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DELIMITATION OF RISK GENERATING GEOMORPHOLOGICAL PROCESSES IN CLUJ'S METROPOLITAN AREA

I. DANCI[1], I. H. PAVEL[2], A. FRANTIUC,[3] S. DEAC[4]

ABSTRACT. – Delimitation of Risk Generating Geomorphological Processes in Cluj's Metropolitan Area. The geological substrate, chemical and physical processes, epigenetic movements, the great diversity of landforms from Cluj metropolitan area are all conditioned by its location at the intercourse of three geographical units (Apuseni Mountains, The Someş Plateau and The Transylvanian Plain); moreover, the climatic conditions are influencing the intensity of the erosion processes and also the type and density of the vegetation which is installed in certain conditions of linear and local erosion. The identification and localization of geomorphologic processes plays an important role in drawing, designing, developing and implementing the local, regional and national development strategies. Once the geomorphologic processes are identified, the next step is to execute risk maps, which are essential in urbanism studies and territorial planning, since on their bases the next direction of town expansion, localization of economical implements, (interdictions, conditionings), real estate investments, transportation networks etc. will be drawn. The research was focused on identifying contemporaneous geomorphologic processes from Cluj metropolitan area and their repartition in the territory. Risk generator geomorphologic processes from Cluj metropolitan area are landslides, torrential bodies, ravines and areas of instability.

Keywords: *geomorphologic processes, metropolitan area, landslides, area of instability*

1. GENERAL PREMISES

The establishment of Cluj metropolitan area was made through *Decision no.415/2008* of the Cluj-Napoca Local Council as well as on the grounds of the decisions taken by the Local Councils of the related municipalities, resulting in the new structure called *The Intercommunity Development Association – Cluj Metropolitan Area*. It includes the city of Cluj-Napoca and the communes: Aiton, Apahida, Baciu, Bonțida, Borşa, Căianu, Chinteni, Ciurila, Cojocna, Feleacu, Floreşti, Gârbău, Gilău, Jucu, Petreştii de Jos, Tureni and Vultureni, its purposes being economic development, as well as the development of local, rural and urban investment, environmental protection, improving and developing infrastructure, developing public services in order to increase people's welfare. The present study aims to identify and localize the geomorphologic processes from the Cluj metropolitan area which are susceptible of geomorphologic risks.

[1] *Babeş-Bolyai University, Faculty of Geography, 400006, Cluj-Napoca, Romania, email: ion.danci@geografie.ubbcluj.ro*
[2] *Babeş-Bolyai University, Faculty of Geography, 400006, Cluj-Napoca, Romania, email: horatiu.pavel@geografie.ubbcluj.ro*
[3] *"Ştefan cel Mare" University, Faculty of Geography, Suceava, Romania, email: alecsx_1988@yahoo.com*
[4] *Cluj County Council, 400094, Cluj Napoca, România, email: simomircea@yahoo.com*

2. METHODOLOGY

In order to identify the geomorphologic processes existing in the Cluj metropolitan area we began by consulting the existing bibliography and risk studies, orthophoto maps (2009), maps with a scale of 1:25000, as well as Google Earth website, using GIS software, and field observations. Using the othophoto maps (2009) and satellite images, we have identified and digitised (using GIS) geomorphologic processes susceptible of geomorphologic risk, as well as landslides, torrential bodies, ravines and instable areas presenting complex geomorphic processes. By means of comparison between the othophoto maps and Google Earth website we managed to observe some changes which occurred in the evolution of geomorphologic processes (reactivated landslides, ravine expansions, torrential bodies etc.). Therefore, we identified and digitized landslides, instability areas (generated by landslides, torrential bodies, erosions, creep, solifluction etc.), torrential bodies, ravines, areas dominated by surface erosion (denudation of rain, torrent, stream etc.).

3. PHYSICO-GEOGRAPHICAL AND SOCIO-ADMINISTRATIVE PREMISES

From the geographical point of view, according to the communes' administrative limits belonging to the metropolitan area, the northern limit of the metropolitan area is given by the hills between Lonea valley and Borşa valley, placed in the proximity of the Bonțida village (Cocoşului hill of 492 m, Ucigaşului Hill of 527 m, Bislăului Hill, Crăcinoasei Hill), in the north – west Măzăreşti Hill of 610 m. The western limit is given by the Dâmbului Hill of 627 m, Morilor Hill, Pietri Hill of 685 m, crossing the lane of the Someşul Mic River stretching up to the Tarnița Lake. The southern limit is given by the Sec Hill, Agrişului Hill of 800 m, (the hills between Iara and Hăşdate Rivers), Cheia Hill (near Tureni village), Bărnățoiu Hill, Lobodoş Hill, Răzoarelor Hill of 488 m. The eastern limit is marked by the Găina Hill of 509 m, (the hills between Suatului and Cătunului valleys), Căianului Hill, Sic Hill, Tanlău Hill of 522 m (near Bonțida village), Hârşa Hill, at the border with Iclod commune. Although we do not completely agree with the manner of constitution and today's limits of the Cluj metropolitan area, in our scientific approach we will take into account this situation given by the legislation, because only under such circumstances this given study will find a practical applicability.

The Cluj Metropolitan Area Geology is given by two big structural entities placed here: *the crystalline-Mesozoic* area of the Carpathian orogen, made of crystalline shales, dolomites and granites (Gilău-Muntele Mare Massive), banatitic eruptive (manly dacites, rhiolites and andesites) and several areas with Mesozoic limestone (the northern extension of Trascău Mountains until Hăjdate-Tureni area) and also formations belonging to the *Transylvanian Basin* which were assigned to the Paleogene, Neogene and Quaternary (D. Ciupagea, 1970).

The geographic relief of the metropolitan area appears as an amphitheatre, descending from the west, southwest, towards the northeast, east, from the Someşan Plateau (Cluj and Dej Hills) towards the Transylvanian Plain, the limit between these two relief units being delimited in the northern part by the Someşul Mic Corridor up till Cluj-Napoca, Zăpodie valley, the eastern part of Feleac Massive, Racilor Valley until the inferior corridor of Aries. The main feature of the Cluj metropolitan territory is complexity, given by the relief units the metropolitan area contains. *Dej and Cluj* in the northern side, *Feleacului Massive*, in the southern - representing a particular territory within the marginal region, *Cojocna-Sic Hills*, in the east - measuring more than 500 m height only in some places, *Aiton-Viişoara Hills*, in the southeast, *Gilăului Mountains* in the metropolitan southwestern side - stretching on a small surface (on the administrative territory of Gilău commune), *Someşului Mic Lane*, which stands as an obvious geographical discontinuity area, *Căpuşului Lane* which, apparently extending, represents a modest sized unit, stands out due to its geographical position, orography and function: making Cluj and Dej Hills meet Gilăului Mountains (Gr. Pop, 2001).

Hydro-climatic elements. From the *climatic* point of view, the Cluj metropolitan area territory falls into the continental climate section i.e. moderate; its southwestern side pertains to the medium-height mountains climatic region (partially), whereas the eastern part to the Transylvania Plateau climatic region. Average annual rainfall range from 600 – 1000 mm, while quantities exceeding 1000 mm are more frequent in the mountain area. The least amount of precipitations is in the east, exceeding 700 mm only in a few places. The value of multi-annual average temperature is 8.4ºC, ranging between 6,9ºC and 9,9ºC, having a multi-annual amplitude of 3ºC. The coldest month is January (-4,6ºC) and the warmest is July (19,3ºC).

Hydrographical network. Most of the rivers in the metropolitan area belong to the Someşul Mic hydrographical basin; this is the main river that drains the metropolitan area grounds (from Gilău downstream to Bonțida), along 153 km, and the hydrographical basin measures 3.775 km^2 in surface (the entire Cluj county). The hydrographical network of the southern part of the metropolitan area belongs to Arieşului hydrographical basin (Hăşdate, Micuş, Valea Racilor, Cheița, Valea Caldă Mare).

Alluvial aquifers. Alluvial fan and terraces are made of coarse gravel deposits, boulders and sands, of variable thickness, thicker in areas with active subsidence until the late Quaternary (areas which also are hydrographical convergence). On Someşul Mic River the thickest silts were evident at the confluence with Nadaş where they reach 11 m thickness; generally the alluvial aquifer is up to depths of 4 m. On the tributaries, alluvial deposits are generally sandy, developed up to depths of 2 m; maximum thickness was found on Nadaş, 5 m.

Lithology is characterized by complexity and high alternation of litho-types. Diorite sands, tuffs are present in the eastern part of Cluj and Dej Hills, exceeding in the east Somes Mic lane (up to the metropolitan area) and in the south the Feleacului Massif consisting of diorite, gravel and sands. In the north-eastern metropolitan area what stands out is the presence of conglomerates, sandstone, diorite clay (Hida layers). Limestone, diorite, gypsum can be found in the northwestern metropolitan area (Gârbău commune) and in the southwest (Ciurila, Petreşti de Jos). Crystalline schist (Arada series) present in the Gila Mountains occupies small areas. Gravel and sands are predominant on the valley lanes.

Climatic elements, together with soil types and lithology lead to geomorphologic processes (landslides, torrents etc.). Excessive rainfall has contributed and still contributes to the emergence and evolution of misbalanced phenomena, since through the infiltrated rainwater the slope's overload increases, thus reducing its stability.

Vegetation. Although the difference of heights is not very much outstanding over the metropolitan area, the variety of landforms and environmental conditions lead to a diversification of the vegetal layer, reflecting in the distribution of the geomorphic processes. The presence of salty soils favours the development of *intrazonal and azonal vegetation* on small areas (halophile associations with Salicornia Europaea and Suaeda maritime). On the metropolitan area level, forests represent 16,68% of the total area (25 655 ha). Vegetation can play both a positive and a negative part in triggering and enhancing geomorphologic processes. Roots can contribute to increasing soil cohesion or, on the contrary, they can produce cracks on the rock surface. Forest vegetation stabilises areas subject to risks of geomorphologic processes, adjusting the hydric balance in the soil by retaining rainfall in the crowning and litter, just like it's done in large water consumption (V. Surdeanu, 1998).

Usage of land. Analysing the usage of land within the metropolitan area territory we can notice that agrarian lands occupy the most significant surface i.e. 104.172 ha, representing 67,75% of the metropolitan territory, followed by forests 25.655 ha (16,68%) and unproductive lands 12.029 ha (7,8%). The consequence of the high percentage of agrarian lands and unproductive lands is the great number of geomorphologic processes susceptible of risk.

4. IDENTIFYING GEOMORPHOLOGIC PROCESSES

The geomorphologic processes in the Cluj metropolitan area derive from the complex features of the earth surface. The most frequent geomorphologic processes within the Cluj metropolitan area are *landslides* (present in most of the places of the metropolitan area, more active the built area of 9 communes and in the city of Cluj-Napoca, but stretching all over the territory, including the outskirts of the Cluj metropolitan area), *torrential bodies*, *instability areas* (generated by complex geomorphologic processes, landslides, torrents etc.), *ravines, erosion affected areas* – rain-denudation, torrents, streaming etc.).

Over the metropolitan area there were identified and mapped (digitized using GIS software on othophoto-maps) 686 geomorphologic processes susceptible of generating geomorphologic risk, of which approximately 300 landslides, 73 ravines, 145 torrential bodies, 123 instability areas (coastal slopes), 45 areas with serious surface erosion (rain-denuded, torrents, gutters, streaming etc.). Due to the complexity of the earthly surface on which the Cluj metropolitan area stands, we can identify three specific units for grouping geomorphologic processes: *plains unit* (Transylvania Plain), *hills unit* (Cluj and Dej Hills, Feleacu Heap), *mountain unit* (Gilău Mountain), presenting geomorphologic processes typical of every relief unit. The “plain” fraction that falls within the Cluj metropolitan area’s territory is characterized by a strip of the medium Miocene, consisting of badenian (diorite clay, sandstone, salt, tuffs) but more than anything of inferior Sarmatian (diorites and tuffs) on top of which there still are some remaining patches of the rest of the Sarmatian (diorite, sands and gravel). The strip stretches along the left side of Someşul Mic too, but on the “plain” it is also marked by salt appearances, diapiric crimps apparently arranged on a saddle which starts from Ocna Dejului, passing by Gherla, Coasta Gădălin, Cojocna, where it meets the saline saddle coming from Apahida and Someşeni and ending up in Ocna Mureş. This alignment stimulates a valley enlargement, especially where salt is present, triggering massive slope slides. There are fewer and less powerful slides on those slopes with harder rocks (sandstones, tuffs) and on forest covered slopes. Other than that, slopes gather into bigger complexes starting from the watershed, meeting again in some kind of tongues which widen towards the river meadows. Under the watershed they are shaped like a staircase, like waves, sometimes huge, presenting various stages of evolution. Over the “tongue” grouped slides there are streaming torrents which sometimes stimulate the sliding of certain portions, and sometimes act as drainage, helping their stabilization.

In this unit there have been identified and mapped (digitized using GIS software from the othophoto-maps) 336 geomorphologic processes susceptible of generating geomorphologic risk, out of which 55 are active slides, 10 are re-activated slides, 118 stable slides, 21 ravines, 49 torrential bodies, 61 instability areas (coastal slopes), 22 areas with surfaces seriously affected by erosion (rain-denuded, streaming, gutters etc.). For a better identification and analysis of geomorphologic processes, in their distribution we shall take into account their framing within municipalities. Thus, the most significant areas presenting landslides, prone to geomorphologic risk, can be found in such communes as Cojocna, Aiton, Jucu. This is also due to their positioning inside built-in areas of the villages or right next to it. However, most of the geomorphologic processes susceptible of generating geomorphologic risk are situated outside built-in areas, affecting, therefore, mostly agricultural lands. Therefore in Cojocna commune – Cojocna village there are landslides around the large cemetery area (prone to affect 7 households and 1.5 km of the road), Republicii St. (prone to affect 15 households and 0.6 km of the road), S. Barnuțiu St. (prone to affect 6 households and 0.6 km of the road), Durgau Lake area, prone to affect the access road; Cara village – Republicii St. (prone to affect 5 households and 0.3 km of the road). These landslides are slow and have low motion speed. The greatest landslide is in Boju village, measuring 1000 m length, 2500 m width, 1-3 m depth, 2,500,000 sq m, volume 5,000,000 m³. Prior preparation causes to these landslides are: the slope, ravines and streaming; triggering causes are excessive humidity, abundant rainfall etc. (*Cojocna village sheet*). Outside the built-in area, landslides are more frequent in the south-eastern part of the commune, on those slopes which present more exposure to the south-west, south and south-east, at heights ranging between 350-450 m (north-west of Iuriu de Câmpie village, Straja Hill).

Most of the landslides from Aiton commune occur in the south-east of the commune, outside built-in village areas. These are "primary" landslides (an area with a high landslide likelihood) generally occurring in springtime, on clays and flysch, and have been identified in the built-in areas of Aiton and Rediu villages. The slides measure 130 m (Rediu) and 900 m (Aiton) in length, their widths ranging from 300 m (Rediu) to 2000 m (Aiton) and depths from 1 to 5 m, having a low motion speed. These slides present preparation causes such as the slope, streaming, torrential erosion, surface erosion and triggering causes such as excessive humidity (*Aiton village sheet*). Outside built-in village areas, landslides affect agricultural lands (pastures) and are more frequent on south and south-west oriented slopes (Viilor Hill, Borzâc Hill).

In Jucu commune, landslides have been located only inside built-in areas of Jucu de Sus village, on the slope standing on the right of Someş, in the area covered in orchards and briers. This landslide is "reactivated" on vegetal soil, clayey diluvium, sliding very slowly due to such causes as the slope and erosion, and triggering causes such as excessive humidity (*Jucu village sheet*). Outside built-in areas landslides are more frequent in the eastern part which overlaps Cergheş Hills, Netedu Hill, Someş Hill, at heights between 350-400 m, occurring more often on those slopes that have a south-western orientation. In the northern part of the unit (the eastern part of Bonțida commune), landslides (partially stabilized landslides) occur outside built-in areas, in the eastern part of the commune (Urieşului Hills), at heights ranging between 350-400 m, on slopes with southern and south-western orientation.

Landslides in Căianu commune arise outside built-in areas of Căianu Vamă village, Căianu Mic village, the north-eastern part (Soma Hill), the eastern part of Căianu. These are active and partially stabilized landslides, arising at 350 -450 m height on north-east and north-west oriented slopes.

In Apahida commune landslides are generated outside built-in areas (partially stabilized landslides), in the proximity of Pata village (Bodrog Hill), Dezmir (the northern part of the village) and it affects agricultural lands. They are more frequent on those slopes oriented towards the north-east and north-west, at heights of 350-400 m. Landslides arise mostly in springtime by reactivating old sliding bodies, on diluvium and clay. The great number of geomorphologic processes existing in this section is also due to the alignment of diapiric creases on the western side of the Transylvanian Plain. The geomorphologic processes arise at the same heights, reaching up to 500 m, except for the strip that meets Feleacului Mountain, where they reach 600 m, and along the valleys where they go under 400 m. The diapiric creases are marked by badenian formations (including salt grains in Cojocna), are embedded in sarmatian stacks (consisting mainly of clays and sands), and have speeded up not only the arousal of old landslides on the Cojocna hillsides (Dărvşteu Hill at 350-400 m high) but also along Mărăloiu, Văii Florilor vally (Gr. Pop, 2001a). The presence of salt and limestone in these spaces triggers more complex manifestations of the processes by speeding them up. Usually, actual processes affect both surface stacks (disturbed in a previous dynamic activity) and the rock of that place. On the slopes one can find driving of materials of several thicknesses (from meters to tens of meters), which consequently make post-occurrence interventions very expensive and, more often than not, without an exact result. Torrential bodies represent another category of geomorphologic processes susceptible of geomorphologic risk. All over the sub-division there are approximately 51 torrential bodies, having a greater density in the northern part of the sub-division (Jucu, the northern part of Bonțida commune, Căianu, the northern part of Apahida commune). Their dimensions vary and they arise on highly inclined slopes, sometimes overlapping old landslides. They are predominantly directed to the south-east, at heights between 500-300 m. They arise outside built-in areas, affecting agricultural lands.

The presence of small torrents and ravines within the Cluj metropolitan area is closely related to the lithologic substrate, the slope side, the usage of the train etc. Ravines are present especially in the middle and inferior part of the slopes (in Someşeni-Apahida peripheral hills sphere, the border area of the Transylvania Plain etc.) and are associated with landslides, solifluction, swampy areas caused by the presence of a large number of springs, so that in some places one can find bad-lands (I. Mac, T. Morariu, 1969). Within this sub-division there have been identified approximately 21 ravines outside the built-in area of the villages. Due to the complexity of the landforms present in this subdivision we have identified 61 areas with complex geomorphologic processes, which, considering affected areas and spreading, represent causes of slope instability. Moreover, they are the main processes that generate geomorphologic risk. These instability areas have as characteristics complex geomorphologic processes, active landslides, reactivated or partially stabilised, torrents, ravines, streaming, rain-denude, solifluctional flows etc. These ”instability areas” are present along the whole sub-division, more pronounced on the top areas, featured by steep slope (15.1 – 35%), with south-western, southern and south-eastern orientation. They expand outside built-in areas, affecting agricultural lands (pastures). On some surfaces there are pine “clumps” which have been artificially planted in order to stabilise the slopes. On the municipalities' level most “instability areas” are found in Cojocna 27 commune's territory, due to the presence of diapir, various hills and reduced wooded areas.

Because of special geological, relief, climatic, hydrographical and vegetation conditions but, even more, due to anthropogenic interference in this sub-division, there are approximately 22 areas affected by surface erosion processes (creep, rain-denudation, streaming etc.). These usually arise outside built-in areas (in the proximity of settlements) on agrarian lands subject to excessive grazing. The most affected ones by this process are the soils - great quantities of material that comes especially from the fertile section are carried towards the grounds of the slope. In these sections geomorphologic processes are highly effective during transition season (when there is no plant layer) and torrential rain seasons.

4. 2. Geomorphologic processes associated to plateau units

The plateau unit comprises most of Cluj metropolitan area: in the North – Cluj Hills, and in the South the Feleac Massive. There have been identified and marked (digitized using

GIS system from the orthophoto-maps) 350 geomorphologic processes susceptible of generating geomorphologic risk, out of which: 118 landslides, 52 ravines, 94 torrential bodies, 63 areas of instability (hill slopes), 23 surface erosion areas (rain-denudation, streaming, torrents, small torrents etc.). Due to the complexity of this area and for a better identification and regionalization of the geomorphologic processes, we shall divide this unit into two sub-units: The Hills of Cluj and Dej, and the Feleac Massive.

The Hills of Cluj and Dej . They are characterized by the presence of Eocene formations (inferior course chalk, sandstones, gypsum and superior striped clay) and Oligocene- inferior Miocene (sands, sandstones and clay). This relief unit owes its essential feature to the frequency slope the presence of terraces on every valley, maintained in the sectors where they pass the Dej tuffs. (I. Savu, 1963). In the hills of Cluj and Dej, under the top areas**,** for example Capuş or Nadaş, the landslides are more abundant and massive, but, on the other hand, on the slope ridge**,** rain-denudation and streaming prevail. All the basins of the valleys tributary to the Someşul Mic, on the left, are inflicted, sometimes on very extended surfaces, by storied landslides (Borşa, Lonea), divided according to the form, in two-three levels; close to the valley riverbed tongue-shaped slides can occur, directed sometimes by torrential valleys, on the median slope dominate the superficial but extended and mostly in the spring-slides, on the pastures and grasslands, under the inter-fluvial sweeps, there are detachment gaps, in massive stairs, a combination of slides and collapses.

The most important slide areas susceptible of geomorphologic risk can be found in Vultureni, Chinteni, Floresti, Feleacu Ciurila and in Cluj Napoca, this also being due to their localization inside the cities or in their immediate vicinity, generating material damage. The Northern part of the Cluj and Dej Hills, in the Vultureni commune there where identified two surfaces with slide risk inside Chidea, in the Central-East and Central-North-West, affecting orchards, gardens and built areas. In Faureni, situated South-West from the commune residence, on Dc 150, a surface with high risk of slide which occupies the entire central part of the area (built area, orchards, grasslands) was identified. These are ‘primary’ slides, on sandy clay, diluvium, with small motion speed. The slides measure between 220 m (Chidea) and 472 m (Faureni) in length, and between 235 m (Chidea) and 765 m (Faureni) width, the depth ranging between 1 and 2 metres. An active slide has been identified in the North-West of Soimeni. In the commune there have been identified 13 areas of geomorphologic processes susceptible of risk. The slides have as preparatory causes the slope, the streaming, torrential erosion, surface erosion**,** and trigger causes rainfall. Outside the localities, the landslides affect agricultural fields (pastures) and are situated on the slopes with a South Eastern, South Western orientation, at altitudes between 300-450m. In the Southern part of the subdivision, landslides are found in Baciu commune, and occur usually in springtime due to the reactivation of old slide bodies, on sandy diluvium clays, sands, diluvium clays and sandy clay. The slides measure between 150 m (Popesti) and 900m (Coruşu) length, and widths between 150 m (Coruşu) and 1100 m (Coruşu), the depth varying from 1 to 10 m, with a small movement speed, but there are also slides with high speed (Popeşti). The biggest landslide has been in Coruşu, having a length of 900 m, 400 m width, 5-10 m depth, surface 360000 sq m, volume 1 404 000 m3. Outside the built-in areas, the slides affect agricultural fields (pastures), with a larger frequency on the slopes with a Southern and South Western orientation (Lorin Hill), at altitudes of 350-450 m. In the Northern, North-Eastern, and North-Western part of Chinteni, on both slopes of the Chintenilor Valley, there is an area highly affected by sliding phenomena. This area is partially covered with constructions, orchards, pastures and forests, while in the intensely affected areas there is a lack of vegetation.

In Padureni locality, situated on Dc 148 and Dc 147, at approximately 4 km from Chinteni, the slides are present in the North Eastern part of the village, on both slopes of the Hurudelor river. The slides occur usually during the spring by reactivating old sliding bodies on clay, diorite clays and sands. The slides' lengths vary between 500 and 1000 m (Chinteni), their widths between 130 m (Pădureni) and 1000 m (Chinteni), and their depths vary from 2 m (Pădureni) to 13 m (Chinteni); they all have small movement speed. The biggest landslide is in Chinteni with a length of 1000 m, width 1000 m depth 10-13 m, surface 1000000 sq m, volume 62400000 m3. Outside the built-in areas, slides arise on agricultural fields (pastures), with a bigger frequency on the slopes with a Southern orientation (Chinteni Hill), on the superior part of the slopes at altitudes between 400-500 m. In the commune there have been identified 16 areas with geomorphologic processes susceptible to risk. The slides have as preparatory causes the slope and the surface erosion, and as triggering factors the torrential erosion, the excessive humidity.

In Cluj Napoca, massive landslides occur mostly in the sectors where the peaks of the hills are covered with gravel sarmatian sands that have a diorite-clay base, these representing slide surfaces for the covering deposits. Inside Cluj Napoca, the slides have occurred in Eocene striped series of the Cetatuia Hill, Southern slope (Dragalina Street, Taietura Porcului Street, Uliului Street). These deposits are characterized by the alternation of pervious powders and impervious clays, the latter being sliding surfaces for the pervious and semi-pervious humid deposits, lacking the protecting vegetal coverage. In the Southern part of the city, the slides occur on the entire Northern edge of the peak of Feleacul, the springs of Becaş–Borhanci streams and small torrents, these geodynamic phenomena occurring in most of the locality.

The slides occur usually during springtime, by reactivating old sliding bodies, on sandy diluvial clays, sands. The slides measure between 100 m and 150 m length, between 75-90 m width, the depth varying between 1 and 5 m with a small movement speed. The slides have as preparatory causes the slide and the surface erosion, and as trigger cause rainfall. Outside the built-in areas, the slides affect agricultural fields (orchards, pastures), with a higher frequency on the slopes oriented to the South, South West, with altitudes between 350-450 m. Between the landslides there can be found quartered swampy micro-ground submergences, many springs that maintain humid the substrate, determining the apparition of hydrophilic vegetation (Chinteni Hill). In Gârbău, Borşa, the landslides are fewer, present only outside the localities, affecting the agricultural fields (pastures). They are situated at altitudes of 350 m-450 m, on slopes with a Southern, South-Western orientation (Porumbului Hill, Morii Hill- Gârbău commune, Cetatea Caprei Hill- Borşa commune).

The Felacului Massive represents a particular territory, situated at the convergence of well-known units: The Someşan Plateau (Dejului and Clujului Hills), in the North, being separated from it by the lane of the Small Somes, in the East it meets the Transylvanian Plain, on the Dezmir- Aiton alignment, (Valea Zăpodie – Mărtineşti – Valea Racilor) - Ceanu Mic – Tureni, in the South descending towards the calcareous bare of the Sandulesti Mountain (Sandului Hill 795 m), and the Hasdate depression, in the West arriving at the Savadisla-Luna de Sus Lane. Between these borders, the Feleacului Massive represents a crystalline schist hillock, similar to the ones in the Intra-Carpathian yoke or the Western Hills, well buried in Miocene, Eocene, Oligocene sedimentary formations, so that the crystalline schist have only been uncovered in a small area in Magura Salicii, while on Peana Peak (832 m), there are present only in situ crystalline schist. The sarmatian sands dominate, followed by clays that have formed diagenetically (successively from the deposition of sandy formations)- the well-known grate concretions of Feleac, to these being added, in the Western part, on the Savadisla-Luna de Sus lane, the Eocene and Oligocene deposits, represented by inferior coarse chalk, inferior striped clay, sands etc. (Gr. Pop, 2001a).

The most important areas with slides susceptible at geomorphologic risk are found in Feleacu, Ciurila, Floreşti, and due to their localization inside the localities they can produce material damage. The slides occur usually during springtime, by reactivating old sliding bodies, on sandy diluvial clays, sands, sandy clay (Gheorgheni). The slides measure between 200 m (Flelecu) and 450 m (Georgenes) in length, between 300 m (Feleacu) and 1500 m (Gheorgheni) width, the depth ranges between 1 and 4 m, having a small movement speed. The biggest land slide is in Gheorgheni, with a length of 450 m, 1500 m width, 4 m depth, a surface of 67 500 mp, volume of 2 000 000 m3 (wave shaped slides). Outside the built-in areas, the slides affect agricultural fields (pastures, orchards) with a larger frequency on the slopes oriented to the South, North (Feleacului Massive, Rediu Hill), in the superior part of the slopes at altitudes between 500-700 m. In the commune there have been identified 26 areas with geomorphologic processes susceptible to risk. The slides have as preparatory causes the slope, the surface erosion, and as trigger factors torrential erosion and excessive humidity. In Ciurila commune, slope geomorphologic processes (collapses, slides) have been identified inside Ciurila, in the North-Eastern part of the locality and in Sălicea, where inside the locality there have been identified three areas with sliding risk, areas covered with houses and orchards. The slides occur usually during springtime, by reactivating old sliding bodies, clays and sandy clays. The landslides measure between 50 m (Sălicea) and 300 m (ăalicea) in length, between 50 m (Sălicea) and 600 m (Ciurila) width, the depth varying from 3 to 5 m with a small movement speed, but there are also high speed slides- translation slides (Ciurila). Outside the localities, the landslides affect agricultural fields (pastures, orchards). Most of the slides are quartered on the slopes with a Southern, South-Eastern orientation, at altitudes between 550-650 m. Inside Floreşti commune, there have been localized two areas of slides in Tauti locality, situated in the North of the locality. In Luna de Sus, in the North-West of the locality, there has been outlined an area affected by erosion, area covered with Greenland and agricultural cultures. The slides occur mostly during the spring, primary slides, on diluvium and clay. The slides measure between 143 m (Tauți) and 200 m (Luna de Sus) in length, between 420 m (Tauți) and 840 m (Luna de Sus) in width, the depth varying from 1 to 3 m, with a small movement speed. The biggest landslide is in Luna de Sus, measuring of 200 m length, 840m width, 1-2 m depth, surface 168 000 sq m, 252 000 m^3 volume. In the commune there have been identified three areas with landslides. The landslides have as preparatory causes the slope and the erosion, and as triggering cause excessive humidity. Outside the localities, the landslides affect agricultural fields (pastures) situated on the slope oriented to the North and Eat (Gârbău Hill), at altitudes between 350-450 m. In Tureni commune, the landslides are found in the North-Eastern (Argil's Hill), Eastern part of the commune, they are active slides of great dimension and partially stabilized slides (Cheița Valley). The slides are situated on the South Western slope at altitudes of 350-500 m. The Northern part of the Commutes locality is affected by an active slide of small dimension. These slides are found outside the localities, affecting only agricultural fields.

In Petreşti de Jos commune, the active slides are found in the Northern part of the commune outside the localities, where there have been identified 9 areas with slides (Muncelu Hill, Rotund Hill). The slides are situated on the slopes with a predominantly Western orientation, at altitudes between 400-500 m.

Another category of geomorphologic processes susceptible of geomorphologic risk are torrential bodies. In the entire hill unit there are present about 96 torrential bodies, with a greater density in the Northern, North Eastern (Vultureni, Borşa, Bonțida), Western part (Gârbăd, Gilău, Floreşti), in the South (Ciurila, Petreşti de Jos). They vary in size and are situated on inclined slopes, overlapping sometimes old landslides. Most of the torrential bodies are situated outside the localities, affecting agricultural fields. Just like the case of torrential bodies, the presence of *ravines and small torrents* is more frequent in the northern part (Vultureni, Chinteni) and in the southern and south-western part (Floreşti, Ciurila). Ravines are more pronounced especially in the middle and inferior slope sides, sometimes being associated to landslides, solifluction, swampy areas caused by a large number of springs. Thus, in some places we can find bad-lands (I. Mac, T. Morariu, 1969). On the grounds of this subdivision we have identified 52 ravines outside built-in areas. Due to the complexity of the landforms present in this subdivision we have identified 62 areas with complex geomorphologic processes, which, considering affected areas and spreading, represent causes of slope instability. Moreover, they are the main processes that generate geomorphologic risk. These instability areas have as characteristics complex geomorphologic processes, active landslides, reactivated or partially stabilised, torrents, ravines, streaming, rain-denude, soliflectional flows, creep etc. These ”*instability areas*” are present along the whole hill unit, outside built-in areas, and are more frequent in the northern part, on slopes which feature steep slopes with south-western, southern and south-eastern orientation (the left slope of Feiurdeni valley). Moreover, they feature active slides, torrential bodies, ravines on the north- oriented slopes as well (south of Măcicaşu village, Teleacului valley, the right slope of Borşa valley), characterized by partially stable slides, torrential bodies, creep, solifluction. In the southern part of the hill area the “instability areas” are present on the slopes facing the north (Feleacu, Ciurila). They are situated at heights ranging from 350 to 700 m and they affect agrarian lands (especially pastures).

Because of special relief, climatic, hydrographical and vegetation conditions but, even more, due to anthropogenic interference in this subdivision, there are 23 areas affected by *surface erosion processes* (creep, rain-denudation, streaming etc.). These usually arise outside built-in areas (in the vicinity of settlements), affecting agrarian lands (pastures) subject to excessive grazing. The most affected ones by this process are the soils - great quantities of material that comes especially from the fertile section are carried towards the grounds of the slope. In these sections geomorphologic processes are highly effective during transition season (when there is no plant layer) and torrential rain seasons. The mountain unit is the only unit in the southwest of Gilau Mountains (commune Gilau), composed of hard rocks, which makes this to be the dominant processes and river-torrential plus other processes, differentiated by as we are in alpine or woodland on steep slopes, the valley bottoms or other local conditions.

Alpine, greatly expanded by anthropogenic processes, it is dominated by crionivale of rain-denuding. (Gr. Pop, 2001). Because large areas occupied by forest and geological and lithologic constitution landslides are very small (hardly noticeable).

5. CONCLUSIONS

The morpho-graphic and morpho-metric characteristics of landforms of Cluj metropolitan area, as well as climatic elements, vegetation, excessive rainfall etc. have played and continue to play a part in generating and development of present geomorphologic processes. The great number of geomorphologic processes from Cluj metropolitan area derives from the complex features of the earth surface. The “plain” zone is affected by current excessively intensive geomorphologic processes. Here, slides are very widely developed and torrential bodies, ravines, streaming, rain-denuding affect the whole region, being more intense on steep hill slopes oriented towards the south-west, south and south-east. The hill zone is highly affected by landslides, torrents, streaming, rain-denuding and solifluction. Massive landslides are not as frequent as in Transylvania Plain and are to be found at the contact of the badenian and sarmatian: the slides under Feleacului Massive, shaped like waves and having small lakes behind them, or those on the left side of Chintenilor valley stand as examples. The mountain unit, present only in the south-western part, is dominated by fluvial-torrential processes, on top of which we can add other processes: small torrents and torrents whose dejection cones reach the main valleys, often affecting roads. There are, frequently, superficial slides, but they are not very extended (they affect only the alteration layer).

Among the causes that have enhanced these geomorphologic processes we must emphasize wood clearings (sometimes total), ploughing on steep slopes, excessive grazing, excavation works at the grounds of the slope, resource exploitation on the slopes (overcharging the slopes, modifying slopes), geotechnical works, increase of wasted water from the water and drainage systems, the expansion and enhancement of communication channels etc. These represent some of the anthropological causes which contribute to the arousal of geomorphologic processes.

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