Environmental impact of landslides in sub-Carpathian area between the valleys of the rivers Dâmbovița and Prahova (Romania)

OVIDIU-MARCEL MURĂRESCU
GICA PEHOIU
Department of Geography
"Valahia" University of Târgovişte
ROMANIA
e-mail: ovidiu_murărescu@yahoo.com; gpehoiu@yahoo.com; www.fsu.valahia.ro

Abstract. Characteristic shifts for the Subcarpathians is that they are distinguished by their combination and development within the source area. The slopes, mostly cleared, are used for pasture and crops apple growing. The response induced by its negative influences on the process of preparation and triggering landslides (deforestation, overgrazing, cutting of slopes exploata in quarries or underground). The peculiarities of geological, hydrogeological and geomorphological are identified as unfavorable for years to rainfall. The excessive amounts of water given by the heavy rains and long duration of previous years and the rapid melting of snow due to high temperatures, determined the change in the balance on slopes which are of localities, socio-economic institutions, channels of communication, and apple growing agricultural crops, forest areas. Landslides, next generation natural factors, are determined by processes antropogènes (fund holdings irrational forest exploitation works construction materials situated on the banks of the waters that lay on the long downhill portion of the trough few meters), intense process of shoreline erosion, associated with geomorphological conditions favoring the occurrence of landslides.

Key-words: landslides, Sub-carpathians, Dâmbovița river, Ialomița river, Prahova river, natural factors, anthropogenic factors, slope, stability factor.

1. General considerations

The unit of the Subcarpathians situated between Ialomița and Dâmbovița, located in the south-east of Romania and having a general orientation north-west to south-east/east, is a part of the Subcarpathians of Ialomița, which belong to the Curvature Subcarpathians, geographically located in the Sucarpathian hydrographic basins of west Dâmbovița and east Ialomița. It is made up of a succession of anticlines, oriented east-west, which correspond to the summits, and anticlines, which correspond to narrow depressions oriented likewise. The Subcarpathians constitute one of the geographic units where the dynamics of the riverbed and slope geomorphological processes is extremely active, determining extremely unfavorable effects on the economy and the human habitats.

1.1. Geographical position

The Bending Subcarpathians (Subcarpații de la Curbură) subunit is the most complicated of all the morphological and structural external Subcarpathians in Romania, clearly defined unit with mountain and plain from outside. Between Dâmbovița and Trotuş rivers they have a length of over 200 km and widths ranging between 18-35 km, occupying an area of 6800 km^2, which represents 2.83% of the Romania and 41.5% of the Sub-Carpathians. Here are individualized three major subunits: Subcarpathians of Vrancea, of Buzău and Subcarpathians of Prahova (Fig. 1).

Fig. 1. Subcarpații de la Curbură:
A - Subcarpathians of Prahova - □ area analised;
B - Subcarpathians of Buzău
C - Subcarpathians of Vrancea

Maximum amplitude is about 650 m and in the distance, is recorded about 35 km north-south and about 40 km between western and eastern region, hilly area that is of approximately 1080 km^2.

Geographical area analyzed, which monitors the geological phenomena of slope, particularly landslides, is a component of the Prahova Subcarpathians subunit, which is west of the Subcarpathians subunit of curvature, with the limits, east - Teleajenului valley (between localities Măneciu Ungureni and Măgurele), and west - Dâmboviţa valley.

Subcarpathians of Prahova can be divided into two subunits: first - from Dâmboviţa and Prahova valleys (Subcarpathians of Ialomiţa) - and second - between the Prahova valley and Teleajen. Northern boundary alignment can be put on Cetăţeni locality (on Dâmboviţa), Runcu - Moroieni (on Ialomiţa), Talea - Comarnic (on Prahova). It is marked by a bump of 200-300 m. The southern limit of the line can be drawn on Măneşti (on Dâmboviţa), Doiceşti (on Ialomita), Aninoasa - Răzvad - Gura Ocniţei - Moreni - Filipeştii de Pădure and Măgureni (on Proviţa) - Băneşti (on Prahova) - Fig. 2.

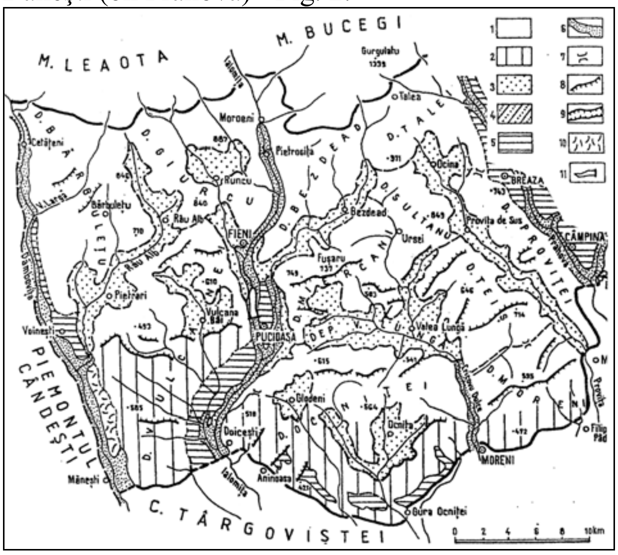

Fig. 2. Subcarpathians of Dâmboviţa and Prahova rivers (1 - hills, 2 - hills with issue of plateau, 3 - depression and depression-looking hilly, 4 - plain depressions and terraces; 5 - areas with terraces; 6 - meadows wide, 7 - saddles, 8 - cuesta, 9 - narrow valleys, gorges, 10 - piedmontal accumulation; 11 - dam lakes

1.2. Genetic factors favorable for production of geomorphological processes (landslides)

The research methodology of landslides in a geographic region with a high potential for achieving these geomorphological processes, we follow the evolution of such phenomena described in the literature since the 1970s. The purpose of our study was to analyze the evolution of such events and location of new geographical areas with potential to trigger landslides, under the impact of human activities on physical and geographical support.

In the following, we will summarize support physical-geographical space analysis.

Geology. Molas area of Carpathian region is one in which is to be seen a surprising continuity of sedimentation from Paleogene to Neogene.

Paleogene is found in blocks settled in Miocene conglomerates.

Miocene is forming marginal basin filling, represented by heterogeneous deposits (Marne, clays, carbonate, sandstone, conglomerates, evaporites, etc.), with sedimentation and frequent changes chaotic side.

Lower Miocene is characterized by a complex of 300-400 m thickness, represented by rock salt, potassium and magnesium salts, plus clay with thin layers of sandstone. Salt formations are characteristic of Cornu stratelor the Prahova Valley. Over this is a flis complex, 400-500 m thick, composed of an alternation of sandstones and other rocks.

Miocene are characterized by the unstable environment, now taking flis deposits rise thicknesses up to 2000 m. Underground presents sandstones and gray marls with an alternation of gypsum, followed by a series of sands, sandstones and gray-red patches of marl. Suite ends with the upper horizon composed of gypsum interspersed with shale and sand deposits.

In the early period, deposits were formed by heterogeneous deposits of facies changes, making high salt formation, which occupies some troughs. This is presented as a brecie sedimentary clay-shale with a matrix of gray-blue color with the addition of sand, sandstone, gypsum and salt.

Lower Miocene is characterized by advancing water in the vorland. It is remarkable for the variations litofaciale and stratigraphic discontinuities.

Lower Miocene zone's sedimentation is noted only by Ialomiţa valley, west of this sector because it is raised and no deposits were made in Miocene. La est de Valea Ialomiţei, depozitele miocene sunt reprezentate prin faciesuri de conglomerate şi apariţii de calcare lumaşelice şi oolitice.

Pliocene and Miocene deposits is consistent over or discordant, the external marginal sectors. The deposits are clay and sandstone, with different thicknesses, they coming into the composition area with clusters of salt.

Meotian includes sandy clay deposits of marna, the alternation of calcareous sandstones and oolithic limestones. They come to contact the palaeogene flis.

Dacian includes sedimentary deposits from the upper Pontian horizon with deposits predominantly sandy shale with weak sandy components. Dacian deposits are represented by an alternation of sands and clays and sandstones with marnes, plus layers of coal. It has full development of the external walls of anticlinal Moreni - Gura Ocniței.

Levantine completes this suite and Pliocene deposits include deposits represented by marnes with layers of coal exploited in the localities Doiceşti and Şotânga.

Changes in vertical layers and the presence of coal show marked reduction of subsidence and warping tends to be perfect in Quaternary.

Altitude. Landforms appropriate Subarpathians developed between the rivers Dâmbovița and Prahova place between 905 m, maximum altitude and located 252 m high on Talea hill, minimum recorded in Dâmbovița, Slănic and Cricov rivers in contact with the plain.

Hilly area sector lying between the upper and Ialomița river has the highest altitudes in which it establishes contact with the mountain area and the presence of hilly peaks with high altitudes. Only 5% of the area studied is between about 750 m to 900 m. The overall fit of the altitudinal step are higher hills Bărbulețului (860 m), Giurcuța, Bezdead, Talea (905 m) and south of Sultanului.

The next altitude, the imposing heights of 600-750 m, extends on the hill slopes in the river beds which are in contact with the mountain area, but includes other peaks less high hills situated to the south (Vulcana, Miercani, Teiuş, Provița). This stage occupies 17% of the hilly region.

Area between 450-600 m occupies 37% of the hill. It's the lower and mid slopes of the hills of the central and northern region and the bottom runs until interfluve level hills at the contact with the field (Ocniței hill and Filipeşti).

The largest share is a next step between 300-450 m. It has 39% of the entire area and corresponding lower parts courses near major rivers of the region (Dâmbovița, Ialomița, Prahova) that goes due north to internal hills latitude. It also extends to the bottom of the hill slopes from contact with the plain and ascends to the north to the depression, single inter-hills (Pietrari, Vulcana, Pucioasa, Valea Lungă, Urseiu, Sultanu).

The smallest area is occupied by altitudes below 300 m, each occupying only 2% of the entire area. This step of altitude, although common plains, manages to reach the level of Subcarpathian hills of Ialomița, through meadows of Cricov and Slanic, the area of confluence that creates the contact with the field increasing its area of deployment. Furthermore, depression areas creates a number of less obvious (even Ocnița and Gorgota depressions).

The analysis of this area highlights the characteristics of rolling hills, between the limits already mentioned that the transition between the mountainous north, and the plain, in the south.

Density fragmentation. On took into account all the hydrographic network of topographic map at scale 1:100.000. Subunits reported in the fall of relief (hills, depressions), hydrographic network density, which had fragmented and a high variety. Thus, we obtained values between 0.1 and 3.6 km/km^2, which were divided into equal intervals with an amplitude of 0.6 km/km^2.

Areas with the lowest fragmentation meet the top level of summits hills - the interfluves (<0.7 km/km^2), but at some portions of meadow along the rivers Dâmbovița, Prahova and Ialomița. This occupies 11% of the area within the area. Also quite low values (0.8 to 1.4 km/km^2) on meet in the middle of slopes, areas where the hydrographic temporary begin to develop drainage valleys. This portion occupies a large area, by 39%. In fact, this period is characterized by morphological connection areas - slopes that have developed secondary valleys of the rivers. Regions with less fragmentation value of density that can lead to the predominance of rocks more resistant to erosion: conglomerates, shale, sandstone, but a higher afforestation of slopes, as the upper contact region.

Areas with a higher fragmentation (from 1.5 to 2.1 km/km^2) are characteristic of the lower parts of slopes, usually linear and convex slopes and facilitate heavy erosion. On meet depression areas that valley, like rivers, acts as catchment areas for the collection of temporary and permanent network. These outlines areas and areas with the greatest degree of degradation of land, that deal with steep slopes affected by processes of alternation favored ravenare Paleogene and Neogene formations. These outlines areas and areas with the greatest degree of degradation of land, that deal with steep slopes affected by linear erosion processes favored by the alternation of Paleogene and Neogene formations.

The highest values of density fragmentation (from 2.2 to 2.8 and> 2.9 km/km^2) occur along the convergence of rivers and torrential bodies (the upper Râu Alb, the convergence of Ialomita and Ialomicioara on Bizdidel, the upper Proviței etc.). In the interfluve, the highest values occurring on the interfluve Cricov - Provița. In fact, the highest density areas of network floods, which led to a strong fragmentation, is developed mainly in the sectors trough (basin of Provița, depression

Ocnița, interfluve between Cricov and its neighbors) and lithologic contacts (basin of Vulcana and Vulcana hill). The two intervals of density fragmentation deal with only 9.2% of the total area of the Subcarpathian hills.

The degree of tilt is a key element in the analysis of relief and thus the analysis of its influence on local climate. In the area studied, the analysis made in this regard indicates differences between the northern and southern hilly region or between the interfluve and valley corridors. Thus, we see that dominate areas with slopes between 5-10° and 10-15°, unlike the south, where the predominant slopes between 15-20° and 20-25°.

Reported throughout the region, the distribution ratio of slopes is as follows: <5 ° is 25% of all of them, the specific corridors valley (valleys of Dâmbovița, Ialomița, Prahova - all with great scope to close the internal depressions).

Slopes with values between 5-10 ° have the highest share in the total area of Subcarpathian hills, occupying 35%. The largest spread in the north-west region on the northern slopes of the hill Miercani following in general and trough lines that enter the area studied.

Areas with moderate inclination (10-20°) handle 35% of the downy zone. They have a proliferation in the middle and upper interfluve, especially interfluve between Prahova and Ialomița.

Areas with high slopes (> 20°) are found mainly in areas affected by the collapse or the steep tectonics. They appear completely isolated, both in upper slopes (in the central kernels of massive hills) and the bottom (in sectors with increasing erosion in depth the main tributaries of Cricov springs and Vulcana's). Areas with large slopes are characteristic Miercani southern slopes of the hill, hills Ocnița, Bezdead, Teiuş and in the interfluve between rivers Dâmbovița and Ialomita, the hill Bărbulețu and the central part of Vulcana hill.

The exhibition slopes takes into account different degrees of insolation (solar radiation). It stimulates topo-climate and climate elements, changing temperature, air movement and turbulence, precipitation and humidity.

Heating slope is rising with a lag time delayed the necessary transition from one exhibition of the Sun to the next one. The explanation is that, for example, the exhibit south (south-western previous exhibition), in the morning, has an amount of heat consumed by evaporation of water fallen on the floor at night (hoar-frost, dew, rain), heating ground being made in the afternoon, namely with a south-western slopes of the exhibition, which until that time they are dried by the morning moisture. Slopes with similar conditions in terms of heating are the following (classification made after the exhibition grounds):

- southern and south-western slopes of the exhibition, described as warm and sunny slopes;
- slopes with south-eastern and western exhibition is partly sunny and warm hillside;
- slopes with east and north-west exhibition is part shade and cold;
- slopes with northern and north-east exhibition are shaded and cool.

It is a conclusive way, as will take into account not only the exhibition but also the amount of solar energy received on all side, or only a certain portion of it, depending on many factors (exposition, slope, slope position). In this system, the slopes are grouped in pairs.

Spatial analysis of the types of slopes in relation to the degree of sunburn shows that one third of the area studied (30%) is defined by areas sunny and warm (14% to 16% with southern and south-western exhibition). Shade and cool slopes occupy the smallest one (19% of which 11% is due north-west of the exhibition).

Introducing these morphographical indices shape morphologic aspects of Dâmbovița and Prahova Subcarpathian hills. They help us to synthesize the main features, which anticipate the physical and geographical factors that print a general climate of local character elements.

The main elements are the result of climatic factors radiative interaction, dynamics and physical-geographical. For the climatological analysis of Subcarpathian area of Dâmbovița and Prahova rivers' valleys have been processed and interpreted data from meteorological stations Voineşti, Câmpina and Târgovişte and the pluvial posts Moreni, Pucioasa, Fieni, Malu cu Flori, Dealu Frumos, Moroeni, Râu Alb. Data from the stations mentioned in a period of 40 years (1961-2006), atlas climate, altitude and latitude distribution, knowledge of the laws and various meteorological parameters enable highlighting the main features of climate.

Air temperature. Air temperature is an important climate parameter because the record, while a high variability, leading and other elements of climate change.

Due to physical and geographical diversity of conditions there is a uniform spatial distribution of air temperature within analyzed teritory. Value analysis of monthly and annual average temperature of the air, it is found that there is a clear zonal altitude. In this regard it is noted that the meteorological station of Târgovişte, located at 296 m altitude, at the contact between Subcarpathians and plains, the average annual temperature is 9.6^0 C, and Câmpina - Voineşti weather stations located in the Subcarpathian area, located at 511 and 461 m respectively, where the average annual temperature is 9.1^0 C, respectively 9^0 C.

Highest temperatures recorded in summer, when they climbed up to 5.4^0 C at Voineşti, 6.1^0 at Câmpina and 6.3^0 C in Târgovişte. Differences decrease monthly and average temperature increase is the consequence of reducing continental heat from plain to mountainous areas.

The most significant decreases in temperature from one month to another are recorded between October and November in the Subcarpathians: 5.2^0 C to Voineşti, 5.3^0 C at Câmpina and 5.6^0 C in Târgovişte.

In knowledge development processes and geomorphological phenomena, an importance and values have seasonal average temperatures. In winter, temperatures average from the previous season range from fairly large limits: -1.1^0 C to Voineşti, -0.9^0 C at Campina and -0.5^0 C in Târgovişte. In spring, mean air temperature varies between 5^0 C and 9.7^0 C. The summer average temperature increases by more than 9^0 C values in the hills.

With reference to the monthly average deviations, caused by the annual average, it may be noted that the thermal excesivitatea decreases from south to north, the average amplitude being 21^0 C at Târgovişte and 20.6^0 C in Voineşti.

Rainfalls. In Subcarpathian hills area, annual precipitation amounts remain below 750 mm, while the contact area with the field they are less than 650 mm.

Analyzing annual amounts in the range 1961-2006, the high degree of variability is observed while the rainfall in the area examined.

Changes in rainfall during the year are influenced by baric systems operating in the area, but also by the underlying surface characteristics. In the Carpathian foothills, Voineşti and Câmpina, the annual rainfall regime is characterized by two minumums: in February-March (30.0 mm) and October (45.2 mm) and a peak in June (96.4 mm - Voineşti and 112.7 mm - Câmpina).

The contact area between the hills and plains recorded a variation in monthly rainfall, with a peak in June (94.0 mm) and two minimum in February (33.5 mm) and October (33.5 mm) in Târgovişte.

Analyzing the average values, are found between the months of extreme precipitation are differences of 80-90 mm in the mountain, 60-70 mm and 50-60 mm in Subcarpathians, in the contact between hills and plains.

Quantitative distribution of average rainfall has differences from one semester to another and from one season to another. Since the average amount of precipitation, about 2/3 is done in the warm period (the months April to September), the difference of 1/3 in the cold period (October to March).

Quantities of water stored in snow may trigger some geomorphological processes when it melts. Snow specific time interval when the temperature is negative is dependent on temperature, frequency and duration vary depending on altitude.

Average date of manufacture of the first snow is in the first decade of November in the Subcarpathians at Voineşti and Câmpina, and the second decade of November, in Târgovişte. Last day with snow on average is recorded as early in the third decade of March in Târgovişte and second decade of April to Voineşti and Câmpina.

If they are to the average annual number of days with solid precipitation in the Subcarpathians, it is in Voineşti and Câmpina, 37 days, and in Târgovişte, the contact area hill-plain, 24.2 days.

Duration of snow cover depends on rainfall conditions necessary for sound to make and to persist as snow. This area has an average duration of 100-120 days and in Târgovişte approximately 60-80 days.

Basin issues. Subcarpathians caught between rivers Dâmboviţa and Prahova are fragments of two types of rivers. The first is represented by those which spring from the mountain area, Dâmboviţa, Prahova and Ialomiţa, which only passes through hilly area.

Dâmboviţa falls in an average flow of subcarpathian area with 9.5 m^3/s at Malu cu Flori, having a specific average flow of 10.6 l/s/km^2. Few tributaries receive the Subcarpathian area are due to modest increases in flow across hilly area, at Conţeşti registered only 11.2 m/s. The only major tributary on the left is Valea Largă (S = 29 km^2, L = 12 km) and Râu Alb (S = 98 km^2, L = 23 km).

Ialomita, main river road drainage hilly area studied, shown in the Subcarpathian area a relatively symmetric basin. The major tributaries receive are: Ruşeţ (S = 14 km^2, L = 7 km), Valea Lupului and Bizdidel (S = 92 km^2, L = 26 km), on the left, Ialomicioara (S = 95 km^2, L = 24 km) and Vulcana (S = 105 km^2, L = 9 km), on the right. Other tributaries having their source in the Subcarpathians receive in the plain: Slănic (S = 41 km^2, L = 16 km) and Cricovul Dulce (S = 611 km^2, L = 71.7 km).

In the category of local river arteries, Cricovul Dulce can be considered the most important representative gathering of hills and waters and Ocniţa, Miercani through Strâmbu streams and Tisa, receiving the most important tributaries on the left. This includes Urseiu (S = 60 km^2, L = 5.7 km), Ruda and Proviţa (S = 218 km^2, L = 49 km). So, rivers that come from mountain area and the domestic drainage direction are north-west - south-east.

Prahova, in Subcarpathian hills across a large valley with ramifications. In this sector it receives tributaries notables on the right side (of interest to the area studied), standing out Talea, operating in the contact with mountain area.

Shell plant belong predominantly deciduous forest in contact with the mountain and there are higher hills mixed forests (beech or oak tree). Many of these have been cleared, their place being taken by secondary grassland and agricultural crops or fruit trees. This work led to an imbalance of the slopes, with the possibility of landslides.

Geographical space analised is considered one of the densely populated regions with population density values ranging from 70-150 inhabitants per km^2, which represents a great impact on the land.

Another element with an important effect on the onset and maintenance of landslides is the intense economic activity going on in this geographical area. This is manifested by the energy industry - primarily coal mining, oil and gas -, building materials, etc.

Agriculture is another economic activity that has contributed to the onset of such events, the methods of processing the land and by intensive farming.

2. Landslides

To analyze landslides in the area studied were conducted field research which was to follow the development of such events. To that end, it was updated existing geomorphological maps, by locating new zones of products affected by landslides, particularly, during the years 2001-2006 (Fig. 3).

A characteristic feature of the landslides of the Subcarpathians of Ialomiţa is the fact that they have a special arrangement and development in the hydrographic basins. The potential conditions and the forces that trigger landslides influence large areas in the Subcarpathians between Dâmboviţa and Ialomiţa, as they are made up of Miocene and Pliocene formations with more or less cemented clay and sand strata, included in folded and fault structures, being affected by neotectonic uplifts. The slopes, most of them deforested, are used for intensive grazing and tree cultures. The anthropic intervention, with its negative aspects, influences the process of landslide preparation and triggering (deforestations, excessive grazing, sectioning of the slopes, exploitations in quarries or in mines). The geological, hydrogeological and geomorphological characteristics favor the appearance of landslides, during rainy years (1970-1972, 1975, 1995-1996, 2001, 2003-2006).

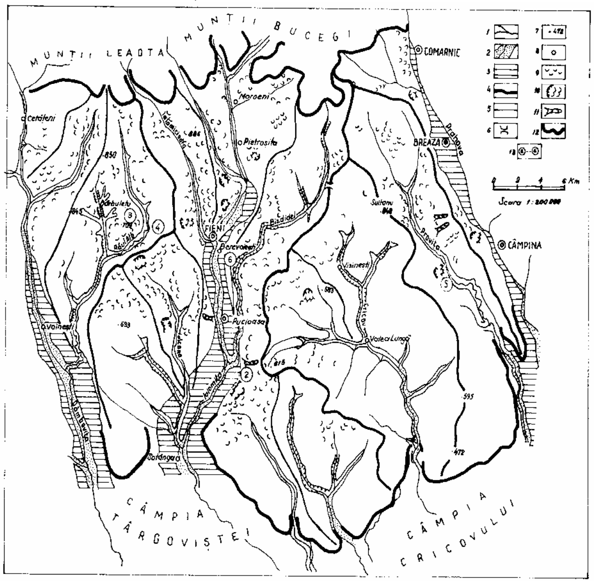

Fig. 3. Landslides in Subcarpathians between Dâmboviţa and Prahova: 1 - hydrographic network; 2 - meadows, 3 - terraces, 4 - main interfluves; 5 - interfluves side, 6 - saddles, 7 - peaks, 8 - localities, 9 - landslides in the nest, 10 - sliding in grooves, sliding in steps and waves, 11 - sliding linear, 12 - limits of Subcarpathian area

3. Areas undergoing the risk of landslides

In the upper basin of Ialomiţa River, there is an area of argillaceous schists, argillaceous and marly schists and dusts, characterized by a high frequency of the stratification layers that hold and store water, triggering landslides (Bezdead, Buciumeni, Glodeni, Vârfuri, Vişineşti, Vulcana Băi) - fig. 4.

Fig. 4. Landslide reactivated from Măgura (March-April 2006)

Causes for reactivation of land slipping from Măgura (2006) are: overfilling geological body deluvial slope by water infiltration from snowmelt and rainfall on a drainage line; increased weight and volume old deluvial sliding; reduction of internal cohesion and internal friction angle of the deluvial part; undermined by erosion deluvial base side slope (Bizdidel Valley) in the right part of the county road Pucioasa - Bezdead.

For the same phenomenon, we exemplifie suplimentarily by Fig. 5.

Fig. 5. Landslide in the area of Măgura (2006)

In the hydrographic basin of Dâmbovița, the presence of Eocene formations in a 600-700 m thick *facies of sotrile*, with intercalations of fine and rough grit stones, sometimes friable, with clays and marls, constitutes well-defined stratification surfaces, on which, when there is humidity excess, landslides may occur (Bărbulețu, Malu cu Fori, Pucheni, Râul Alb, Văleni Dâmbovița).

In the area of the localities Cobia, Dragodana, Hulubeşti, Lucieni, Valea Mare, there are deposits of gravels, sands and clays, low-cohesion strata where large water quantities can be stored. When riverbeds are eroded and descend, the drainage from these deposits to the watercourse accelerates, triggering landslides.

The events occurred and the observations made so far allow us to state that the periods of landslides in the Subcarpathians of Ialomița, occur during or after the melting of the snow layer (Vârfuri - February 1980, Râu Alb - March 2005 - fig. 6-7, Răzvad- March 2005).

Fig. 7. Landslide from Râu Alb
in the year 2005

Also during the periods with lengthy rains on noticed the same fenomena in Malu cu Flori - June 1979, Vişineşti - June 2001, May-September 2005, Mărgineanca - 2003-2004 - fig. 7, Buciumeni, Bezdead, Pucheni, Răzvad, Văleni Dâmbovița - 2005 (fig. 8-10).

Fig. 8. Landslide from Mărgineanca, 2004

Besides the natural generating factors, landslides are triggered as well by anthropic activities, like: excessive exploitation of the forest fund, begun at the end of the 19th century and continuing at present (Malu cu Flori, Pucheni, Văleni Dâmbovița, Vişineşti, Vârfuri, etc.), exploitation works for construction materials on the watercourse, without feasibility studies and the approval of specialized institutions, determining a several meters lowering of the talweg on long sectors, intense riverside erosion processes, associated to landslides.

Fig. 9. Landslide from Bezdead (2005)

In the hydrographic basin of Ialomița, the geological substratum made up of clays, marls and grit stones, the morphometric and morphographic features of the slopes, the low degree of afforestation, associated to different forms of anthropic intervention - deforestations, inadequate agricultural exploitation of slopes (excessive grazing on the communal land; orientation of the arable land perpendicular on the level curve - for example, on the left slope, in Doiceşti area; inadequate exploitation of construction rocks - in

Fieni, Pucioasa and Doiceşti), determined an intense degradation of the sloping lands.

The most representative landslide occurred in Vârfuri Commune on February 13, 1980 beginning with 10.00 a.m.; it occurred over a period of 6 hours and affected the civic center of the locality (the town hall was completely destroyed, as well as the new cultural center, local shops and school and 60 dwellings of the local population) and the fruit-growing trees plantations situated on the slopes affected by the landslide (between Valea Neagră and Valea Păruşului).

Fig. 10. Landslide in Buciumeni (2005)

The landslide occurred on the direction south-south-west, on a slope with a 10% incline, had a speed of 6-7 m/h, and concerned a 700-800 m long stripe, whose widths varied from 200 m to 600 m, while its depth ranged between 5 and 20 m, triggering crevasses and landslides. Nearby this locality, other areas have been affected by (new or reactivated) landslides in 2001, 2005, 2006: Buciumeni, Fieni, Moţăieni and Pietroşiţa, their local economy suffering losses.

Near Vârfuri, in nort-east, there is Vişineşti Commune, where landslides affected dwellings, ways of communication and fruit-growing plantations situated on the slopes (1980, 2001, 2005, 2006).

In the area of the localities Răzvad, Ocniţa, Gura Ocniţei, landslides are present on the slopes under the form of canyons on the most abrupt slope line, which evolved in links of deep erosion. In the geographic area of Fieni, Runcu and Brebu, on Ialomicioarei Leaotei Valley, landslides associated to ravine erosions affect the slopes.

Landslides are active as well in the localities: Vulcana Băi, Şotânga, Glodeni, Doiceşti and Aninoasa, triggering important material damage - they affected the ways of communication (departmental and communal roads - DJ, DC), dwellings, socioeconomic institutions, hydro-technic and art works (bridges, riverside protection and consolidation).

The actual geomorphological processes affecting Vulcana Hills are characterized by massive land displacements, associated here and there with ravines and erosion at the surface. The right slope of Ialomiţa River, as well as the left slope of Vulcana rivulet, are the typical image of a relief resulted from the association of several categories of massive land displacements, superposed in time and space.

In the hydrographic basin of Dâmboviţa, landslides affected several localities, both in the past and at present. The relief of Dâmboviţa basin in the Subcarpathian area is characterized by slopes with a 10-40% incline and a 100-300 m relief energy, a low degree of afforestation (15%), which, in association with average yearly precipitations of 700-900 mm and a favorable geological structure (alternances of grit stones, marls and clays), triggers landslides, too.

In the locality Văleni Dâmboviţa, on Muscel Valley, in 1979, the excess of soil humidity and the underground springs triggered landslides. In the area of the locality Malu cu Flori (the villages Micloşanii Mari and Micloşanii Mici), made up of strata with a general slope of 10^0-18^0 to the nord, while the structure in the Şotrile deposit is made up of yellowish-gray friabile, grit stones, and intercalations of gray and purple clays and marls and in Pucheni, the slopes of Valea Largă have been and continue to be affected by landslides (1921, 1941-reactivated in 1955, 1970, 1979, 2001-2006) produced by springs and excessive precipitations, which created water accumulations that continually feed the underground strata made up of series of grit stones, clays and marls, creating the grounds for triggering such processes.

The antropogenic factors (intense exploitation of the river rock for constructions) determined the deepening of the riverbed of Valea Largă Rivulet, intensifying its riverbed erosion and removing the earth at the foot of the slopes, favoring the appearance of landslides.

In Malu cu Flori, landslides have seriously affected scores of dwellings, ways of communications (the national road DN Târgovişte-Câmpulung in 1979, 2001, 2005, 2006, the communal road DC in Micloşani), the left side of Dâmboviţa River, more than 1600 ha fruit-growing tree plantations, and the course of Dâmboviţa River risked to be blocked.

Landslides are active in the localities Râu Alb, Bărbuleţu, Voineşti, being caused by the springs and the excessive precipitations that created water accumulations that feed the underground strata (grit stones, clays and marls) creating the grounds for triggering landslide processes and affecting dwellings, ways of access and plantations.

3. Landslide prevention and post-landslide management

Landslide prevention and post-landslide management requires a knowledge and analysis of the activities that need to be carried out in such situations, according to pre-established procedures. These activities take place at all levels, from a national level to a local level, in order to assure the realization and the application of the forecasting, prevention, protection and intervention measures, as well as the estimation of the effects and damages.

Civil protection measures and actions in case of disasters must be conceived for all the phases of such events: pre-disaster, during and after the disaster, as well as long term measures and actions. Preventive measures are conceived and applied in order to avoid or limit the consequences of disasters and are completed by measures of preparation, which represent a set of actions and measures meant to assure a rapid intervention in order to minimize losses and distructions.

A major influence on slope stability goes to water, which maintains a supplementary humidity in the strata, triggers leaks on the slopes or concentrated flows under the form of torrents and rivulets, which requires the application of complex measures for diminishing their effects, like:

- reducing or annulling the erosion at the foot of the slopes, given by concentrated flows (torrents, rivers) by an adequate arrangement of the riverbed (riverside defense, bottom thresholds, dams for decreasing the slope in the riverbeds that have a torrential character);
- interception of the surface waters that flow on the slope and their fast evacuation by executing specific antierosional works (inclined canals, outlet), determining a reduction of the quantity of water that infiltrates in the slope;
- technical-economic programs to intensify the measures of slope afforestation in the case of landslide-prone slopes;
- control of the underground waters ascensional levels by executing drilling works to lower them; this action can have a major influence on the stability of the slopes that have been affected by older landslides;
- interception of the underground water flows with horizontal drainages achieved transversally or longitudinally on the slope; decrease of the underground water level, along with the determination of the humidity decrease in the land mass situated above the depression curve and the reduction of the influence of the hydrodynamic force of the underground current by modifying the flow direction and the hydrodynamic slope;
- eliminating the possibility of appearance of water accumulations in the large fissures of the slope by filing them with a low permeability degree soil, which will trigger the elimination of the hydrostatic forces in the fissure and will influence the energetic balance of the slope’s stability;
- fighting against the phenomenon of electroosmosis present at the boundary between clay strata and marl strata, because of the activity of anaerobic bacteria, by creating some strata with iron rods penetrating in the strata and shortcircuiting them, which leads to the removal of the excess of humidity;
- protecting the coast springs in order to prevent their blocking (which can occur when certain slope arrangement works are carried out) in order to maintain the natural drainage of the slope;
- reducing the weight determined by the construction of heavy buildings on the upper third of the slopes, and avoiding the construction of transversal roads on the slopes;
- maintaining/ increasing the capacity of biodrainage given by the vegetation on the slope, which results in the rapid elimination of water excesses and a supplementary resistence thanks to tree roots.

Preventing, fighting against and stabilizing landslides and fighting against soil erosion, all these were carried out by means of complex works during the period 1975-1984, in the zones identified as presenting landslide hazards, on an area of over 9000 ha; the works amounted to around 90 milion lei. For instance, in the localities Hulubeşti, Ludeşti and Valea Mare, in order to stabilize these processes, there were executed regularization works for the leaks on the slopes, consisting in coast chanels connected to outlets constructed on the slope line, leveling works as well as works for filling out the holes produced by landslides in order to avoid the infiltration and the accumulation of the water coming from precipitations and from the melting of the snow, while in the upper area of the slopes, afforestations were carried out. In the area of Văleni Dâmbovița, Pucheni, Malu cu Flori (on Turnului Valley, Valea Preotesei and Valea Largă) the same kind of technical solutions was applied as in the zones of Hulubeşti, Ludeşti and Valea Mare. Moreover, depending on the local specific needs, other underground drainage networks and transversal works on the ravines were achieved. In the area of the localities Runcu, Bărbulețu, Pietrari, landslide stabilization works and soil erosion limitation works were achieved by regularizing the leaks on the slopes, in 1984-1985.

After 1990, given the lack of financial fonds ans the lack of interest on the part of the central and local authorities, no more landslide stabilization works and soil erosion limitation works were carried out, and no other investments for repairing and maintaining these watercourse arrangements were carried out. The dangerous hydrometeorological phenomena recorded especially after 2001, affected and even destroyed the works achieved previously, landslides being reactivated mostly in the same areas known from before 1990. One can state that, if the existing works are not rehabilitated, they will become dangerous, triggering landslides and having major repercussions on the social and economic life of the areas concerned.

4. Conclusions

External Subcarpathians' river valleys located between Dâmboviţa and Prahova rivers are a geographical area affected by a whole range of geomorphological processes of slope, which were analyzed only landslides.

We have seen, for the last 40-50 years, a succession of such events that have affected different areas, some of them with a direct impact on human settlements and human activities.

The potential occurrence of such phenomena, geomorphological risk is high due to lithologic and physical factors of space considered, over which overlaps an intense popular, with an economic activity developed.

Although local and regional know these problems, yet there are insufficient resources to combat the negative effects. The problem remains to study, in order to observe and analyze the future development of such phenomena and the detection of a potential space for the emergence and development of risk profile.

References

[1] Badea L., Niculescu Gh., Sandu Maria, Roată S., Micu M., Sima Mihaela, Jurchescu Marta, *Unităţile de relief ale României*, III, "Dealurile pericarpatice. Dealurile Crişanei şi Banatului. Subcarpaţi", Editura Ars Docendi, Bucureşti, 2008.

[2] Bălteanu D., Badea L., Dinu Mihaela, Cioacă S., Sandu Maria, Constantin Mihaela, *Geomorphological hazards in Romanian Subcarpathians*, Institutul de Geografie, Bucureşti, 1994.

[3] Blidaru V., State Irina, Blidaru T.V., *Amenajări hidrotehnice pentru dezvoltare rurală prin recuperări, protecţii de terenuri şi amenajări complexe*, Editura Performantica, Iaşi, 2006.

[4] Buga D., Zăvoianu I., *Judeţele patriei. Judeţul Dâmboviţa*, Editura Academiei, Bucureşti, 1985.

[5] Bumbova Alena, Risk Identification on Run Landfill for Non-Hazardous Waste, *2nd International Conference on Waste Management, Water Pollution, Air Pollution, Indoor Climate* (WWAI '08), Corfu, Greece, October 26-28, 2008, p. 71-76.

[6] Dinu Mihaela, Loghin V., Alunecările de la Pucioasa (Subcarpaţii Ialomiţei). Evoluţie şi influenţe antropice, *„Rev. Geogr."*, IV, 2006.

[7] Ercanoglu M., An Overview of the Landslide Susceptibility Assessment Technique, *1st WSEAS International Conference on Environmental and Geological Science and Engineering* (EG '08), Malta, September 11-13, 2008, p. 131-134.

[8] Gâştescu P., *Managementul mediului*, Editura Sfinx 2000, Târgovişte, 2001.

[9] Ielenicz M., Pătru Ileana, Ghincea Mioara, *Subcarpaţii României*, Editura Universităţii Bucureşti, 2003.

[10] Loghin V., *Modelarea actuală a reliefului şi degradarea terenurilor în bazinul Ialomiţei*, ediţia a II-a, Ed. Cetatea de Scaun, Târgovişte, 2002.

[11] Murărescu O., *Resursele de apă din spaţiul carpatic şi subcarpatic dintre Dâmboviţa şi Prahova şi valorificarea lor*, Editura Transversal, Târgovişte, 2004.

[12] Mutihac V., *Structura geologică a teritoriului României*, Editura Tehnică, Bucureşti, 1990.

[13] Popp M.N., Subcarpaţii dintre Dâmboviţa şi Prahova. Studiu geomorfologic, *"Studii şi cercetări geografice"*, III, Societatea Regală de Geografie, Bucureşti, 1939.

[14] Popescu-Argeşel I., *Valea Dâmboviţei*, Editura Sport-Turism, Bucureşti, 1986.

[15] Rotaru Ancuţa, Oajdea D., Răileanu Paulica, Dynamics of a Landslide Surface, *1st WSEAS International Conference on Climate Changes, Global Warming, Biological Problems* (CGB '08), Bucharest, Romania, November 7-9, 2008, p. 22-27.

[16] Sorocovschi V., Voda M., Raţiu Ramona, *Characteristics of natural hazards*, *1st WSEAS International Conference on Climate Changes, Global Warming, Biological Problems* (CGB '08), Bucharest, Romania, November 7-9, 2008, p. 169-174.

[17] ***, *Arhiva Comisiei Judeţene de Apărare Împotriva Dezastrelor Dâmboviţa*, Târgovişte, 1980-2005.