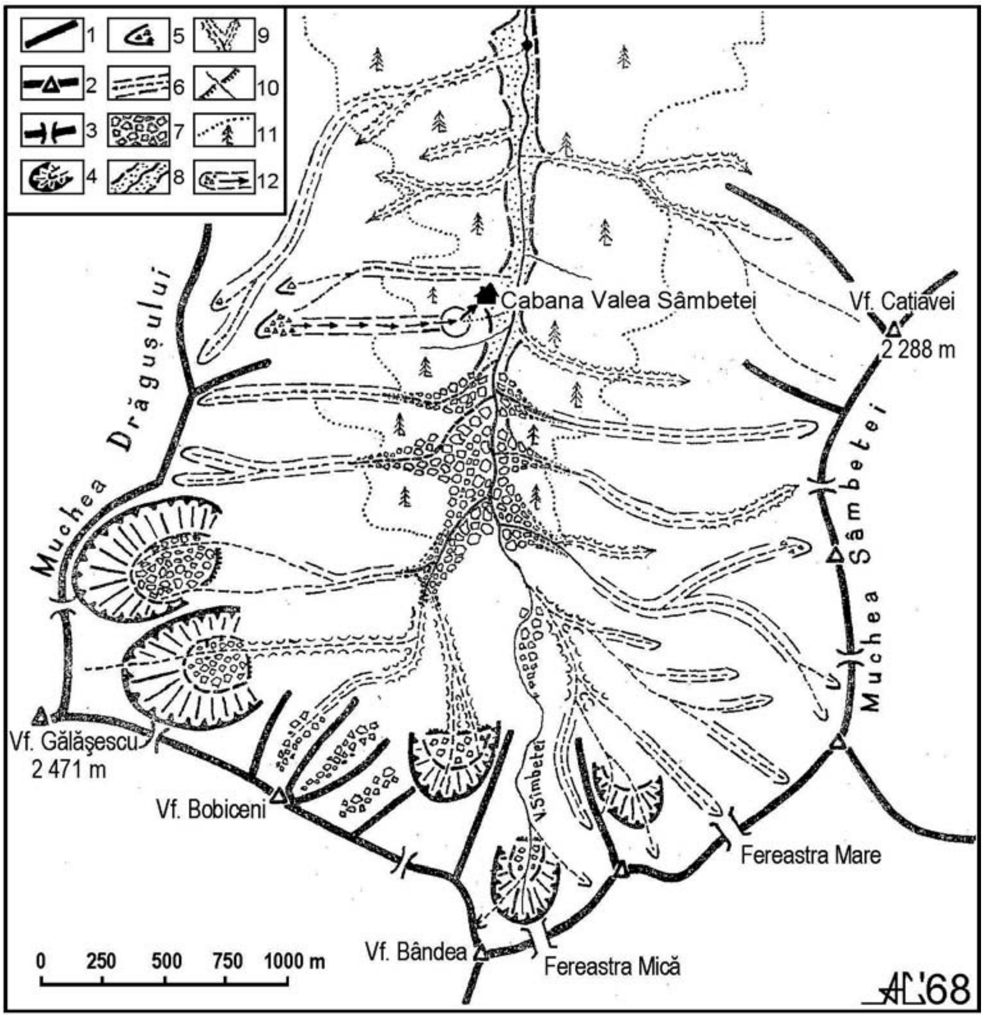

FIG. 6 - Geomorphological sketch of Făgăraş Mountains. The area where the detritus slide was triggered in the night of August 20/21 1968: 1, sharp ridges; 2, pyramid peaks; 3, saddles; 4, glacial cirques; 5, micro-cirques (stony cauldrons); 6, avalanche trails; 7, active detritus; 8, fixed detritus mounds; 9, nivo-fluvial torrents; 10, glacial thresholds; 11, the upper limit of fir tree forests; 12, origin and trail of the case study.

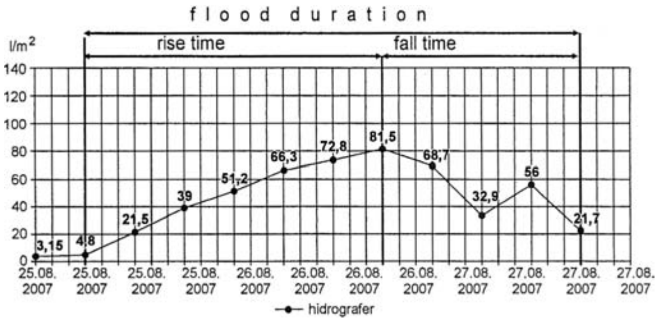

FIG. 7 - The hydrograph of the flood 26-27.08.07 at Sâmbăta hydrometrical station, Sâmbăta River.

the lodge. If no catastrophe has so far occurred it is due to the fact that those avalanche trails and torrent gullies provided their natural evacuation, towards the detritus mound. Present at the massif feet at that time, we could immediately investigate the causes of this catastrophic phenomenon and assess the scope of the geomorphic process.

The rainfalls on the eastern sector of the Făgăraş ridge started on August 19th but reached considerable amounts on the night of August 20th-21st, when daytime rainfalls exceeded absolute maximum values. Based on the documentation we have subsequently analyzed for, we have drawn up the graphic for daytime rainfall evolution. Thus the Urlea station nearby (1,519 m), under similar conditions to those where Valea Sâmbetei lodge lies (1,480 m), recorded 73.0 mm on August 21st, exceeding the absolute daytime maximum value (70.2 mm/August 18th 1951).

At the origin of the avalanche trail, made up of waterproof rocks ad lacking any vegetation that would mitigate the fast slide, these rainfalls led to the lubrication of the clay-sand bed that rocks from the slope were lying on. Under these circumstances, almost the entire rain water filled the snow micro-depression where the debris flow (the stone river) was triggered. The critical time occurred at 02h10' when the detritus layers started moving, bringing on, in their turn, those along the 1.2 km avalanche trail where the fast slide took place. This would not have been catastrophic if the mobile detritus cone filling the ejection exit of the trail at the contact with the detritus mound, hadn't forced the flow towards the lodge. The whole camping site where tents were set up around the lodge was covered by the detritus mass lying 1.5-2.5 m thick over a 1,450 m^2 area and it stopped against the lodge's southern wall. Although it didn't cause any casualties and only limited material damage, the debris flow focused the attention of local and county administration. During the following decade, the entire tourist infrastructure in Făgăraş was resized based on a protection measures program implemented in order to prevent such phenomena.

The hydrometeorological phenomenon on August 26th-27th 2007

Almost 40 years after the previous case study under analysis, and again in the Sâmbata basin, another hydro-weather phenomenon occurred but this time the calamity effected the feet of the massif, in the Sâmbăta de Sus Tourist Complex. Thanks to the updated, improved weather prediction and monitoring system in place, an orange code warning for rainfalls in the Southern Carpathians was issued on August 24th. Thus between August 26th 00.00 hrs and August 27th 00.00 hrs, in the mountain area of Braşov county heavy rainfalls were predicted, with the daytime rainfall amounts exceeding 50 l/m^2 locally and between 70 and 80 l/m^2 in some singular cases. Such values had been previously recorded during the first case, at the rainfall-meter stations of Urlea (71.8 l/m^2) and Podragu (87.3 l/m^2).

This time, the debris flow river triggered at the basis origin in the Sâmbăta glacial cirque crossed the entire forested slope, carrying tree trunks, boulders and drifts that settled into a dam behind a small bridge, at 840 m. the accumulating water formed a temporary lake with a water volume of over 4000 m^3. Because of the pressure, in about two hours, the dam burst and a flood wave was formed, destroying 7 small bridges and breaking river banks for nearly 3 km, downstream. Moreover, the debris flows changed the stream channel direction and isolated, on the right bank, 30 tourists and 4 parked vehicles on the 4m terrace level. The Sâmbăta river bed being clogged, the water overflowed and dragged other 12 vehicles parked next to the Floarea Reginei hotel and destroyed 5 km worth of forest road (fig. 8) as well as the trout farm next to the tourist complex.

The area of heavy rainfalls exceeded this time the local scope of the Sâmbăta river basin, equally affecting the Viştişoara basin to the west and the Breaza and Recea basins to the east. Even though the flood waves were not as strong as on the Sâmbăta valley, river beds were clogged here as well, and the torrents destroyed the trout farm downhill from Colţii Brezei lodge, as well as 31 households in the Breaza, Lisa, Gura Văii, Pojorta and Sâmbăta de Sus, as well as 15 km of forest road. The damage following this hydrometeorological phenomenon amounts to 2 million Euros.

CONCLUSIONS

Due to mountain geosystem diversity, the methodology we employed in the map representation of geomorphic hazards in the entire mountain area of Braşov County, based on a system of accumulated numeric coefficients, has mostly responded to the demands of land-use projects of the mountain area in the county. We have taken into account those structural, lithologic factors of superficial deposits as well as slope factors, in relation with the periodical cycles of rainfall, and the relief exposure to the general atmospheric circulation. The risk areas outlining and isolating have been performed along slope

FIG. 8 - Rainfall prior to the Sâmbăta valley (upper photo: the hydrometric station, destroyed; lower photo: the dam upstream the resort).

change lines, where geomorphic processes evinced qualitative and quantitative changes, as well, and have corresponded to vulnerability classes identified on the field. Yet, all this has relied on a significant amount of work, completed by repeated field mapping, undertaken for many years. Taking into account the morpho-lithic and morphodynamic conditions that are specific to the mountain area of Braşov County, this methodology has proved the most effective.

In order to prevent and mitigate the effects of future hydro-geomorphic processes as those described above, urgent resizing works are called for on the stream channels of main collectors, as well as the need to generalize these case studies.

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(Ms. presented 30 September 2007; accepted 30 December 2008)