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

PhD Thesis

(***Summary***)

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

Scientific advisor:
Professor Virgil Surdeanu, Ph.D.

Ph.D. student:
Poszet Szilárd-Lehel

- CLUJ-NAPOCA -
2011

CONTENTS

Key words: applied geomorphology, Cluj-Napoca, methodology, monoclinic structure, cuest, landslide, pretabilty.

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 antropogen 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 PANNIZA 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.).

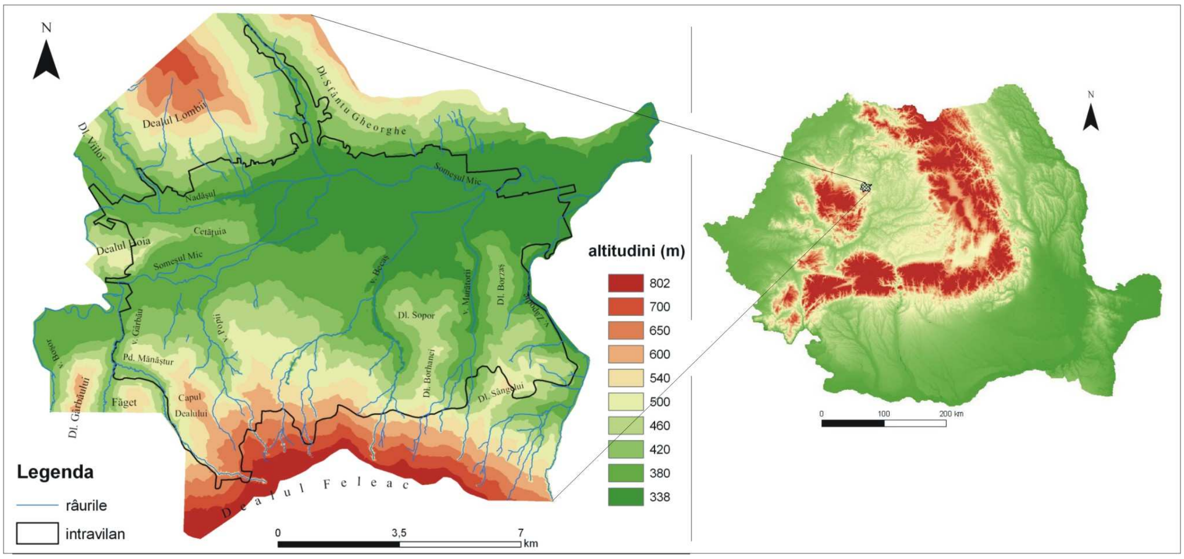


Fig.1. Geographical position of the studied area

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 faze 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

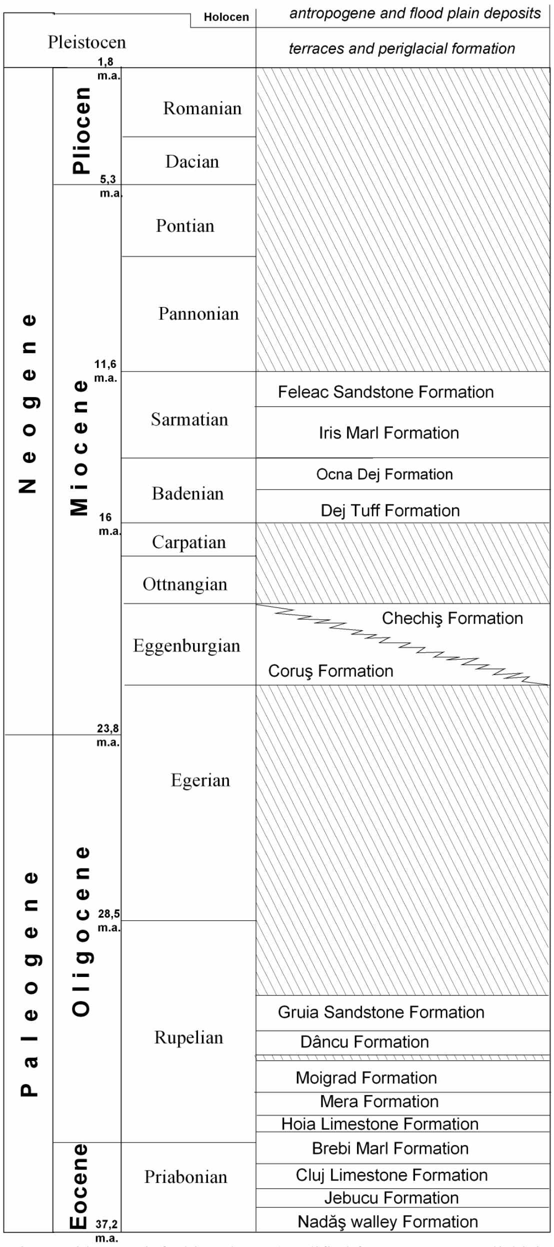


Fig. 2. Litho-stratigfaphic column (modified from Mészáros, Clichici 1976, 1988; Baciu 2002; Krezsek 2004; Wanek 2004)

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 Someşul

Mic dug its valley of subsequent character into these monoclinic strata just like the valley of the Nadăs, 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 Someşul Mic and Nadăş 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 Someşul Mic and Nadăs*; II. *The slopes on the right side of the river Someşul Mic;* III. *The slopes on the left side of the river Nadăs and the river Someşul 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 antropogene activity and that of the susceptibility of the slopes to geomorphologic processes.

5.2. The hills between the rivers Someşul Mic and Nadăs

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 Someşul Mic.

5.2.1. The section between Cetățuie and Tăietura Turcului

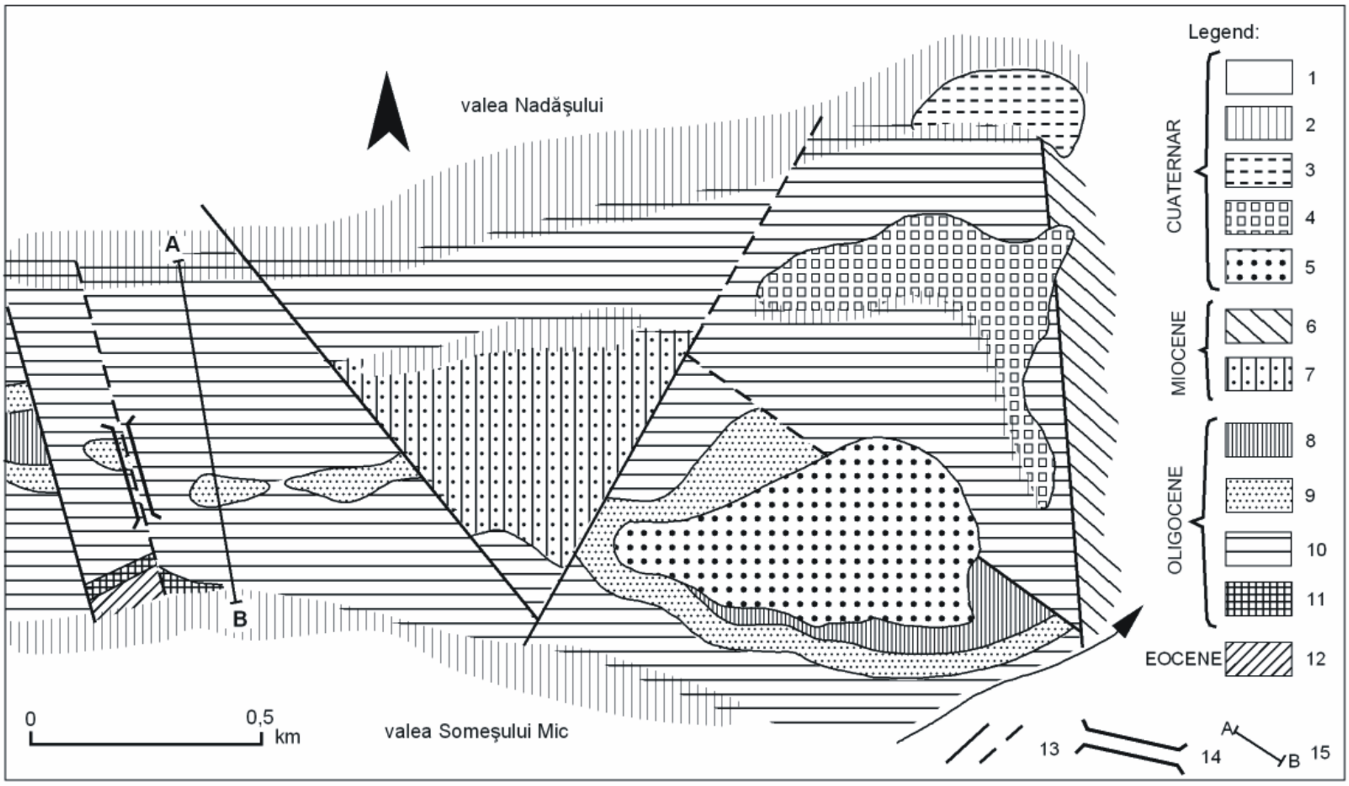
This region has been studied many times by many generations of geologists and geomorphologists. The studies elaborated by them can be divided into two main thematic groups:

- 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.

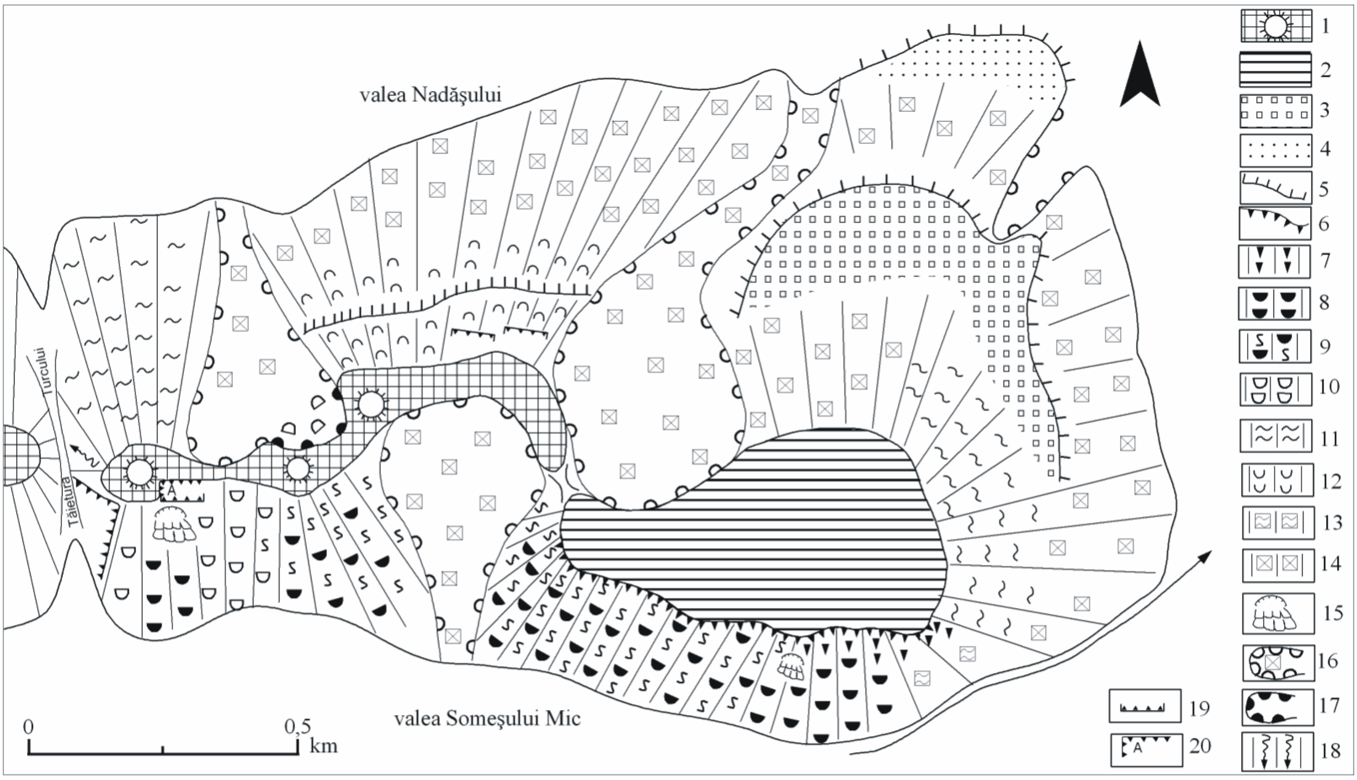
5.2.2. The section between Tăietura Turcului and Haitas Valley – Cheile Baciului

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.



1 = alluviuni; 2 = glacis; 3 = Terraces II. (10-16 m); 4 = Terraces IV. (30-45 m); 5 = Terraces V. (60-75 m); 6 = Iris Formation; 7 = Dej Tuff Formation; 8 = Gruia Sandstone Formation; 9 = Dâncu Formation;10 = Moigrad Formation; 11 = Mera Formation; 12 = Brebi Marl Formation; 13 = fault; 14 = Tăietura Turcului; 15 = profi

Fig.3. Geological map of section between Cetăţuie and Tăietura Turcului



1 = watershed with residual martor; 2 = Terrace V. (60 - 75 m); 3 = Terrace IV. (30 - 45 m); 4 =Terrace II. (10 - 16m); 5 = front of the terraces; 6 =cuesta escarpment; 7=rockfall; 8 = active mobile slopes with landslide; 9 = active mobile slopes with landslide and creep; 10 = undulated surface with fossile landslide; 11 = temporarily motionless landslide slopes; 12= slope with tendency of landslide; 13= temporarily motionless slopes, stabilised by anthropic effect; 14= slope covered with construction, and tendency of landslide; 15 = scarp and corp with landslide; 16 = derasion valley cowered with constructions; 17 = derasion valley; 18 = sheet erosion; 19 = antropogene terraces; 20 = antropogene carving

Fig.4. Geomorphological map of section between Cetăţuia şi Tăietura Turcului

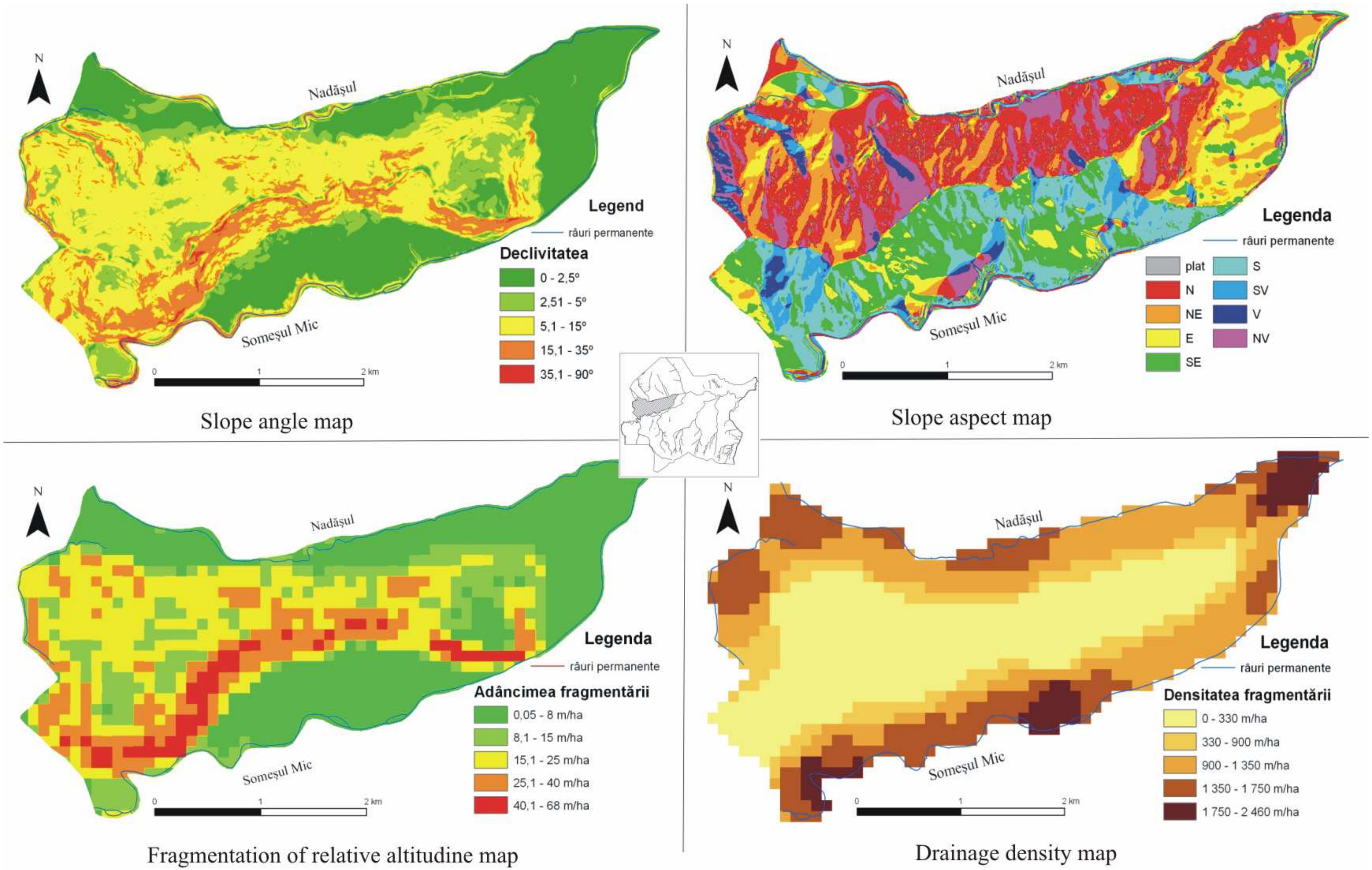
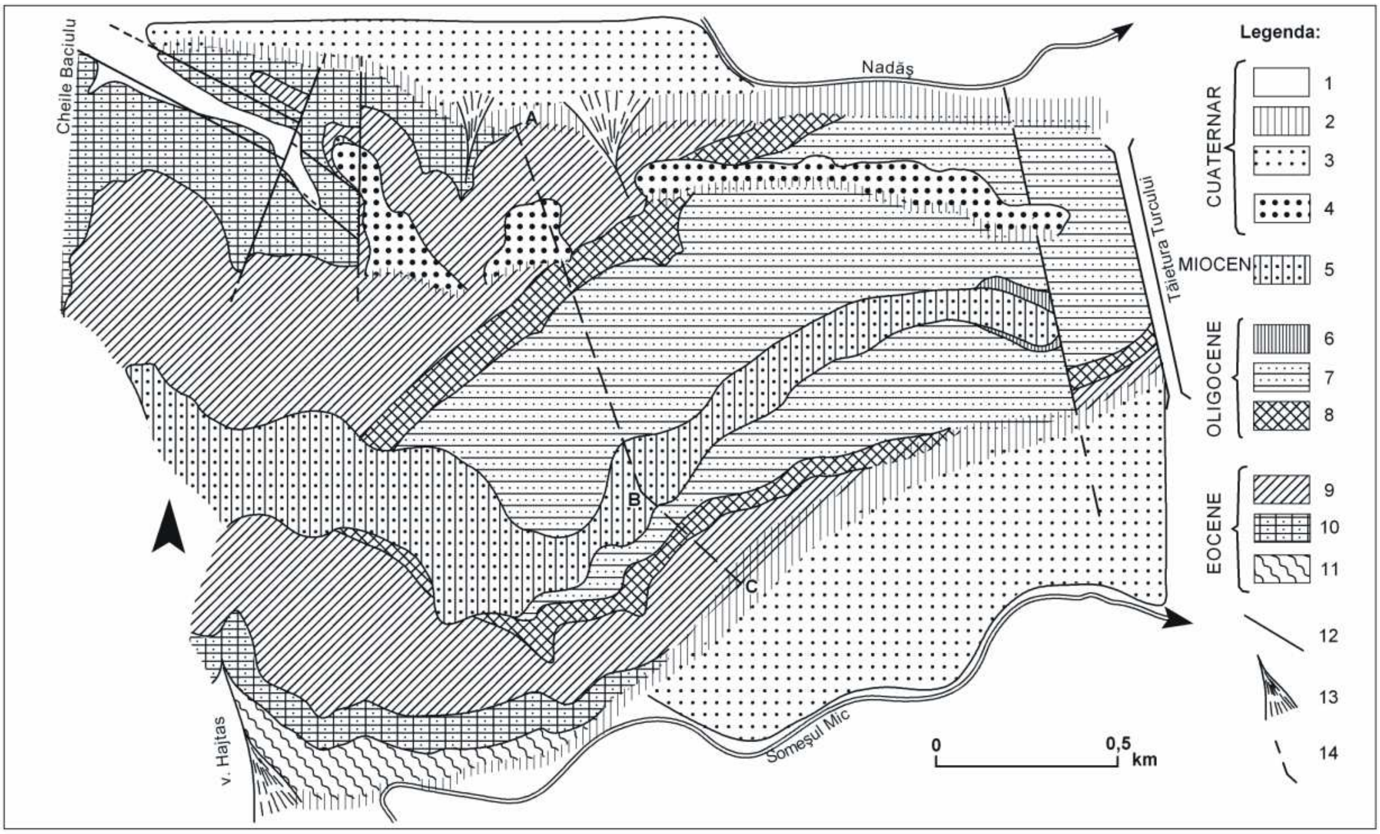
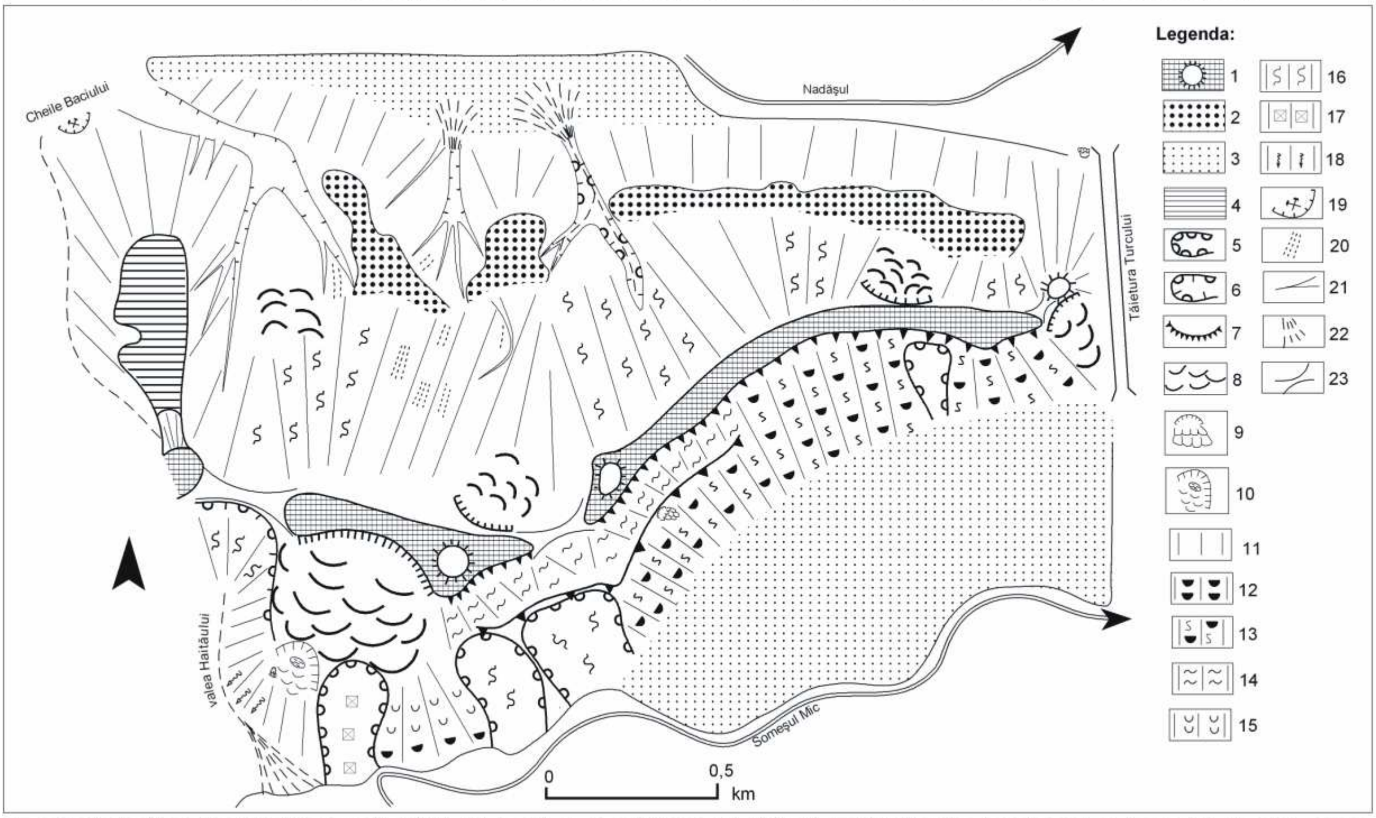


Fig.5. The hills between the rivers Someşul Mic and Nadăş



1= alluvium; 2 = glacis; 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 = Nadăş valley Formation; 12 = fault; 13 = alluvial cone; 14 = the profile

Fig.6. Geological map of section between Tăietura Turcului and v. Hajtas-Cheile Baciului



1= watershed with residual; 2= Terraces V. (60-75 m); 3= alluvium and Terrrace I. (2-6 m); 4= hill ridge; 5= derasion valley; 6= erosion-derasion 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 derasion processes; 17= slope cowered with construction, and tendency of landslide; 18= rill and sheet erosion; 19= abandoned quarry; 20= rill erosion; 21= erosion gullies; 22= aluvial cone; 23= saddle

Fig.7. Geomorphological map of section between the Tăietura Turcului and valea Haitas-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 15-35º), 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.

Fig. 8. Cracked house (Rosetti street, 2008)

Fig. 9. Rosetti street (2008)

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.

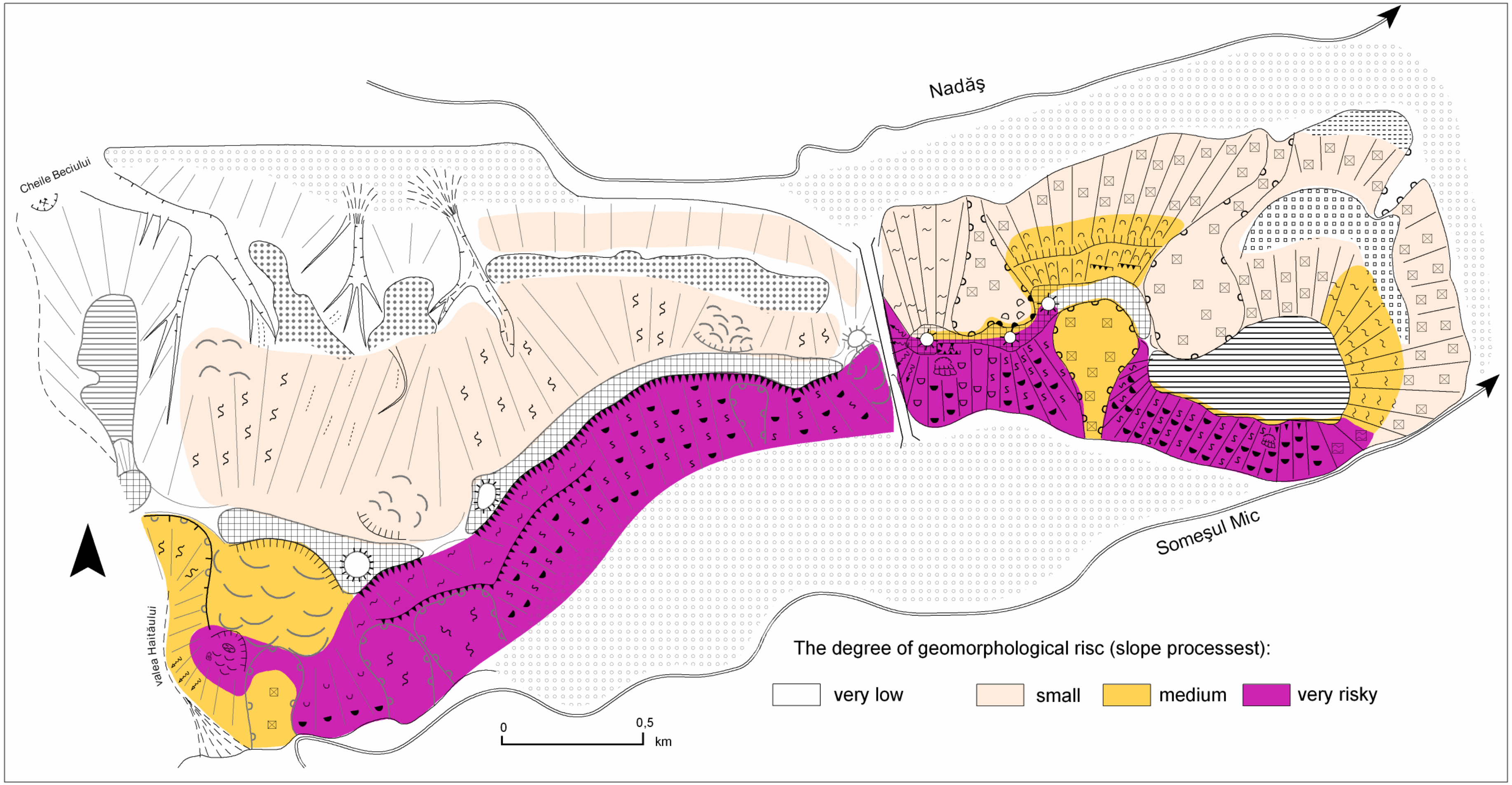


Fig. 10. The hills between the rivers Someşul Mic and Nadăs: the map of susceptibility to slope processes

To the *risky or very risky* group belong the southern slopes on the left side of the river Someşul 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.

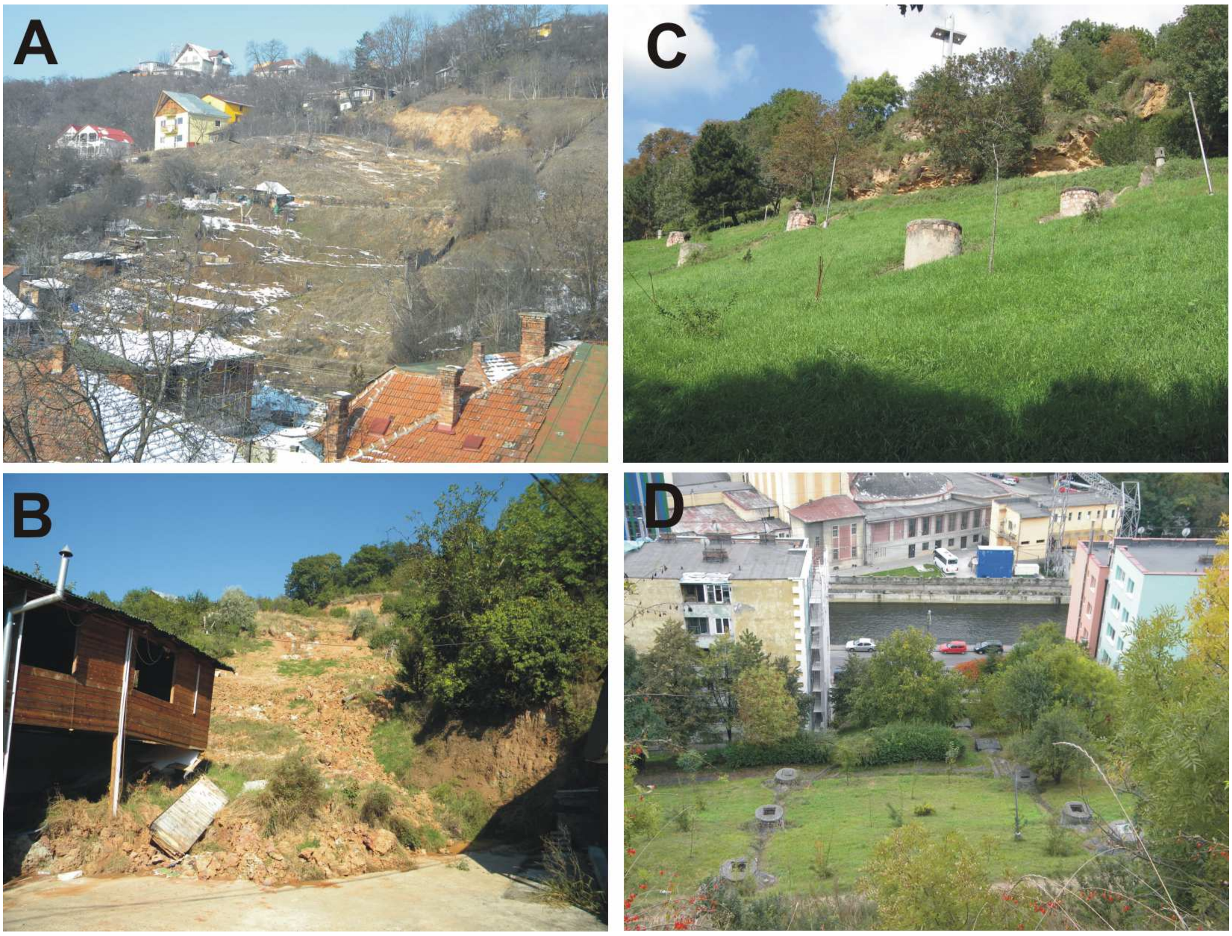


Fig. 11. Landslide above Dragalina street nr. 88 (A. 2010. febr.; B. 2010 aug.). Efforts made for stabilizing the slope above the blocks of flats (C. 2007 iun., D. 2010 sept)

In order to get rid of such problems stabilizing work was done while underground and surface waters were drained. The problem is that such work was done only on a very small part of the surface (Fig.11.C-D), under the Cetățuie in order to protect the block of flats built 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 Someşul 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 Someşul 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 Becaş valley is dominated by the presence of Sarmatian deposits. East from the Becaş valley the presence of diapir folds under the Sarmatian deposits creates a special relief.

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

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

In this region we extended the studied area until the Boşor 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 Mănăştur quarter) of the river Someşul Mic the southern and southern-western parts of this region are presently covered by greenbelt (Mănăştur 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, Pleşca 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 Zăpodie 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 (T_{I}, T_{II}, T_{III}) 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 Mănăştur, Plopilor, Mărăşti, Bulgaria, Someşeni, Andrei Mureşanu, Gheorgheni and Aurel Vlaicu quarters.

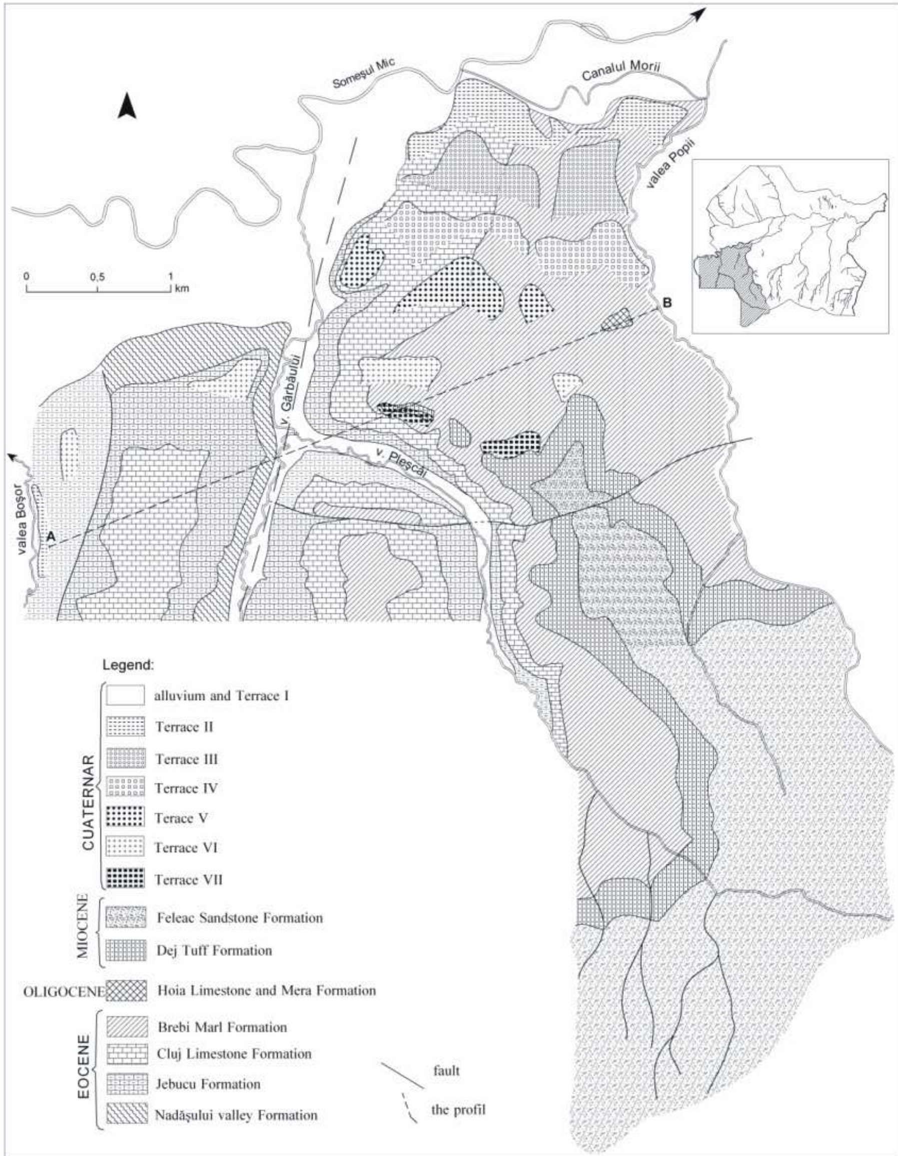


Fig. 12. Geological map of section between the Boşor and Popii valley

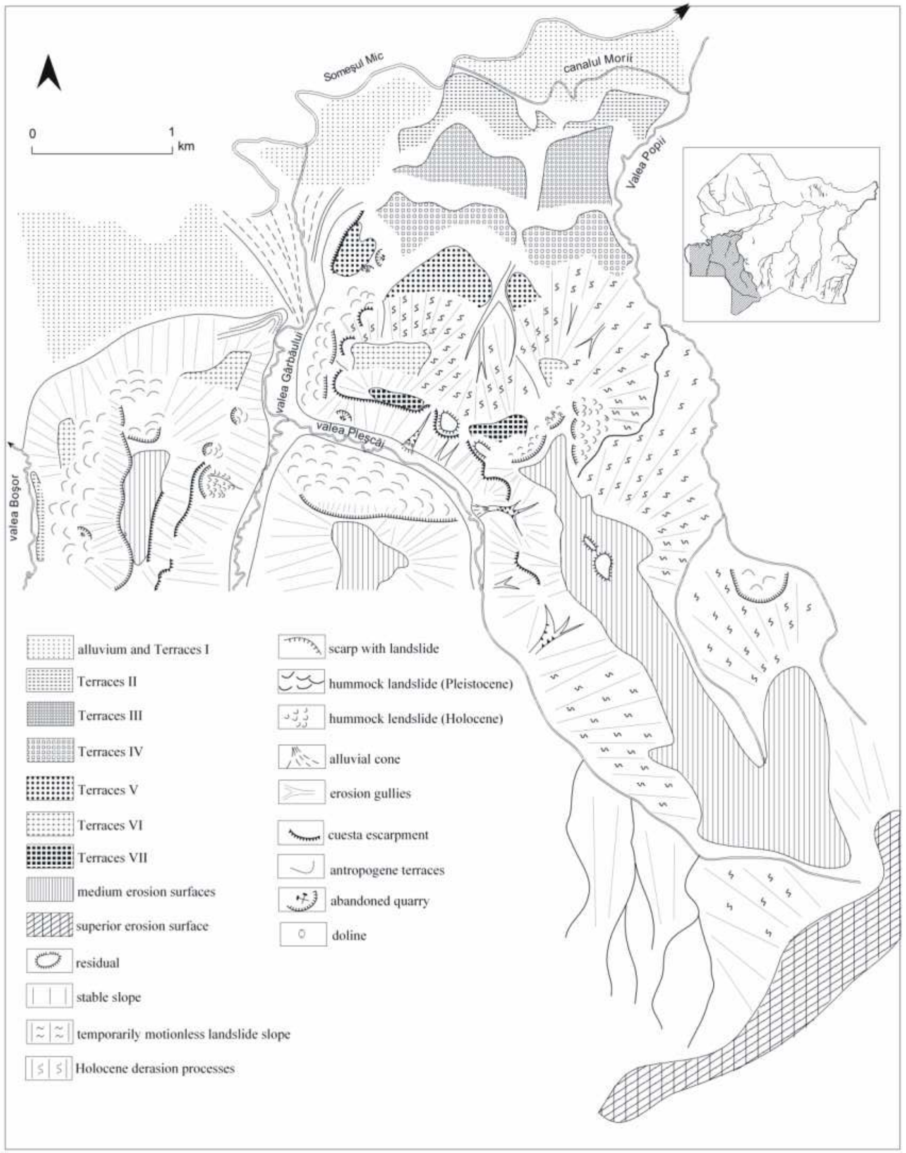
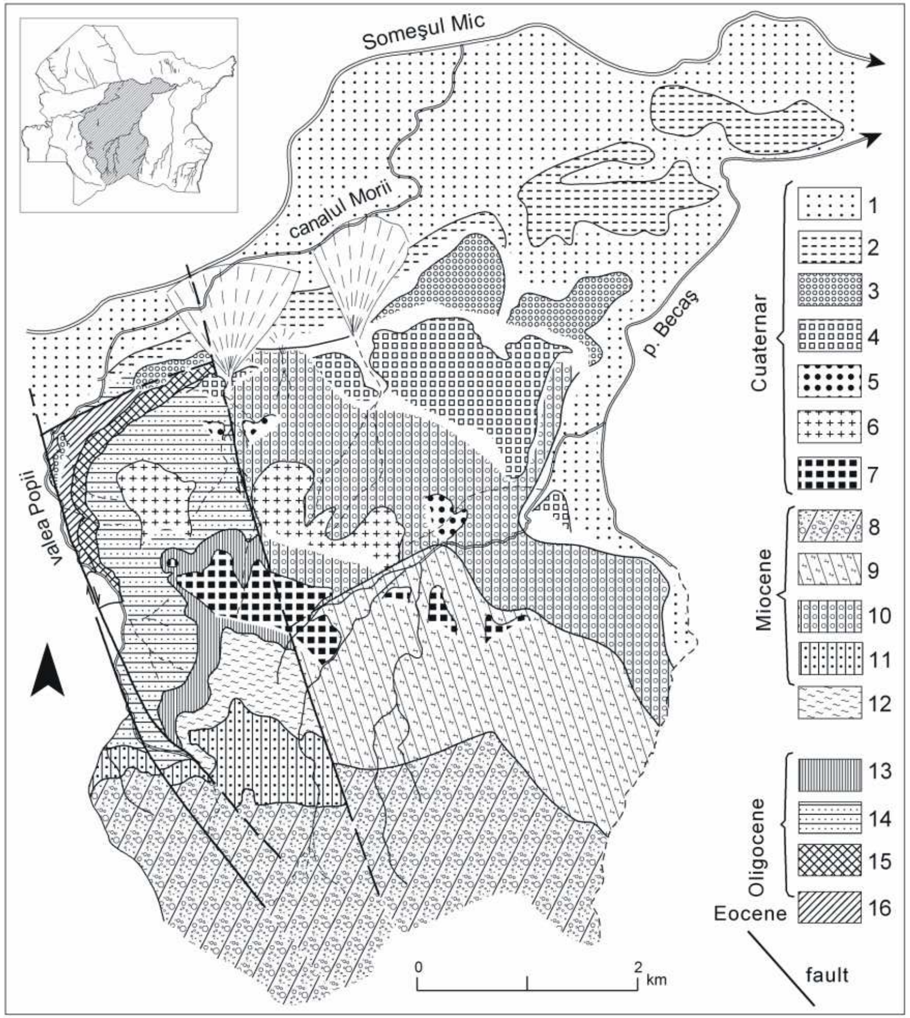
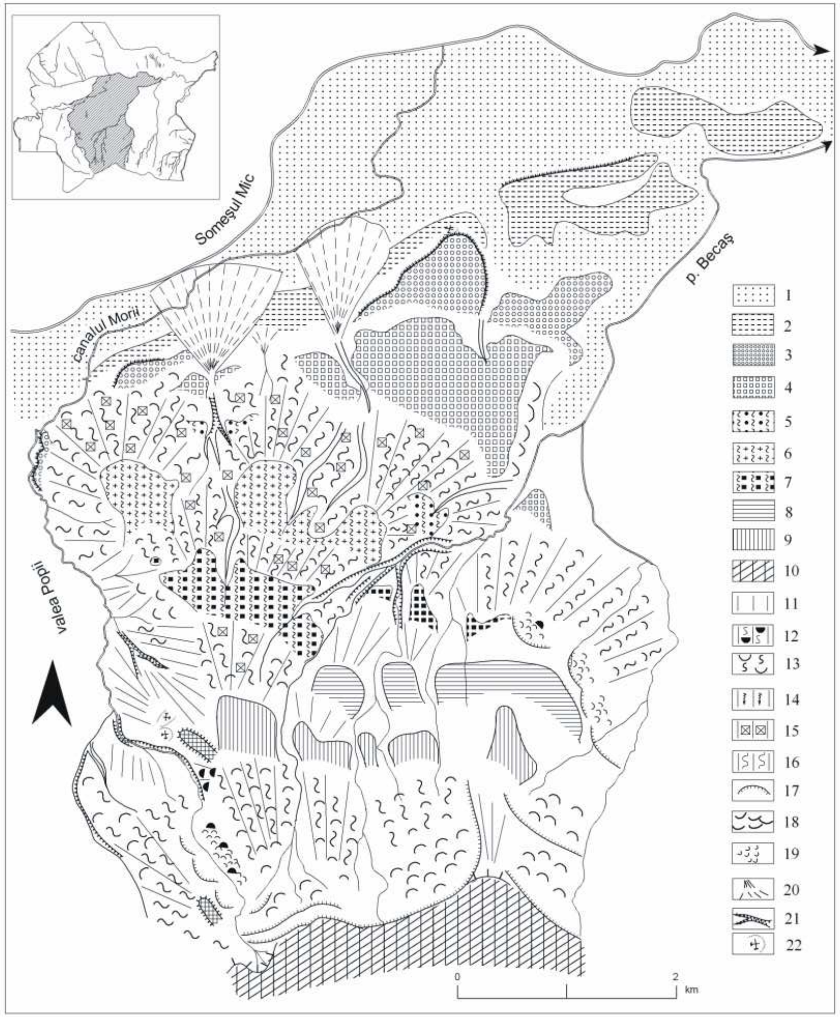


Fig. 13. Geomorphological map of section between the Boşor and Popii valley



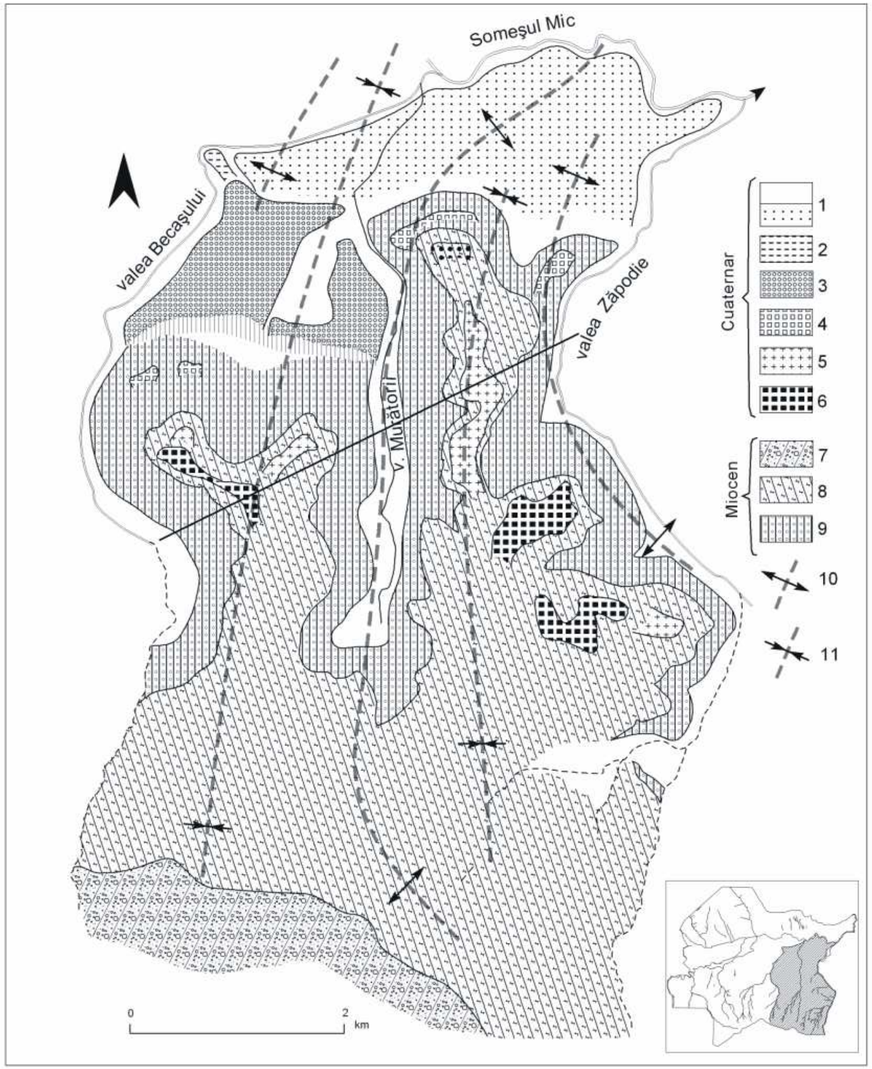
1= alluvium and Terraces I.; 2= Terraces II.; 3= Terraces III.; 4=Terraces IV.; 5= Terraces V; 6= Terraces VI.; 7= Terraces VII.; 8= Feleac Sandstone Formation; 9= Iris Marl Formation; 10= Dej Formations (Badenian); 11= Dej Tuff Formation; 12= Coruş and Chechiş Formation; 13= Gruia Sandstone Formation; 15= Moigrad and Dâncu Formation; 15= Brebi Marl Format

Fig. 14. Geological map of section between the Popii and Becaş valley (modified from Wanek, Poszet 2011, Baciu 2002, Meszaros, Clichici 1976, 1988, Morariu, Mac 1967,)



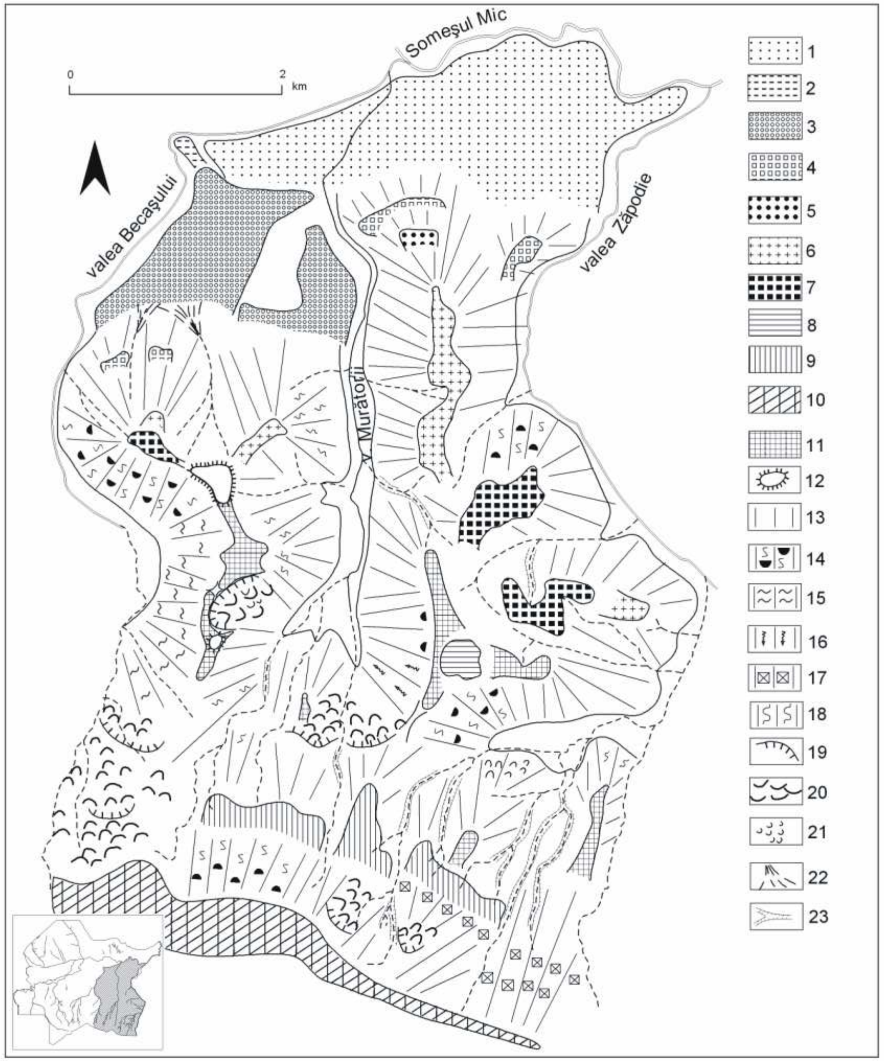
1= alluvium and Terraces I. (2-6 m); 2= Terraces II. (10-16 m); 3= Terraces III. (20-24 m); 4=Terraces IV. (30-45 m); 5= Terraces V. (60-75m); 6= Terraces VI. (100-110m); 7= Terraces VII. (125-140 m); 8= inferior erosion surfaces; 9= medium erosion surfaces; 10= superioar erosion surfaces; 11= stable slope; 12= active mobile slope with landslide and creep; 13= temporarily motionless landslides slopes, and creep; 14= sheet erosion;15= slope cowered with constructions; 16= derasion processes; 17= scarp with landslide; 18= landslides hummock (Pleistocene); 19= landslides hummock (Holocene); 20= alluvial cone; 21= erosion gullies; 22= abandoned quarry

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



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

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



1= alluvium and Terraces I. (2-6 m); 2= Terraces II.(10-16 m); 3= Terraces III.(20-24 m); 4=Terraces IV.(30-45m); 5= Terraces V. (60-75 m); 6= Terraces VI. (100-110 m); 7= Terraces VII. (125-140 m); 8= inferior erosion surfaces; 9= medium erosion surfaces; 10= superior erosion surfaces; 11= hill crest;12= residual;13= stable slope;14= active mobile slope with landslide and creep; 15= temporarily motionless landslide slope; 16= sheet erosion; 17= slope cowered with constructions; 18=holocene derazion processes; 19= scarp with landslide; 20= landslide hummock (Pleistocene); 21= landslide hummock (Holocene); 22= alluvial cone; 23= erosion gullies

Fig. 17. Geomorphological map of section betwen the Becaşu and Zăpodie valley

The *areas of small risk* cover the middle part of the slopes (quarter Zorilor and Zorilor Sud, Bună Ziua, Andrei Mureşanu 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 (Borzaş 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 Pleşca, Gârbăul and Boşor 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.

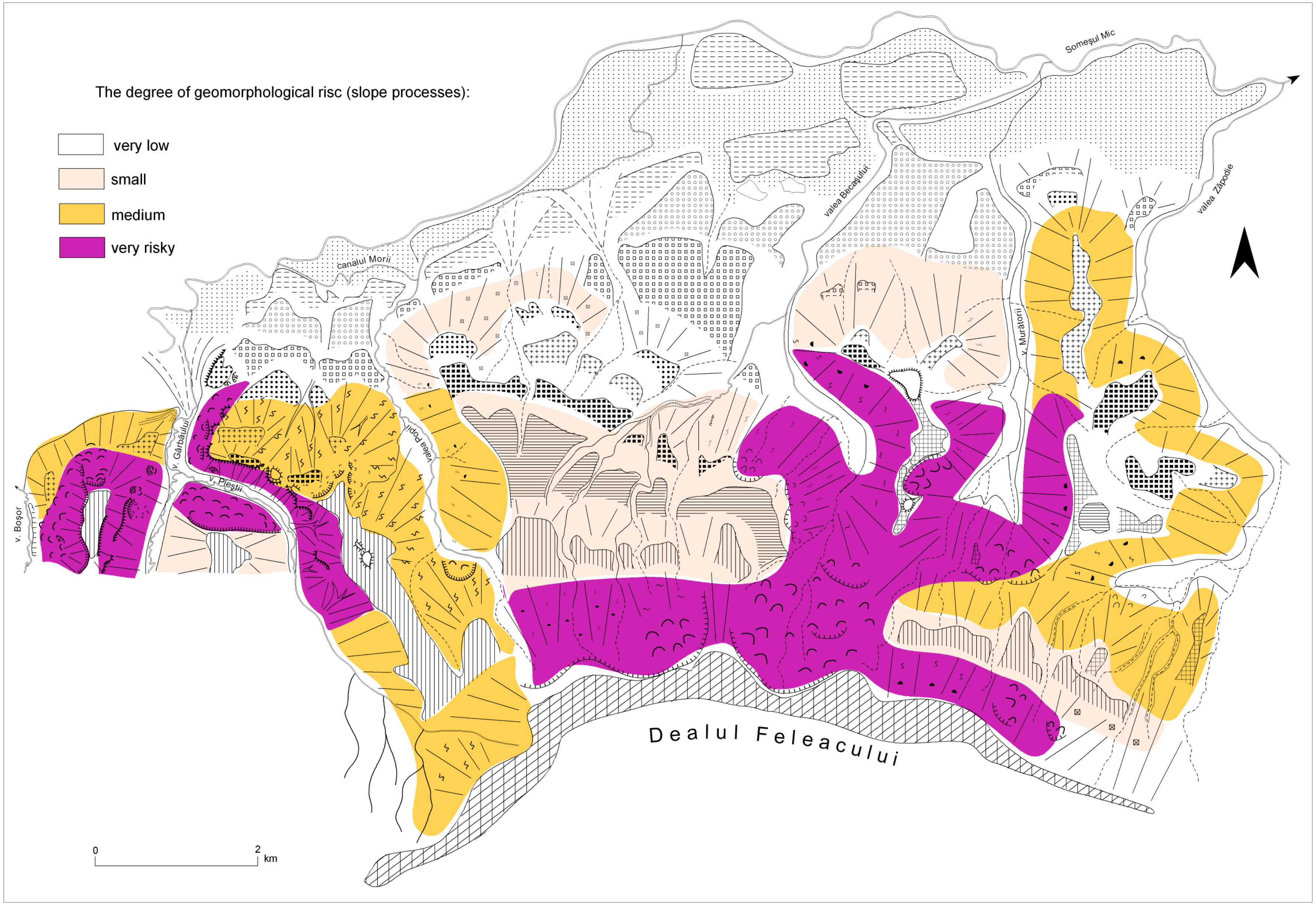


Fig. 18. The slopes on the right side of the river Someşul Mic: the map of susceptibility to slope processes

5.4. The slopes on the left side of the rivers Nadăs and Someşul Mic.

This region is to be found in the northern direction from the valley of the Nadăs and Someşul 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 Popeşti.

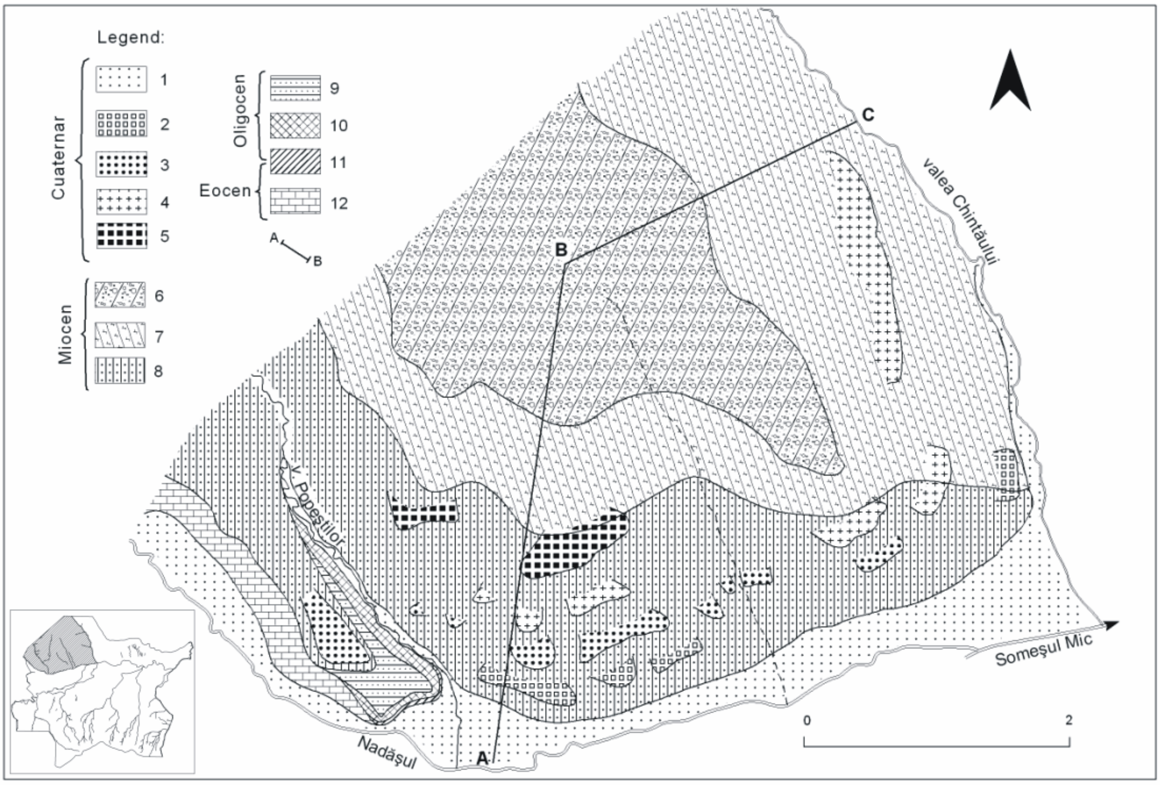
The two delimited sections are: the section between the valley of the Nadăş and Chintău and the section between the valley of Chintău and the Valley Caldă. They differ from the formerly discussed units in the dip and orientation of the slopes, in heights or in the characteristics of the relief and in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

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

To this section belong to units of different characteristics: the Viilor Hill (420 m) between the valley of the Nadăs and the valley Popeştilor; Lomb Hill (682 m, the peak of Popeşti) and Steluța Hill between the valley Popeştilor 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 Nadăş and Someşul Mic (the valley of Popeştilor 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.

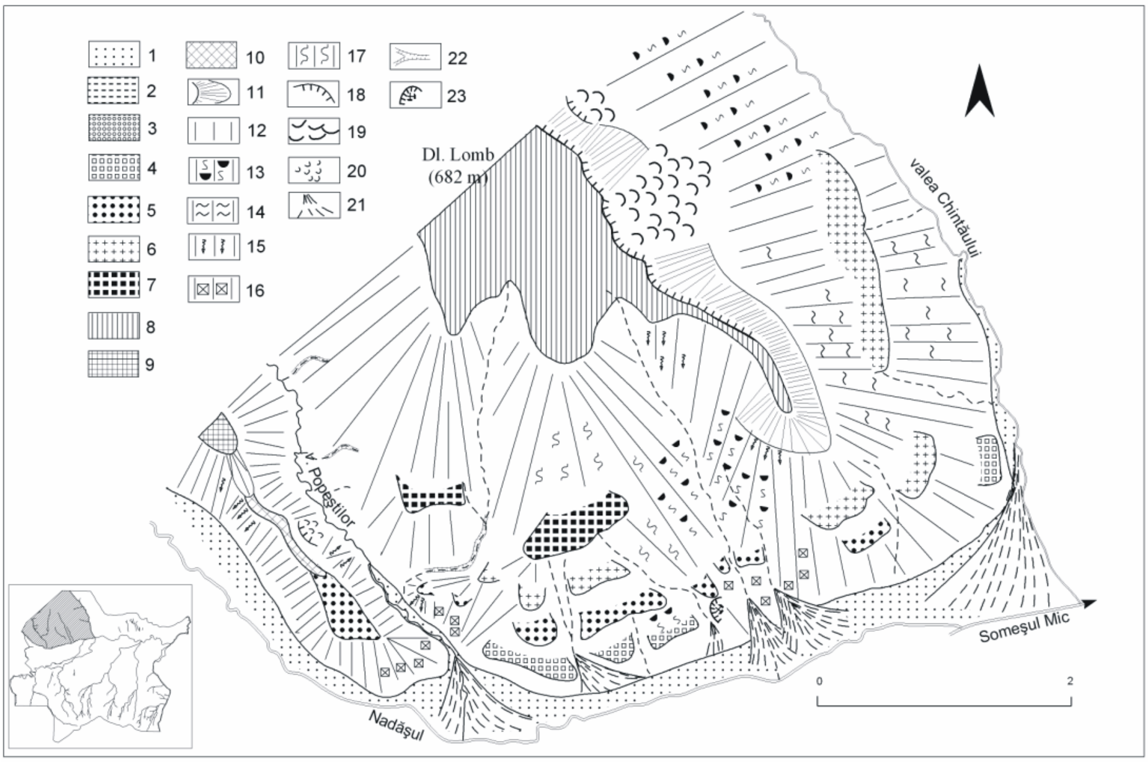
5.4.2. The section between the Valley of the Chintău and the Valley Caldă.

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



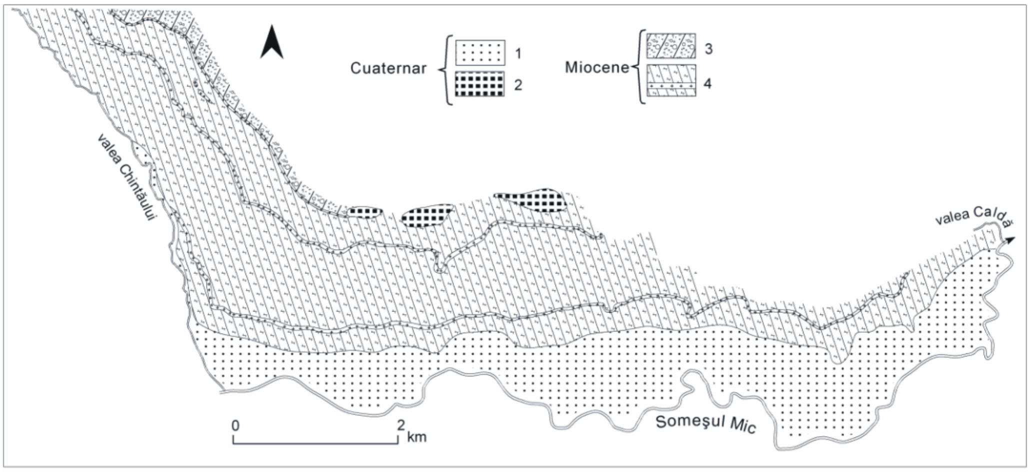
1=alluvium and Terraces I.; 2=Terraces IV; 3=Terraces V.; 4= Terraces VI. ; 5= Terraces VII.; 6= Feleac Formation; 7= Iris Marl Formation; 8= Dej Tuff Formation; 9= Moigrad and Dâncu Formation; 10= Hoia Limestone şi Mera Formation; 11= Brebi Marl Formation; 12= Cluj Limestone Formation

Fig.19. Geological map of section between the Popeşti şi Chintău valley
(modified from Meszaros, N., Clichic, O. 1976, 1988, Moraiu, T., Mac, I. 1967, Baciu, C. 2002)



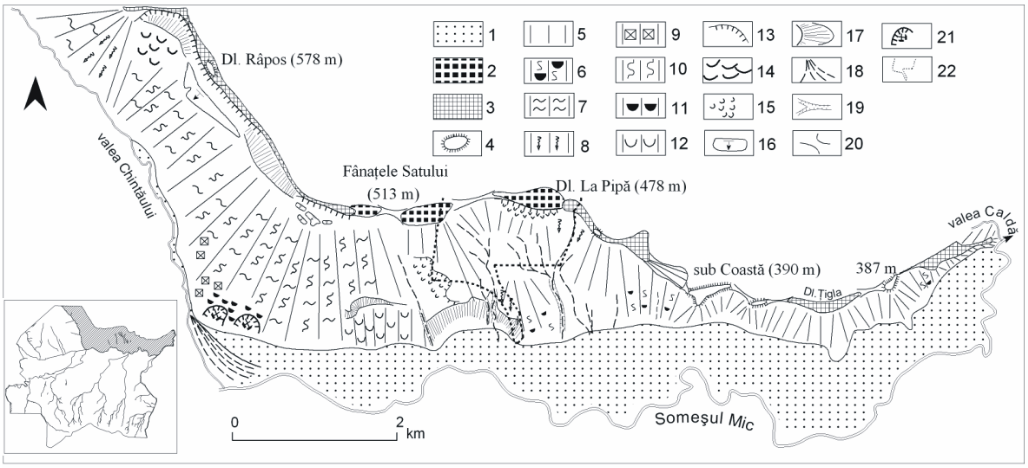
1= Alluvium and Terraces I.; 2= Terraces II.; 3= Terraces III.; 4=Terraces IV.; 5= Terraces V; 6= Terraces VI.; 7= Terraces VII.; 8= medium erosion surfaces; 9= structural surface; 10= watershed; 11= abrupt; 12= stable slope; 13= active mobile slope with landslide and creep; 14= temporarily motionless landslide slope; 15= sheet erosion; 16= slope cowered wit constructions; 17= derazion processes; 18= scarp with landslide; 19= landslide hummock (Pleistocene); 20= landslide hummock (Holocene); 21= alluvial cone; 22= erosion gullies; 23= abandoned quarry

Fig.20. Geomorphological map of section between the Popeşti and Chintău valley



1= alluvium and Terraces I.; 2= Terraces II.; 3= Feleac Sandstone Formation; 4= Iris Marl Formation with tuff

Fig.21. Geological map of section between the Chintău and Caldă valley
(modified from Meszaros, N., Clichic, O. 1976, 1988, Moraiu, T., Mac, I. 1967, Baciu, C. 2002, Wanek 2004)



1= aluvium and Terraces I.; 2= Terraces VII.; 3= structural surface; 4= residual; 5= stable slope; 6= active mobile slope with landslide and creep; 7= temporarily motionless landslide slope; 8= sheet erosion; 9= slope cowered with constructions; 10= derazion processis; 11= active mobile slope with landslide; 12= temporarily stable slope; 13= scarp with landslide; 14= landslide hummock (Pleistocene); 15= landslide hummock (Holocene); 16= glimee; 17= abrupt; 18= alluvial cone; 19= erosion gullies; 20= saddle; 21= abandoned querry; 22= Tineretului quater (proiect)

Fig.22. Geomorphologycal map of section between the Chintău and Caldă valley

The altitudes descend step by step from west towards east: the highest peak on Rapoş 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 Someşul 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 Nadăs and Someşul 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).

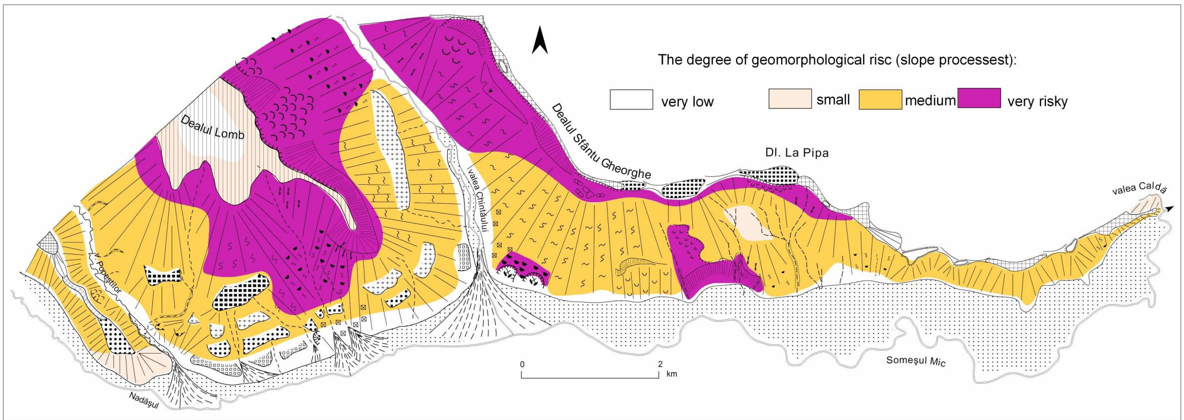


Fig. 23. The slopes on the left side of the rivers Nadăs and Someşul Mic: the map of susceptibility with slope processes

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 Chintău 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 – Cetățuie- 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 Cetățuia 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 Someşul Mic and the Nadăş 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 Someşul Mic and the valley of the Nadăs the area with pretabilty 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 Someşul Mic and the valley of the Nadăs, 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 Mănăştur Forest the Popii valley, the Borzaş Hill, the Rosetti street present a moderate risk of geomorphologic processes through the different processes of derasion (creep, sliding of the active terrain, pseudo-solifluctions), 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 Someşul Mic and the Nadăs, the upper section of the slopes with northern orientation of the Feleac 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.

Bibliografie

1. Asztalos L. (2004) – Kolozsvár, Helynév- és településtörténeti adattár, (Térkép melléklettel), Kolozsvár Társaság – Polis Kiadó, p. 613
2. Asztalos L. (2005) – A korai Kolozsvár, Rubicon Történelmi Folyóirat, XV. Éf.,152-153.szám,Bp.,p. 16-22.

3. Ádám L., Pécsi M. [ed.] (1985) – Mérnökgeomorfológiai térképezés, MTAFKI, Elmélet-Módszer-Gyakorlat, 33, Budapest
4. Baciu, C., Filipescu, S. (2002) – Structura geologică, , in: Cristea, V., Baciu, C., Gafta, D. [ed.]: Municipiul Cluj-Napoca şi zona periurbană. Studii ambientale, Ed. Accent, Cluj-Napoca, 25–36.
5. Baciu, C., Fărcaş, V., Bâlc, Ramona, Roşian, G., Maloş, C. (2009) – Planul Urbanistic General al Municipiului Cluj-Napoca, Capitol Geologie-Geomorfologie, Studiu preliminar, elaborator UBB din Cluj-Napoca, Fac. De Ştiința Mediului, 33 p.
6. Bălteanu D. (1983) – Experimentul de teren în geomorfologie (Aplicații la Subcarpații Buzăului), Editura Academiei RSR, Bucureşti
7. Bălteanu D., Alexe R. (2000) – Hazarde naturale şi antropogene, Corint, p. 108
8. Bălteanu D., Cheval S. Şerban M. (2004) – Evaluarea şi cartografierea hazardelor naturale şi tehnologice la nivel local şi național. Studiu caz, Institutul de Gf. al Acad. Române, Buc
9. Beaujeau-Garnier J., Chabot G. (1971) – Geografia Urbană, Ed. Șt., Bucureşti, p. 489
10. Benedek J. (2000) – A társadalom térbelisége és térszervezése, Risoprint, Kolozsv., p. 152
11. Benedek J. (2006) – Területfejlesztés és regionális fejlődés, Presa Univ. Clujeană, p. 299
12. Belozerov, V. (1972) – Clima oraşului Cluj şi împrejurimilor, Teză de doctorat, Universitatea „Babeş-Bolyai”, Facultatea de Biologie–Geografie, Cluj
13. Binard, M., Devillet, G., Erpicum, M. (2003) – La geographie appliquee a l`Universite de Liege, Societe Geographique de Liege, 43, pp. 127-139
14. Bogdan A. şi colab. (1967) – Contribuire la sistematizarea zonei preorăşeneşti a Clujului, Studia Univ. „Babeş-Bolyai”, p. 307-313
15. Brooks, S.M. (2003) – Slopes and slope processes: research over the pst decade, Progress in Phisical Geography 27/1, p.130-141
16. Brunsden, D., Doornkamp, J.S., Jones D.K.C. (1978) – Applied geomorphology: A British view, in: Geomorphology, Present Problems and Future Prospects, Oxford Univ. Press, p. 251-262
17. Brunsden D. (1993) – The nature of applied Geomorphology (First Europen Intensiv Cours on Applied Geomorphology), Univ. Studi di Modena – Erasmus, p. 3-11
18. Bullock, P. [ed.] (1991) – Soils in the Urban Environment, Blackwell Scientific Publication, Oxford
19. Buzilă, L., Perşoiu, A., Surdeanu, V. (2001) – Dinamica alunecării de teren de pe strada Dragalina, Revista de Geomorfologie, nr. 3. 119–122, Bucureşti.
20. Buzilă, L., Drăguț, L., Drăguleanu, C., Baciu, C. (2002) – Geomorfologia şi riscul geomorfologic, in: Cristea, V., Baciu, C., Gafta, D. [ed.]: Municipiul Cluj-Napoca şi zona periurbană. Studii ambientale, Ed. Accent, Cluj-Napoca, 15–24.
21. Carvalho Anna, Santos M. (1960) – A Geografia Aplicada, Publicationes da Universidade da Bahia, Brasilia, p. 34
22. Chorley R.J., Schumm S.A., Sugden D.E. (1985) – Geomorphology, University Press, Cambridge, p. 607
23. Cholnoky J. (1919) – A kolozsvári Feleki-hegy, Földrajzi Közlemények, p. 32-40
24. Clichici, O, Nistor, P., Tövissy, V. (1990) − Raionarea geotehnică a municipiului Cluj-Napoca, Studia Univ. Babeş–Bolyai, ser. Geogr., XXXV/1., Cluj, 101–109.
25. Coates D.R. (1976) – Geomorphic engineering, (Geomorphology and Engineering), Hutchinson&Ross, Stroudsberg, p. 3-21
26. Cooke R.U., Doornkamp J.C, Brunsden, D. and Jones D.K.C. (1983) – Urban geomorphology in Drylands, Oxford Univ. Press
27. Cooke R.U., Doornkamp J.C (1974, 1990) – Geomorphology and Environmental Management, Calderon Press, Oxford, p. 413
28. Craig, R.G., Craft, J.L. (1982) – Applied geomorphology, Allen and Unwin, London
29. Cristea, V., Baciu, C., Gafta, D. [ed.] (2002) –Municipiul Cluj-Napoca şi zona periurbană, Studii ambientale, Edit. Accent
30. Crişan I., Zemianschi S., Cacoveanu H. (1994) – Corelații geomorfo-pedogenetice pe tipuri de versanți în împrejurimile municipiului Cluj-Napoca, Studia UBB,G, p. 33-39
31. Croitoru, Adina-Eliza (2006) – Excesul de precipitații din Depresiunea Transilvaniei, Editura Casa Cărții de Ştiință, Cluj-Napoca
32. Csapó I. (1951) – Cartografiere solurilor din regiunea Cluj-Floreşti, Buletin Ştiințific, secțiune de Ştiințe Biologice, Agronomice, Geologice, Geografice, p. 112 – 169
33. Csetri E. (2005) – Kolozsvár népessége, Rubicon Történelmi Folyóirat, XV. Évf., 152-153.szám,Bp.,p.6-13.
34. Csima P. (2006) – A települések antropogén geomorfológiai sajátosságai. Az antropogén geomorfológia és a felszínalakítás települési sajátosságai. „Antropogén geomorfologia” edit. Szabó J.–Dávid L., Kossuth Egyetemi Kiadó, Debrecen, p. 191-201

35. Demeter G, Szabo Sz. (2008) – Morfometriai és litológiai tényezők kapcsolatának kvantitativ vizsgálata a Bükkben és északi előterében (A statisztikus felszinelemzés alkalmazásának lehetőségei a geomorfológiában), Debrecen, 183 p.
36. Doornkamp J.C (1982) – Applied geography, Nottingham Monograph in Applied Geography, p. 1-53
37. Drăguț I. (2000) – Evaluarea peisajelor geografice din teritoriul administrativ al municipiului Cluj-Napoca, Studia UBB, G, p. 11-15
38. Dumitrescu, I. (1968) – 10. Cluj, Harta geologică, Scara 1:200 000. Redactori: Saulea, Emilia, Dumitrescu, I., Bombiță, Gh., Marinescu, Fl., Borcoş, M., Stancu, Iosefina, Buc.
39. Fărcaş, I. (1999) – Clima urbană, Casa Cărții de Ştiință Cluj, p. 124
40. Filip, S. (2008) – Depresiunea şi Munceii Băii Mari, Presa Universitară Clujeană, p. 248
41. Filipescu, S. (2002) – Stratigrafie, Presa Univ. Clujeană, p. 277
42. Florea, M.N. (1979) – Alunecări de teren şi taluze, Editura Tehnică, Bucureşti, p. 301
43. Fuchs H. (1961) – Őséletnyomok az erdélyi középsőmiocén tenger partszegélyi övezetéből. Földt. közl. 91/1. 73–77. Budapest.
44. Gábris Gy. (2007) – Földfelszín és éghajlat, ELTE Eötvös Kiadó, Budapest, 225 o..
45. Gaal Gy. (2001) – Kolozsvár. Polis Könyvkiadó, Kolozsvár, p. 185
46. Géczi R., Bódis K. (2001) – Az emberi hatás mértékének térbeli megoszlása Kolozsváron, Földrajzi Konferencia, Szeged
47. Goțiu D., Surdeanu V. (2006) – The challenge of interdisciplinarity in integrated risc assesment, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj, p. 55-61
48. Goțiu, Dana, Surdeanu, V. (2007) – Noțiuni fundamentale în studiul hazardelor naturale, Presa Universitară Clujeană, Cluj-Napoca
49. Goțiu, Dana, Surdeanu, V. (2008) – Hazarde naturale şi riscuri asociate din Țara Hațegului, Presa Universitară Clujeană, Cluj-Napoca
50. Grigore, M. (1979) – Reprezentarea grafică şi cartografică a formelor de relief, Ed.Acad. RSR, Buc., p. 247.
51. Grecu F. (2003) – Aspecte ale reprezentării cartografice ale riscului geomorfologic, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 323-331
52. Grecu F. (2004) – Hazarde şi riscuri naturale, Ed. Univ, Buc.,p. 168
53. Haidu I. (2002) – Analiza de frecvență şi evaluarea cantitativă a riscurilor, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 180-207
54. Hațieganu, Alexandrina M. (1949) – Evoluția teritorială a oraşului Cluj, Extras din lucrărileinstitutului de Geografie, vol. VIII., 1947, Cluj
55. Hosu, Al. (1999) – Arhitectura sedimentației depozitelor eocene din nord-vestul Depresiunii Transilvaniei, Editura Presa Universitară Clujeană, Cluj-Napoca
56. Houhtalen, R.J., Akan, A.O. (2003) – Urban Hydrology, Hydraulics and Stormwater qualitz, John Wilez
57. Ielenicz M. (2005) – Geomorfologie, Editura Universitară, Bucureşti, p. 344
58. Irimuş I.A., Sanda Zemianschi (1992) – Observații asupra fenomenelor geomorfologice de risc în sectorul căii ferate Salva-Vişeu, An. Univ. Oradea, tom. II, geografie, p. 29-34
59. Irimuş, I.A. (1997) – Cartografiere geomorfologică, Editura „Focul Viu”, Cluj-Napoca
60. Irimuş, I.A. (1998) – Relieful pe domuri şi cute diapire în Depresiunea Transilvaniei, Presa Univ. Clujeană, Cluj-Napoca, p. 299
61. Irimuş I.A. (2002) – Riscuri geomorfice în regiunea de contact interjudețeană din nord-vestul României, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj-Napoca
62. Irimuş I.A. (2006) – Vulnerabilitatea şi riscuri asociate proceselor geomorfologice în planningul teritorial, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj-Napoca
63. Irimuş I.A. (2006) – Hazarde şi Riscuri asociate proceselor geomorfologice în aria cutelor diapire Depresiunea Transilvaniei, Casa Cărții de Ştiință, Cluj-Napoca, p. 287
64. Irimuş, I.A. et al. (2009) – Climatic and antropogenic conditions in the transylvanian dynamics of the landscapes, Studia Universitatis Babeş-Bolyai, LIV,1, p. 7-18
65. Irimuş, I.A. et al. (2010) – Vulnerability of Cluj urban area to contemporary geomorphologic processes, Studia Universitatis Babeş-Bolyai, LV,1p. 19-32
66. Jakab E. (1870, 1888) – Kolozsvár története (I.− III.), Buda
67. Jakab E. (1870) – Kolozsvár története, világositó rajzai, Buda
68. Jones, D.K.C. (1980) – British applied geomorphology: in apprasial, Zeits für Geomorphology, 36.,pp.48-73
69. Krézsek, Cs, Filipescu, S. (2005) – Middle to late Miocene sequence stratigraphy of the Transylvanian Basin (Romania), Elsevier, Tectonophysics 410, p. 437-463
70. Koch A. (1879) – Kolozsvár vidéke forrásviszonyainak egy érdekes példája. Orv. Term.tud. Ért. II. szak. I(IV)/I. 1–3. Kolozsvár.
71. Koch A. (1888) – Új adatok a kolozsvárvidéki diluviális fauna ismeretéhez. Orv. Term.tud. Ért. II. szak. X(XIII)/I. 13–18. Kolozsvár.

72. Koch A. (1894) – Az erdélyrészi medence harmadkori képződményei. I. Paleogén csoport, MKFI Évk., X., Budapest, 159–358
73. Legget R.F. (1976) – The role of geomorphology in planning (Geomorphology and Engineering), Hutchinson&Ross, Stroudsberg, p. 315-328
74. Leighton B.F. (1976) – Geomorphology and engineering control of landslides (Geomorphology and Engineering), Hutchinson&Ross, Stroudsberg, p. 273-287
75. Loczy D. (2006) – Az antropogén geomorfológia szerepe a környezetgazdálkodásban. „Antropogén geomorfologia” [ed.] Szabó J.–Dávid L., Kossuth Egyetemi Kiadó, Debrecen, p. 31-46
76. Mac, I. (1969) – Subcarpaţii Transilvaniei dintre Mureş şi Olt, Teza de doctorat
77. Mac, I. (1980) – Modelarea diferenţiată şi continuă a versanţilor din Depresiunea Transilvaniei. Stud. UBB, Geol-Geog, XXV, 2, pp. 60-66
78. Mac I. (1986) – Elemente de geomorfologie dinamică, Ed. Acad, p. 207
79. Mac I., Irimuş I.A. (1991) – Zonele susceptibile fenomenelor geomorfologice de risc în sectorul căii ferate Apahida-Câmpia Turzii, Studia Univ. „Babeş-Bolyai”, ser. Geogr., XXXVI, nr. 1, p. 3-8
80. Mac, I., Irimuş, I., Zemianschi, Sanda (1995) – Pretabilitatea reliefului pentru amenajările urbane în zona Turda, Studia Univ. Babeş–Bolyai, ser. Geogr., XL/1, p. 25–29, Cluj-N..
81. Mac I., Zemianschi, Sanda (1995) – Precizări referitoare la terminologia şi definirea depozitelor de cuvertură, Studia Univ. Babeş–Bolyai, ser. Geogr., XL/1., p. 35–39, Cluj-N
82. Mac I. (1996) – Geomorfosfera şi geomorfosistemele, Ed. Presa Univ. Clujeană, p. 365
83. Mac I., Petrea D. (2002) – Polisemnia evenimentelor geografice extreme, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărţii de Ştiinţă, Cluj Napoca, p. 11-23
84. Mac, I., Pendea, I. (2002) – Consideraţii asupra morfologiei periglaciare din depresiunea Transilvaniei, Studia Univ. Babeş–Bolyai, ser. Geogr., XLVII/2., Cluj, 17–24.
85. Mac I., Petrea D. (2003) – Sisteme geografice de risc, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărţii de Ştiinţă, Cluj Napoca, p. 13-26
86. Mac I., Rus I., Şerban Gh. (2003) – Cartografierea, o alternativă în evaluarea riscurilor naturale, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărţii de Ştiinţă, Cluj Napoca, p. 313-322
87. Mac, I. (2008) – Geografie normativă, Presa Universitară Clujeană, 413
88. Mac I., Sorocovschi V., Maier A. (1979) – Forme ale complexiunii geografice în structura peisajului Podişului Someşean şi a zonelor sale de bordură, Studia UBB, GG, p. 55-63
89. Marosi S., Szilárd J. (1969) – A lejtőfejlődés néhány kérdése a talajképződés és talajpusztulás tükrében, MTA FKI , p. 53-65
90. Martiniuc, C., Safca-Schram, M. (1957) – Cercetări geomorfologice asupra regiunii Criveşti – Docani din bazinul Bârladului, An. Şt. Univ. „Al. I. Cuza”, Iaşi, tom. III, seria II, fasc. 1, p. 423-439
91. Martiniuc, C., Băcăuanu, V. (1959) – Harta geomorfologică a oraşului Iaşi, An. Şt. Univ. „Al. I. Cuza”, Iaşi, tom. V, seria II, p. 182-190
92. Martiniuc, C., Băcăuanu, V. (1962) – Contribuţii la studiul geomorfologic al teritoriului oraşului Suceava şi al împrejurimilor sale, An. Şt. Univ. „Al. I. Cuza”, Iaşi, tom. VI, seria II, fasc.4, p. 371-384
93. Martiniuc, C., Donisă, I., Hârjoabă, I. (1962) – Geomorfologia teritoriului oraşului Vatra Dornei, An. Şt. Univ. „Al. I. Cuza”, Iaşi, tom. VIII, seria II, p.45-56
94. Martiniuc C., Băcăuanu V. (1963) – Cercetări de geomorfologie aplicată în sprijinul sistematizărilor urbane şi rurale din Moldova, An. Şt. Univ. „Al. I. Cuza”, Iaşi, p. 91-101
95. Martonne, E. de (1922) – Dealurile terţiare ale Clujului, p. 217 – 223
96. Mészáros, N. (1957) – Fauna de moluşte a depozitelor paleogene din Nord-Vestul Transilvaniei. Bibl. Geol. Paleont.. 1. Ed. Acad. R. P. R. 174. Bucureşti
97. Mészáros, N. (1963) – Paleogeografia depozitelor marine eocen-superioare de la vest şi sud-vest de Cluj. Asoc. Geol. Carpato-Balc, Congr. V. Buc. 4–19 sept. 1961. III/1. Com. şt., Secţ. II. Stratigr. 307–312. Buc.
98. Meszaros N., Marosi P. (1967) – Orizonturile acvifere din împrejurimile oraşului Cluj, 9. 215-223
99. Meszaros N., Clichici, O. [ed.] (1976) – Pe poteci cu bănuţei de piatră (Ghid geologic al zonei Cluj), Editura Sport-Turism, Bucureşti, p. 159
100. Mészáros, N., Clichici, O. (1988) La géologie du municipe Cluj-Napoca. Studia Univ. Babeş–Bolyai, geol.–geogr. XXXIII/1. 51–56. Cluj–Napoca.
101. Mihăiescu, R; Man, T.; Oncu, M. (2004) – Evaluarea riscului de eroziune a solului în bazinul Someşului Mic prin aplicarea modelării GIS, editor Sorocovschi V, Ed. Casa Cărţii de Ştiinţă, Cluj Napoca, p. 251-261
102. Mihăilescu V. (1964) – Contribution de la geographie a l’elaboration des projets de systematisation territoriale (region et villes) en Roumanie entre 1948-1963, Rev. Roum. Geol.Geoph.Geogr., serie de geographie, tom. 8, p. 219-222
103. Mihăilescu V., Herbst C., Băcănaru I. (1964) – Methods of geographical reserch of towns in Rumania, Rev. Roum. Geol.Geoph.Geogr., serie de geographie, tom. 8, p. 5-11

104. Mihăilescu V. (1968) – Geografie teoretică. Principii fundamentale. Orientare generală în științele geografice. Edit. Academică R.S.R., București
105. Mihăilescu V. (1969) – Geografia aplicată în România, Lucrări de geografie aplicată, p. 1-7
106. Moisescu, V. (1968): Cercetări geologice în împrejurimile oraşului Cluj, Sud. cerc. geol, geofiy., geogr., Geol., 13/2., Bucureşti, 491–503.
107. Morariu T., Pascu Şt. (1957) – Evoluția urbanistică a oraşului Cluj, Bul. Şt., Secția G.G., Cluj-N., p. 47-73
108. Morariu T., Pascu Şt. (1957) – Considerații geografico-istorice asupra etapelor de dezvoltare a oraşului Cluj, p. 325 – 335
109. Morariu, T., Gîrbacea, V. (1959) – Terasele râurilor din Transilvania, Studia UBB, Geologie-Geographie, pp. 539-545, Cluj
110. Morariu T., Tufescu V. (1964) – Problemes de geomorphologie appliquee en Roumanie, Rev. Roum. Geol.Geoph.Geogr, serie de geographie, tom. 8, pp. 213-218
111. Morariu, T., Diaconeasa, B., Gârbacea, V. (1964) – Age of Land-Sliding in the Transylvanian Tabeland. Rev. roum. géol. géophys. géogr., Géogr. 8. 149–157. Bucharest
112. Morariu T. (1967) – Actual problems of applied geomorphology in Romania, Simpozium de geomorphologie appliquee Bucarest-Cluj
113. Morariu T, Mac I. (1967) – Regionarea geomorfologică a teritoriului oraşului Cluj şi împrejurimilor, Studia UBB, p. 75 -88
114. Morariu T., Gârbacea, V. (1968) – Studii asupra proceselor de versant din Depresiunea Transilvaniei, Studia UBB, Geologia-Geographia, vol. I, Cluj, pp. 81-90
115. Mózes H., Turánitz J. L [ed.] (1993) – Térképlapok Kolozsvár történetéből. Erdélyi Szépmíves Céh, Kolozsvár
116. Nicorici, E., Bucur, I. (1994) – Noutăți geologice în zona municipiului Cluj–Napoca. Simpoz. jub. geol. 75 ani înf. Univ. Daciei Sup., Cluj–Napoca, 2–5 iun. 1994. [előadás]
117. Nyárádi E. Gy. (1941) – A kolozsvári Szénafüvek suvadásos tereületeiről, Földrajzi közlemények, p. 40-52
118. Orosz E. (1903) Őslénytani adatok az erdélyi medence területéről. Orv. Term.tud. Ért. II. szak. XV(XIX)/III. 196–207. Kolozsvár.
119. Panizza M. (1993) – Geomorfologia applicata, La Nuova Italia Scientifica, Roma, p. 340
120. Pascu, Şt. (1974) – Istoria Clujului, Consiliul Popular al Municipiului Cluj
121. Pávay E. (1871) – Kolozsvár környékének földtani viszonyai, Magyar Királyi Földtani Intézet Évkönyve, Khór és Wein Könyvnyomdája, Pest, pp. 327-472
122. Pécsi M. (1970) – A mérnöki geomorfológia problematikája, Földr. értesítő, XIX, 4. füzet, p. 369-379
123. Pécsi M. (1971) – Geomorfológia (mérnökök számára), Tankönyvkiadó, Bp.
124. Pécsi M. (1991) – Geomorfológia és domborzatminősítés, Tudományos Akadémia, Bp., p. 296
125. Pécsi M. (1997) – Szerkezeti és váztalajképződés Magyarországon (Tekintettel a deráziós – korráziós – domborzatalakulásra, talajhordalék- és üledékképződésre a negyedidőszak során), MTAFKI, Budapest
126. Pendea, I.F. (2005) – Paleomediile geomorfologice ale cuaternarului superior în Depresiunea Transilvaniei (Eemian-Weichselian-Holoce), Teză de doctorat, UBB, Fac. de Geografie
127. Perry N.H. (1969) – Geography and local government reform (Trends in Geography – An Introductory Survey), p. 233-243
128. Philipponneau, M. (1960) – Geographie et Action, Colin, Paris
129. Piciu, T., Simihăian, Marinela, Stan, Georgeta (2002) – Aspecte pedologice, in: Cristea, V., Baciu, C. [ed.]: Municipiul Cluj-Napoca şi zona periurbană. Studii ambientale, Ed. Accent, Cluj-Napoca, 67–79
130. Pop, Gr. (2001) – Depresiunea Transilvaniei, Editura Presa Universitară Clujeană, Cluj Napoca
131. Pop, Gr.. (2007) – Județul Cluj, Seria Județele României, Editura Academiei Române, Bucureşti, p. 277
132. Posea Gr. (1961) – Relieful de cuestă din apropierea Clujului, p. 1-10
133. Posea Gr. (1962) – Aspecte de relief din jurul Clujului, Geographia, p. 119-139
134. Posea Gr. (1963) – Folosirea practică a reliefului de cuestă din zona Căpuş – Cluj, Probleme de geografie, vol. IX, Editura Academiei, p. 273-279
135. Posea, Gr., Popescu, N., Ielenicz, M. (1974) – Relieful României, Editura Ştiințifică, Bucureşti
136. Posea, Gr., Grigore, M., Popescu N., Ielenicz M. (1976) – Geomorfologie, Ed. Didactică şi Pedagogică, Bucureşti, p. 535
137. Rădoane, Maria, Rădoane N., Ichim I., Surdeanu V. (1999) – Ravenele. Forme, procese, evoluție. Ed. Presa Universitară, Cluj-Napoca, p. 268
138. Rădoane, Maria, Dumitru, D., Ichim, I. (2000) – Geomorfologie I, II. (ediția a II-a) Editura Universității Suceava, Suceava, p
139. Rădoane, Maria, Rădoane I. (2004) – Geomorfologia aplicată în analiza hazardelor naturale, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 57-68
140. Rădoane, Maria, Rădoane, N. (2007) – Geomorfologie aplicată, Editura Universității Suceava, p. 377
141. Rotunjeanu, I. (2005) – Stabilitatea versanților şi taluzurilor, Editura Infomin, Deva, p.351

142.Rózsa P. (2006) – Az ember felszínformáló tevékenzségének mennyiségi és minőségi értékelése – antropogén geomorfológiai szintézis. „Antropogén geomorfologia” Szabó J.–Dávid L. [ed.], Kossuth Egyetemi Kiadó, Debrecen, p. 291-313
143.Rusu, A (1970) – Corelarea faciesurilor Oligocenului din regiunea Trezena−Bizuşa (nord-vestul Bazinului Transilvaniei), St. cerc. geol. geof. geog. , Seria geol., t. 15, nr. 2, p. 513-525, Bucureşti
144.Rusu, A. (1972) – Semnalarea unui nivel cu Nucula comta în Bazinul Transilvaniei şi implicațiile lui stratigrafice, Dări de Seamă ale Şedințelor, Inst. Geol., vol. LVIII/4 (1971), p. 265-282, Bucureşti
145.Rusu, A. (1977) – Stratigrafia depozitelor Oligicene din nord-vestul Transilvaniei (regiunea Treznea−Hida−Poiana Blenchii), Anuarul Inst. de Geol. Geof., vol. LI, p. 69-225, Bucureşti
146.Rusu, A., Brotea, Despina, Ionescu, Ana, Nagymarosi, A., Wanek F. (1993) – Biostratigrafic Study of the Eocene-Oligocene Boundary in the Type Section of the Brebi Marls (Transylvania, Romania). Rom. J. Stratigraphy, 75., p. 71–82, Bucureşti.
147.Savu, Al. (1963) – Podişul Someşan, Teza de doctorat
148.Savu, Al., Mac, I., Tudoran, P. (1973) – Aspecte privind geneza şi vîrsta teraselor din Transilvania, in: Realizări în geografia României, Ed. Ştiinț., Bucureşti, 169–175.
149.Schreiber, W.E. (1994) – Munții Harghita – Studiu geomorfologic; Editura Academiei Române, Buc, p. 134
150.Schreiber, W. E. (2000) – The Neogene and the Quaternarz evolution of the Feleac hilly massif relief, Geomorphology of the Carpatho–Balcan Region, Edit. Bălteanu, D., Ielnicz, M., Buc., pp. 107-112
151.Schreibert, W.E. [ed.] (2003) – Analiza peisajelor geografice din partea de vest a Câmpiei Transilvaniei, Presa Universitară Clujeană, p. 135
152.Schweitzer F., Tiner T. (1996) – A mérnökgeomorfológiai kutatások szerepe a nagylétesítmények telephely kiválasztásában, MTA FKI, Bp., p. 17-89
153.Sorocovschi V. (2005) – Prevenirea riscurilor naturale, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 39-58
154.Soroconschi V., Mac I. (2004) – Percepţia environmentală şi răspunsurile umane faţă de risc, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 25-38
155.Strida, M. [ed.] (1966) – La geographie applique dans le monde – Applied geography in the world, Academia, Prague
156.Surdeanu, V. (1975) – Alunecările de teren din valea Bistriței în sectorul Bicaz-Piatra Neamț, Lucrările Stațiunii Stejarului, Geologie Geografie, Iaşi
157.Surdeanu, V. (1975) – Dinamica alunecărilor de teren din zona lacului Izvorul Muntelui, Lucr. Simpozion. Naț. de Geomorfologie Aplicată şi Cart. Geomorfologică, Iaşi
158.Surdeanu V. (1976) – Le glisement de terrain de Ticoş, Anuarul Muzeului SN, Piatra Neamț, G.G. tom. III. Piatra Neamț
159.Surdeanu V. (1982) – Rolul proceselor geomorfologice actuale în modelarea reliefului din valea Racovei (jud. Vaslui) Lucr. St. I.I.S. Bacău
160.Surdeanu V. (1998) – Geografia terenurilor degradate. Alunecări de teren. Presa Univ. Clujană, Cluj – Napoca, p. 273
161.Surdeanu V. (2002) – Gestionarea riscurilor – o necesitate a timpurilor noastre, Rev. „Riscuri şi catastrofe”, Editor Sorocovschi V, Ed. Casa Cărții de Ştiință, Cluj Napoca, p. 37-42
162.Surdeanu V., Goțiu, Dana, Rus, I., Crețu, Andrea (2006) – Geomorfologie aplicată în zona urbană a municipiului Cluj-Napoca, Revista de geomorfologie, vol. 8, pp. 25-34
163.Surdeanu V., Rus, I., Goțiu, Dana (2007) – Perceperea hazardelor naturale într-o lume în schimbare – perspectiva Românească, Global Changes and Problems, Bulgaria
164.Surdeanu V., Rus, I., Irimus, I.A., Danut, P., Cocean, P. (2009) – Rainfall influence on landslid dynamics (Carpathian flisch area, Romania), Geogr. Fis. Dinam. Quat., 32, pp. 89-94
165.Şuraru, N., Meszaros, N., Petrescu, I., Gabos, L., Codrea, V., Barbu, O. (1991) – Considerații generale asupra biostratigrafiei badenianului din regiunea de nord-est a municipiului Cluj-Napoca, Stud. Univ. Babeş-Bolyai, Geol., an. XXXVI, nr. 2, p. 51-65
166.Szabo J. (1996) – Csuszamlásos folyamatok szerepe a magyarországi tájak geomorfológiai fejlődésében, Kossuth Egyetemi Kiadó, Debrecen, p. 224
167.Szádeczky Kardoss Gy. (1918) – Pusztító kőomlás a kolozsvári Fellegváron, Term.tud.közl.,L.,Bp,167–173.
168.Szádeczky K. E. (1935) – Újabb adatok városunk geológiájához, Erd. Múz., Új foly. VI., Kv., 269–282.
169.Szentpétery Zs. (1914) – Adatok Kolozsvár ősemlőseinek ismeretéhez, Múz. Füz., II/1., Kolozsvár, 58–77.
170.Tinkler Keith J. (1985) – The short history of geomorphology, Ed. Croom Helm, London, p. 317
171.Tövissi, I. (1989) – The role of the clay minerals from the Oligocene layers int he geomorphological evolution of the slopes, in: Petrescu, I [ed.]: The Oligocene from the Transylvanian Basin, Geological Formations of Transylvania, Romania, 3., Cluj-Napoca, 519–528.
172.Tövissiné L. Ibolya (2004) – Kolozsvár építésföldtani sajátosságairól, Földt.Közl.,134/4.,Bp.,589–600.

173. Treiber I., Tovissi J., Cormos D. (1973) – Studiul alunecărilor de teren de pe versantul sudic dealului Cetățuia – Cluj, p. 19-27
174. Tricart J. (1962) – L'epiderme de la terre. Esquisse d'une geomorphologie appliquee. Ed. Masson&Cie, Paris
175. Tricart J. (1964) – Panorama de la Geomorphologie appliquee dans le monde, Extrait de la Revue Generale des Sciences, Paris
176. Tufescu V., Velcea I. (1964) – Study and mapping of land use in Rumania, Rev. Roum. Geol.Geoph.Geogr, serie de geographie, tom. 8, p. 234-237
177. Tufescu I. (1966) – Modelarea naturală a reliefului şi eroziunea accelerată, Edit. Academică, Buc., p. 618
178. Tulippe, O. (1964) – Les applications de la geographie en Belgique, Liege, in. Földtani Közlemények [1966], pp. 358-359
179. Tulogdy J. (1930) – Kolozsvár környékének geomorfológiai kialakulása, EME, p. 34-52, Kolozsvár
180. Tulogdy J. (1925) – Kolozsvár környékének pleisztocén képződményei, EME, p. 1-8
181. Xántus J. (1942) – Földomlás a Fellegváron, Erdély, XXXIX/5. (347.), Kolozsvár, 70–75
182. Vâlsan G. (1916) – Asupra trecerii Dunării prin Porțile de Fier, Studiu de geografie critică, în Buletinul Societății Regale Române de Geografie, Bucureşti
183. Vâlsan G. (1945) – Procese elementare în modelarea scoarței terestre, Bucureşti
184. Velcea, Valeria (1967) – Probleme de geografie aplicată în masivele Bucegi, Postăvaru – Piatra Mare şi Gârbova, Studia Univ. Babeş-Bolyai, Series Geog.-Geol., fascic. 2
185. Verstappen, H.Th. (1983) – Applied Geomorphology (Geomorphological Surveys for Environmental Development), Elsevier, Amsterdam-Oxford-New York, p. 440
186. Vlaicu-Tătărîm, N. (1963) Stratigrafia eocenului din regiunea de la Sud-Vest de Cluj. Ed. Acad. 204., Buc.
187. Wanek F., Korodi Enikő, Gyapai Sz. (2007) – Kolozsvár területének csuszamlás- és omlásveszélyeztetettsége – in: Máté Cs. et al. [szerk.]: III. Kárpát-medencei Környezettudományi Konferencia, 2007. március 29–31., Kolozsvár, Sapientia, EMTE, Term.tud. Kar, 232–237, Kolozsvár.
188. Wanek, F., Poszet, Sz. (2008) – Slope danger on the territory of Cluj-Napoca resulting from the geological structure and morphology of the hills between the river Someşul Mic and the valley of Nadăş (between the Cetățuia and Tăietura Turcului), Acta Pericemonologica, Debrecen, p. 83-92
189. Wanek, F., Poszet, Sz. (2009) – Slope danger on the territory of Cluj-Napoca resulting from the structure and morphology of the hills between the river Someşul Mic and the valley of Nadăş (between Tăietura Turcului and Cheile Baciului, Acta Universitatis Sapientiae, Agr. and Environment, Volume 1, p. 79-89
190. Wanek F. (2010) – A Szamosfalvi-fürő adottságai, múltja és jövője., A Kárpát-medence ásványvizei, VII. Nemzetközi Tudományos Konferencia, pp. 41-51, Csíkszereda
191. Wanek, F., Poszet Sz. (2010) – A Kis-Szamos jobb oldali lejtőinek földtani felépítéséből és morfológiájából adódó lejtőveszélyeztettség Kolozsvár területén (a Bocsor-patak és a Papok-völgye) között, VI. Kárpát-medencei Környezettudományi Konferencia, Nyíregyháza
192. Wanek F., Poszet Sz., Korodi Enikő, Gyapai Sz. (2010) – Tanulságok Kolozsvár földtani és felszínalaktani rizikóinak eddigi kutatása alapján – Erdélyi Magyar Műszaki Tudományos Társaság, XII. Bányászati, Kohászati és Földtani Konferencia, Nagyenyed, 2010. április 8–11. EME, 191–195, 1 fig., Kolozsvár.
193. Young, A. (1975) – Slopes, London, 288 p.
194. Zaruba, Q., Mencl, V. (1983) – Landslides and their control, Academia, Praha, 1982
195. *** GT 019-98 (2000) – Ghid de redactare a hărților de risc la alunecare a versanților pentru asigurarea stabilității construcțiilor, Buletinul Construcțiilor, vol. 6., Institutul Național de Cercetare-Dezvoltare în Construcții şi Economia Construcțiilor, Bucureşti, p. 117-165
196. *** (1983) Geografia României, I, Editura Academiei RSR, Bucureşti, 662 p.
197. *** (1987) Geografia României III, Carpații Româneşti şi Depresiunea Transilvaniei, Ed. Acad. RSR, Buc.
198. *** (1967) Sympozium de geoorphologi appliquee Bucarest-Cluj, 25 mai – 4 jun
199. *** (1996, 2004) CORINE – Bază de date spațiale
200. *** (1976) Hărți topografice 1:5 000
201. *** (1980) Hărți topografice 1:25 000
202. *** (2005) Ortofotopalnuri
203. *** (1769–1773) Ridicare topografică iozefină – Josephinische Landaufnahme
204. *** (1806–1869) A doua ridicare topografică austro-ungară – Zweite oder Franziszeische Landaufnahme
205. *** (1869–1896) A treia ridicare topografică – Franzisco-Josephinische Landesaufnahme 1:200 000
http://www7.ncdc.noaa.gov/CDO/normals