“Babeș-Bolyai” University Cluj-Napoca
Faculty of Geography

PhD Thesis
(Summary)

STUDY OF APPLIED GEOMORPHOLOGY IN THE URBAN AREA OF CLUJ-NAPOCA

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**Introduction**

Of all the surfaces used by man the relief suffers the most intensive modifications because of such activities as mining and constructions on urban areas. Due to the changes inflicted on the geomorphologic systems the formations and the processes are affected in an irreversible way. We can say that in this case the relationship of interdependence between society and natural support is almost totally neglected.

When urban areas are in a period of very dynamic development, besides many other problems demanding urgent solution, first of all it is necessary to analyze the natural support of the anthropogenic activity that is the relief. In such circumstances the importance of the role of geomorphology is increasing, mostly that of applied geomorphology, which is one of the branches of this science, whose aim was defined by COATES (1971, 1976) as “the practical utilization of geomorphology to solve the problems occurring at those domains where man wants to transform or to use and to change the surface processes” (quoted by PANNIZZA 1996; FILIP 2008).

“The geomorphologic consequences of urbanism are almost totally ignored” (RADOANE, Maria 2007) although it largely alternates the dynamism of the processes, that is: building of roads, moving materials; loading too heavily the slopes with buildings; canals.

In the last decade the urban area of the city Cluj-Napoca has grown significantly, to the detriment of the natural surrounding. The up-to-date character of this problem led to the idea of elaborating this thesis, the aim of it being to try to find solutions to the problems which are often met in a region where the relief is characterized by a great complexity.

The methodology used here is meant to yield as relevant results as it is possible, therefore while elaborating the thesis it was necessary to approach the problem in an interdisciplinary way. I collaborated with geologists, geo-technicians, experts in urbanism etc. hoping that the results obtained like this will prove useful and can be utilized at other domains too.

After a general presentation of the studied zone we tried to elaborate a detailed analysis of the lithologic and geomorphologic features. Measurements were done at the terrain, on topographical maps and on aerophotograms, and this was followed by the drawing of thematic maps, sketches and graphs what made possible the adequate analysis of the processes and their relationships with the main factors that cause them.
1. Introductory Aspects - the Role of Applied Geomorphology in the Study of the Urban Areas

This chapter is dedicated first of all (sub-chapter 1.1) to the brief presentation of the history of applied geomorphology on international and national level. It is divided into three parts: the period before 1945; the period between 1945-1970; the period after 1970. Subchapter 1.2 contains the enumeration of the studies presenting the geological (substrate) and the geomorphologic (relief) characteristics of the urban areas of Cluj-Napoca.

2. The Place of the City in Time and Space

For the sake of a better analysis, when staking out the studied area, we considered two facts: the actual extent of the urban area and the natural borders (hydrographic network and the most important peaks) of the territory where the city is. (Fig.1.).

As a result of the growing number of the inhabitants the city has become larger and larger and the constructions have climbed up on the slopes too. At the beginning only the slopes with a milder dip were built on, but as a result of the development of modern technologies, constructions appeared on the more abrupt slopes too, whose vulnerability to geomorphologic risks is bigger. Up to the end of the 19. century the downtown area was growing in a moderate rhythm, but this has sped up in the 20. This is why I considered it
important to make a survey of the evolution of the built in area during the different eras, in order to gain a better understanding of the relationship between the dynamics of the growing downtown area and the natural setting. I used different cartographical sources.

3. Methodology Used in Research

The methodology of research work used in this study of applied geomorphology was elaborated in the preliminary fase and we tried not to abandon the proposed objectives. We went through the three proposed stages rigorously:

*Gathering documents and information:* scientific reports, mass media sources, local and regional plans of development, cartographic documents, geological and geomorphologic information, old and recently taken photos. On the basis of topographical maps 1:5000 and 1:25000 we created a detailed digital map of the studied area etc.

*Activity on the territory:* by creating detailed geological maps in order to spot the lithologic changes which can influence the susceptibility of the slopes to geomorphologic processes; by drawing up a detailed inventory of the geomorphologic processes from the studied area, first of all of the factors which cause the phenomena; in order to spot geomorphologic processes in time and to study the gaps which were dug as the bases of constructions, we conceived a monitoring system functioning with the help of high school and university students.

*Interpretation of the data and analysis of the results:* by making a synthesis of the data on the basis of the correlations between the frequency and intensity of the process, and the extent of the zone or area which proves susceptible to bear some instability or malfunctioning of the landscape (landslide, creep, solifluction, compaction). After comparing the obtained results and making up a hierarchy we will be able to draw conclusions and give solutions concerning the susceptibility of the slopes to risky geomorphologic processes, the target being the best utilization of the surfaces.

The evaluation of the geomorphologic risk caused by human activity referring to the susceptibility of the slopes was done on the basis of indicators and methodology proposed by SCHREIBER (1994) adjusted with some modifications to the urban area of Cluj-Napoca by the team led by BUZILĂ (2002). We combined this method with the methodology proposed by the Ministry of Public Work and Territorial Administration (2000) in the guide for editing maps of the slopes with sliding risk in order to ensure the stability of the constructions (indicative GT019 – 98).
4. Factors controlling the present geomorphologic processes which can be favourable and restrictive in the development of urban area

The present day geomorphologic scenery was formed during a long period under the influence of the action of morphogenetic agents and processes. These were working continuously, but with a changing intensity, upon the original surface, creating a series of forms. The action of the geomorphologic processes is influenced by some controlling factors: geology, pre-existing relief, climate, hydrology, pedology, vegetation, human etc.

In this chapter we give a general presentation of the geological characteristics of the whole studied area. On the territory of the city Cluj-Napoca there are to be found Paleogene deposits (Upper Eocene, Oligocene), Neogene deposits (Lower Miocene – Medium), and Pleistocene, Holocene deposits structured into many formations bearing local names (these were presented with the help of a litho-stratigraphic column, Fig.2). The monoclinic structure and the characteristics of the formations influence both present-day morphodynamics and the evolution of the formations.

At the interface of the substratum and the external modeling agents are situated the superficial deposits. In order to analyze those formations and to elaborate maps of the superficial deposits (eluvium, deluvium, colluvium, proluvium) we studied geotechnical borings.

In subchapter 4.2 we give a systematic presentation of the forms of relief which were born as a result of the breaking up of the Paleogene and Neogene deposits. The river Someșul
Mic dug its valley of subsequent character into these monoclinic strata just like the valley of the Nadăș, the result being a relief of erosion and fluvial accumulation.

The structural relief, determined by the monoclinic structure and the succession of the varied lithographic formations, is represented in the studied area by: watershed in the form of structural surfaces; by numerous proofs of erosion; by cuesta; by abruptions.

Sculptural relief. We discussed in a more detailed way the fluvial relief (erosion of the surface, slopes, terraces) which was formed by processes of denudation (erosion on the surface, torrents, landslide). We were especially interested in those levels of terraces which are favourable for urban constructions, their classification being based both on our own observations and on the literature of the subject.

Climate (subchapter 4.3.) through solar radiation, temperature and precipitation it can determine the rhythm, the duration and the intensity of the present-day geomorphologic processes. In the case of the studied area the effect of the climate factor goes together with human activity (deforestation, overloading of the slopes, exhausting the pastures) and this can have negative consequences upon the morphologic system.

The characteristics of the hydrological network on the surface were largely modified by the regularization and channeling of the rivers. The regularization of the river-beds in the case of the rivers Someșul Mic and Nadăș in their urban sections proved necessary because of more than one causes: in order to improve the conditions of flowing, to stop floods, to limit lateral erosion (to stabilize the banks) and erosion in the depth.

In natural conditions vegetation is supposed to largely reduce the negative effects of the processes of erosion (on the surface) and of the processes of mass movement, but in urban areas this role gradually fades away because of human activity. In the studied area the vegetation has slowly lost its protective character, its importance in maintaining the state of equilibrium of the upper crust on the slopes. As it was removed from extensive areas, the possibility of reducing or stabilizing present-day geomorphologic processes with the help of the vegetal layer is very small, it can no longer diminish the impact of the drops of rain on the soil or the energy of the rainwater dashing down on the slope. Anyway, its positive effects must be taken into consideration.
5. A complex analysis of the urban area of Cluj-Napoca taking into consideration the susceptibility of the terrains to slope-processes, based on geomorphologic and geologic data

In the past decades the technology of erecting buildings has largely developed, therefore we think that we are able to include in the space of construction those areas which in reality are dangerous. In this case we speak about slopes vulnerable from the point of view of constructions, but where the petrography (compact limestone) makes it possible we can build even on 70º slope decline.

Therefore it is necessary to make a complex qualitative – quantitative analysis of the surface forms and of their present state. When planning a building it is not enough to produce geotechnical studies of a precise character, but it is equally important to elaborate studies surveying the whole geologic and geomorphologic environment of the future construction. It is not possible to set apart just a portion from the functioning system, because after a time it can turn into a hostile environment.

In order to make our geomorphologic study as adequate as it is possible we divided the urban area of the city Cluj-Napoca into three big regions: I. The hills between the rivers Someșul Mic and Nadăș; II. The slopes on the right side of the river Someșul Mic; III. The slopes on the left side of the river Nadăș and the river Someșul Mic.

For each region we created a detailed geological and geomorphologic mapping based on topographic plans 1:5 000, edited in 1971. We digitalized these topographic plans in order to have a cartographic support as adequate and as detailed as possible.

The morphometric parameters of the relief were calculated on the DEM (Digital Elevation Model) derived from topographical plans of small scale. This is a supporting grid, the dimension of the pixels being 1x1 so that it can reflect minutely the actual changes in value. We calculated the parameters on the whole studied area and separately for the studied regions for the sake of a study as adequate as possible.

We identified the degree of geomorphologic risk (first of all in the case of slope processes), by taking into consideration the degree of susceptibility and the state of evolution of the shaping processes by analyzing the mutual conditioning between the processes and the quantitative/qualitative indicators of the surface (geology, morphology), the climate and the hydrology.

Due to the regionalization of the territory of the city and taking into consideration more than one thematic strata, - geological map; map of present-day geomorphologic
processes; a map made after measuring the relief with altimeter; map of geodeclivity; map of
the exposition of the slopes; map of the energy of the surface; map of the density of
fragmentation of the surface; map of the utilization of the terrains – we managed to give a
quantitative evaluation of the geomorphologic risks for anthropogene activity and that of the
susceptibility of the slopes to geomorphologic processes.

5.2. The hills between the rivers Someșul Mic and Nadăș

The area that is to be found in this region is very interesting both from geologic,
geomorphologic and from urban points of view. It is situated in the central part of the city but
in the same time it is present in a periphery zone too. From a geological point of view it is
very complex (diversified lithology fragmented by the faults) and this is reflected by the
morphology of the area too.
Tăietura Turcului seems to divide this region into two sections, therefore we also
differentiated two smaller sections, but some of their characteristics will be discussed
together.
The asymmetry between the northern and southern slopes is very evident and characteristic to
the whole region. This asymmetry is due first of all to the monoclinic lithology and then to the
lateral erosion of the river Someșul Mic.

5.2.1. The section between Cetățuie and Tăietura Turcului

This region has been studied many times by many generations of geologists and
geomorphologists. The studies elaborated by them can be divided into two main thematic
groups:
- vulnerability to slope processes – sliding and collapse – many times having tragic
consequences (SZÁDECZKY-KARDOSS 1918, 1932; XANTUS 1942; MESZAROS et al.
1976; TREIBER et.al 1973; BUZILĂ 2002);
- from the point of view of the possibility of erecting buildings on them (CLICHICI et al.
1990; TOVISSI 2004).
Although we know it as an area that present problems, we still want to build houses on these
slopes of shaky stability.

5.2.2. The section between Tăietura Turcului and Haitas Valley – Cheile Baciului

From geological and geomorphologic points of view it is a more complex region than the
former one (east from the Tăietura Turcului). Another important difference between them is
that presently it suffers a lower grade of urbanization that is there are fewer constructions on
it.
Fig. 3. Geological map of section between Cetățuie and Tăietura Turcului

Fig. 4. Geomorphological map of section between Cetățuia și Tăietura Turcului
Fig. 5. The hills between the rivers Someșul Mic and Nadăș.
1 = alluvium; 2 = glacial; 3 = Terraces I. (2-6 m); 4 = Terraces V. (60-75 m); 5 = Dej Tuff Formation; 6 = Gruia Sandstone Formation; 7 = Moigrad and Dâncu Formation; 8 = Mera and Hoia Limestone Formation; 9 = Brebi Marl Formation; 10 = Cluj Limestone Formation; 11 = Nadâs valley Formation; 12 = fault; 13 = alluvial cone; 14 = the profile

Fig. 6. Geological map of section between Tâietura Turcului and v. Hajitas-Cheile Baciului

1 = watershed with residual; 2 = Terraces V. (60-75 m); 3 = alluvium and Terrace I. (2-6 m); 4 = hill ridge; 5 = denudation valley; 6 = erosion-denudation valley; 7 = cuesta escarpment; 8 = Pleistocene landslide hummock; 9 = scarp and corp with landslide; 10 = Holocene landslides hummock; 11 = stable slope; 12 = active mobile slope with landslide; 13 = active mobile slope with landslide and creep; 14 = temporarily motionless landslide slope; 15 = slope with tendency of landslide; 16 = Holocene derasen processes; 17 = slope covered with construction, and tendency of landslide; 18 = rill and sheet erosion; 19 = abandoned quarry; 20 = rill erosion; 21 = erosion gullies; 22 = alluvial cone; 23 = saddle

Fig. 7. Geomorphological map of section between the Tâietura Turcului and valea Hajitas-Cheile Baciului
But this state can change rapidly because the city is extending and these areas, situated relatively close can become in a very near future covered by buildings. At the southern part (Grigorescu quarter) there are streets climbing up on very abrupt slopes (about 15-35°), presenting a greater risk of slope processes. At the northern extremities of this area (at the edges, under the level of the Ethnographic Museum), together with and industrial plant, further surfaces were built in. The areas covered with forests (Hoia Forest) and pastures can be rearranged.

Analyzing the susceptibility of the slopes in this territory, in the present natural conditions we identified the following areas with different degrees of natural risk.

Areas with a very low degree of risk on the watersheds, river terraces and the flood plain. On such areas buildings can be constructed practically without any risk.

Areas with small risk – to this category belong the northern slopes. On the eastern part of the Tăietura Turcului these surfaces are almost completely covered by buildings, mostly by family homes, but there are to be found some bigger constructions too, like the football stadium of the CFR Club. For such buildings some extra constructions had to be done, the bases being deepened until 20-25 m for the sake of safety.

On the western part of the Tăietura Turcului the slopes are covered by forests and pastures, the Ethnography Museum taking place on the IV. fragment of the terrace.

Areas with medium risk cover but small extensions of the surface and they are mostly used as pastures, agricultural plants or parks. They are only partially covered by buildings for example the derasion valley in which is to be found Rosetti street. Part of the buildings in this street are damaged because of gravitation processes (mostly sliding and creep). These processes speed up because of trepidation caused by a more and more intensive traffic.
Fig. 10. The hills between the rivers Someșul Mic and Nadâș: the map of susceptibility to slope processes.
To the *risky or very risky* group belong the southern slopes on the left side of the river Someșul Mic. These slopes are covered with diluvial deposits of different thickness. They are very instable and their degree of susceptibility to slope processes is high. In the past these processes did not create great problems because the hillsides were used as vineyards and orchards. But the number of the inhabitants of the city started to grow and people needed even these vulnerable surfaces. The houses which were built on the slopes from this area have deep basis and are built on several levels just like the terraces in order to be as stable as possible. Still we have to notice that those constructions are vulnerable to slope processes. What is more this is true not only in the case of the constructions built on the slopes with a high degree of risk but also for the houses which are to be found below them as the sliding material can also be dangerous.

Fig. 11. Landslide above Dragalina street nr. 88 (A. 2010. febr.; B. 2010 aug.). Efforts made for stabilizing the slope above the blocks of flats (C. 2007 iun., D. 2010 sept)
at the foot of the slopes. The western part of this area remained unchanged (Fig.11.A). Landslides are reactivated every time when rainy periods are longer as it happened in 2010 too (Fig.11.B).

5.3. The slopes on the right side of the river Someșul Mic

The greater part of the city and the urban areas are situated on these northern slopes of the Feleacul Hill. It was natural to extend into this direction because on the lower section of the slopes there are large terraces; slopes with a lower dip; insignificant linear erosion; the intensity of the gravitational processes is small (at least at the western and central part of the city). As we come closer to the middle part of the slopes the identification of the terraces becomes more difficult because they are fragmented and concealed by diluvium (generally made up of Sarmatian deposits) originating from the upper parts of the slopes.

At the superior section of the slopes we can identify erosion surfaces (MORARIU, MAC 1967). The upper erosion surface (on the top of the Feleacul Hill) is an evident one, easy to be noticed, but the delimitation of the medium and inferior erosion surfaces is more difficult because they were largely affected and destroyed by geomorphologic processes.

The morphological characteristics of the slopes from the right side of the river Someșul Mic change from flood plain towards watershed (on a transverse profile), but each delimitated section has its own originality in the morphological system of the studied area. The section between the Popii valley and the Becaș valley is dominated by the presence of Sarmatian deposits. East from the Becaș valley the presence of diapir folds under the Sarmatian deposits creates a special relief.

5.3.1. The section between the Boșor valley and the Popii valley

The morphology of the section between the Boșor valley and the Popii valley is determined by the presence of Eocene formations, its characteristics bearing a resemblance with the hills between the rivers Someșul Mic and Nadăș.

In this region we extended the studied area until the Boșor valley because the northern and eastern slopes of the Gârbăului Hill contain the surfaces were the city keeps growing. Except for the flood plain and the inferior terraces (the Mănăștur quarter) of the river Someșul Mic the southern and southern-western parts of this region are presently covered by greenbelt (Mănăștur Forest, Capu Hill, Făget, Gârbăului Hill), but this situation seems to change in the near future because the city started to extend on the slopes along the Gârbău, Pleșca and Popii
valleys too. The lithologic structure, the climatic conditions of the different periods and the fluvial erosion had a direct impact on the formation of the present day relief. Nowadays to this are added the modifications generated in the morphology of the relief by destructive human activity. Sometimes these are done unconsciously, but very often people are quite aware of them.

5.3.2. The section between Popii valley and Becaş valley

Fluvial and slope processes played an important role in the formation of the present-day morphology of the region. In our days antropogene activity keeps under control the shaping of the relief.

The relief formed on the superior part of the slopes has an erosive-structural character, while on the inferior part it is characterized by a predominantly accumulative relief (terrace levels gaining importance).

In this section is situated the ancient city and due to the favorable natural conditions (extensive surfaces made up of the terrace of the inferior terraces) at the beginning of its development, besides the flood plain of the river Someşul Mic, the built in areas included the inferior part of the slopes which are to be found in this section. But the city kept growing, and recently have appeared constructions on the middle sections of the slopes of Feleacul hill.

5.3.3. The section between the Becaş valley and Zâpodie Valley

It is situated on the eastern part of the city. Due to the diapir folds the hills with about 500 m height in this section differ from those from the other studied sections both in structure and in morphology. Up to 1990 only a tiny fraction of this section of inferior terraces (T₁, Tᵢ, Tᵢᵢ) belonged to the inner part of the city. Beginning from 2009 as the city became larger the surface of the downtown grew bigger too. Taking into consideration the fact that the inhabitants of the city began to buy houses and terrains in the village Gheorgheni, it is sure that in the future more and more people will be interested in these area.

The slopes on the right side of the river Someşul Mic are areas of very small (insignificant) risk, terraces (along the Someşul Mic and on the inferior part of the slopes) and the areas of watershed. From the processes which affect these surfaces we have to mention the compactions in the case of the terraces while the edge on the area between the rivers are eroded by the slides. Here lie the centre of the city and some portions of the Mănăștur, Plopîlor, Mărăști, Bulgaria, Someșeni, Andrei Mureșanu, Gheorgheni and Aurel Vlaicu quarters.
Fig. 12. Geological map of section between the Boșor and Popii valley

Fig. 13. Geomorphological map of section between the Boșor and Popii valley
Fig. 14. Geological map of section between the Popii and Becăș valley

Fig. 15. Geomorphological map of section between Popii and Becăș valley

Fig. 14. Geological map of section between the Becăș and Zăpodie valley (modified from Baciu 2002, Meszaros, Clichici 1976, 1988, Morarul, Mac 1967.)

1= alluvium and Terraces I; 2= Terraces II; 3= Terraces III; 4= Terraces IV; 5= Terraces VI; 6= Terraces V; 7= Feleac Sandstone Formation; 8= Iris Marl Formation; 9= Dej Formations (Badenian); 10= anticlinal axis; 11= synclinal axis

Fig. 17. Geomorphological map of section between the Becășu and Zăpodie valley.
The areas of small risk cover the middle part of the slopes (quarter Zorilor and Zorilor Sud, Bună Ziua, Andrei Mureșanu and the slopes of the Sopor Hill). Generally speaking these are stabilized zones, but due to the physical-chemical characteristics of the superficial deposits landslides can happen any time. On the top of the terraces creep processes are very frequent.

Areas of medium risk cover those territories which are dominated by the presence of deposits made up of clay, marlstone, Paleogene sand in the western part of the studied region (Gârbăului Hill and the slopes of the Popii valley) and Neogene sand (Sarmatian) on the eastern part of the studied region (Borzaș Hill). They are affected by derasion processes (landsliding, creep, solifluction), by lots of torrents and by erosion on the surface.

The areas of great or very great risk can be identified on the upper parts of the slopes and on the very abrupt slopes (the slopes of the Pleșca, Gârbăul and Boșor valleys and the upper section of the Feleacul Hill). These are dominated first of all by landslides, which presently are stabilized but in the same time there are regions of active sliding too. Antropogene activity many times reactivates or actually causes landslides.
The degree of geomorphological risk (slope processes):

- very low
- small
- medium
- very risky

Fig. 18. The slopes on the right side of the river Someșul Mic: the map of susceptibility to slope processes
5.4. The slopes on the left side of the rivers Nadăș and Someșul Mic.

This region is to be found in the northern direction from the valley of the Nadăș and Someșul Mic and presently the actual city occupies only the flood plain – terrace I and a thin strip on the inferior part of the slopes. In the projects of urban development these regions are considered as possible surfaces for the extension of the city. For example on the slopes of the Sfântu Gheorghe Hill was planned the Tineretului quarter (but the constructions were stopped) or on the slopes of the Lomb Hill is planned to extend the Lomb quarter. Because of the high degree of fragmentation of the terraces from this region and due to the fact that it is more difficult to do construction work on slopes, the city mostly extends along the valley of the Chintău and Popești.

The two delimited sections are: the section between the valley of the Nadăș and Chintău and the section between the valley of Chintău and the Valley Caldă. They differ from the formerly discussed units in the dip and orientation of the slopes, in heights or in the characteristics of the relief and in morphological processes. Therefore we decided to analyze them separately.

5.4.1. The section between the Valley of the Nadăș and the valley of Chintău

To this section belong to units of different characteristics: the Viilor Hill (420 m) between the valley of the Nadăș and the valley Popeștilor; Lomb Hill (682 m, the peak of Popești) and Steluța Hill between the valley Popeștilor and valley Chintăului. The slopes generally have a southern orientation and form the northern-eastern border of the city. The characteristics of the surface are determined by the monoclinic structure of the region fragmented by the affluents on the left side of the Nadăș and Someșul Mic (the valley of Popeștilor and that of Chintăului and their affluents). Generally the dipped surfaces were strongly eroded on their surface by erosion processes and landslides. The slopes made up of Sarmatian deposits (Marlstone formation of Iris) have a undulated aspect and are affected by mass movement processes (landslides, creep, solifluction) and by sheet wash erosion.

5.4.2. The section between the Valley of the Chintău and the Valley Caldă.

This section, known as the Sfântu Gheorghe Hill forms the watershed between the valley of Chintău-Someșul Mic and the valley Caldă. To this area belong the watershed and the slopes towards the valley of Cintău and Someșul Mic, but we have to mention that the administrative area of the city stretches quite far in northern direction.
Fig. 19. Geological map of section between the Popești și Chintău valley  

Fig. 20. Geomorphological map of section between the Popești and Chintău valley
The altitudes descend step by step from west towards east: the highest peak on Rapoș Hill is 478.8 m, at Fânețele Satului 513, towards the eastern direction at the residual called La Pipa 478.2 m, la Dealul Tigla 395 m and at the junction of the Someșul Mic and Valea Caldă only 333 m.

Geomorphologic characteristics are determined firstly by the presence of the Iris Formation (Sarmatian) and then by human activity what has had an important role in the formation of the present morphology.

The slopes of the Valley of Chintău, having a southern-western direction, on their upper parts are remodeled by ancient (Pleistocene), deep landslides of “glimee” type. The most important of them is the one from the Râpos Hill. The formation of those glimee and abruptions from the upper part of those slopes is due to the alternation of the following layers: tuff, sand, conglomerate, sandstone, marlstone. The middle and the lower sections of those
slopes are affected by superficial landslides (they can be older or of more recent character), lenticular or having the form of flows, solifluctions and creep.

The slopes on the left side of the Nadâș and Someșul Mic are generally susceptible to geomorphologic slope processes. This is caused first of all by their lithology, by the energy of the relief and by human activity.

To the group of the areas with very small risk belong the terraces (Ti) and the watersheds (these are areas of very small extension and insignificant from the point of view of usage).

The areas with small risk join the watershed in the form of structural surfaces and they also cover areas of small extension.

The largest surfaces belong to the group of the areas with medium risk. Presently they are surfaces temporarily stabilized (due to the forests or to human activity targeting the stabilization of the slopes by plantations), but they are affected by geomorphologic processes (sliding of the older or newer terrains, generally not too deep ones; creep; solifluction; diffuse erosion etc.). On the slopes of affluents of the main valleys appear processes of mass movement (first of all in the region of the Lomb Hill).

![Fig. 23. The slopes on the left side of the rivers Nadâș and Someșul Mic: the map of susceptibility with slope processes](image)

To the group of the areas with great towards very great risk belong the upper parts of the slopes, first of all the both slopes of the Chintâu valley, where beside the older landslides of smaller depths frequently take place slides of bigger depth of “glimee” type.
6. Conclusions

The studied territory is a contact zone, both naturally and economically it is appealing for people living in the neighborhood or in the other regions of the country. Some settle in the outskirts, others try to find a home somewhere in the central area of the city.

In just 20 years time (after 1995) the demand of covering large surfaces with buildings has increased enormously and the natural support has many times been ignored. Presently the relatively stable surfaces (slope angle being less than 5°) of the urbane area are already covered with buildings, and there are only two ways of gaining new territories:

- extension in the eastern-western direction, along the valley of the Someş river,
- extension in the northern-southern direction on the slopes and along the valleys of the main affluences of the Someş river

These circumstances gave the idea of elaborating this study on applied geomorphology.

The geological characteristics of the studied area are reflected by the morphological features. The morphology of the western part of the studied area (western direction from the Popii valley – Cetăţuie-Popeştilor valley) where the Eocene-Oligocene deposits with significant layers of limestone are the dominant ones, is very different from the morphology of the eastern part where the more friable Sarmatian deposits (of sand, marlstone, and clay intercalated with volcanic tuff) are dominant. We can say that, except for the meadows and the inferior terraces, due to the stratigraphic and physical-mechanic particularities of the Sarmatian deposits (clay, and friable sandstone – the Iris Formation) or the Rupelians (rich in clay minerals – the Moigrad and Dâncu formations) on the whole territory the slopes are predisposed to gravitational processes (slope slides and creep).

The topological-climatic conditions imposed by the relief cause a kind of seasonal, annual or multi-annual rhythm, but they affect only very slightly the geomorphologic processes. The annual quantity of precipitation on the other hand, can initiate massive gravitational processes, the high quantity of precipitation in the years 1970, 1999 and 2010 activated mass movements (for example on the southern slopes of the Cetăţuia hill).

Presently antropogene activity is considered to be the most aggressive and active modeling factor able to induce changes in the stability of the slopes. Concerning the studied area such activities can not be considered occasional ones because man is present everywhere. Many times the gravitational processes were caused by: erecting embankment in an inadequate way (and many times leaving them unfinished because of lack of money, without
filling the gaps); artificially increasing the humidity of the upper layers (for example by breaking pipelines); deforestation; overloading the slopes by buildings.

The corroboration of the geological and geomorphologic characteristics with the factors of geomorphologic risks led to the delimitation of the areas with different pretability for urbane constructions.

1. Flood plains, terraces, the surface of inferior erosion surface and some portions of the watershed area between the Valley of the Someșul Mic and the Nadâș have a high grade of pretability for urbane constructions. They are very slightly affected by geomorphologic processes, first of all by compactions and by creep. On the flood plains and terraces are situated the centre of the city, the quarters of the city and part of the industrial area. In the watershed area between the valley of the Someșul Mic and the valley of the Nadâș the area with pretability for construction is the one situated between Cetățuie and Tăietura Turcului.

2. The slopes with a northern orientation of the inter-fluvial area between the valley of the Someșul Mic and the valley of the Nadâș, the middle section of the northern slopes of the Feleacul Hill are surfaces which present a low grade of risk for urbane constructions. They are affected by geomorphologic processes of reduced amplitude: superficial slides (some of them stabilized), creep, erosion on the surface.

3. The Slopes of the Lomb Hill, the Sfântu Gheorghe Hill, the Mănăștur Forest the Popii valley, the Borzaș Hill, the Rosetti street present a moderate risk of geomorphologic processes through the different processes of derasion (creep, sliding of the active terrain, pseudosolifluctions), and ravine formations. They have a reduced pretability and can be used for urbane constructions only after being prepared for it.

4. The slopes with northern orientation of the Hills between the valley of the Someșul Mic and the Nadâș, the upper section of the slopes with northern orientation of the Feleacul Hill, the slopes on the left and the right side of the valley of the Gârbău, the upper part of the Lomb Hill and Sf.Gheorghe Hill have a surface with a high grade of geomorphologic risks: sliding of the terrain (superficially or deeply), creep, ravine formation or the effects of torrent. These surfaces are without pretability for urbane constructions.

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