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PRESENT-DAY GEOMORPHOLOGICAL PROCESSES WITHIN THE SILVANIA AREA AND ASSOCIATED HAZARDS

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Abstract. The hazards and implicitly the geomorphological risk phenomena in the Silvania Mountains are induced by the *present-day shaping processes* and they occur on the composite lithological basement with climatic and water conditions specific to the western province. The morphodynamics induced by these current geomorphological processes in the physiognomy of the Silvania landscape is reflected by the typology of associated hazards: geomorphological and water. The pronounced fragmentation due to the alternation of permeable and impermeable formations, chaotic deforestations and the irrational use of the agricultural land favored the development of these shaping processes in a variety of forms including hazards and geomorphological and water-related risk phenomena.

Key words: processes, shaping, landscape, Silvania, hazards, associated risks.

1. INTRODUCTION

The Silvania Mountains are a particular geospatial entity within the geomorphological landscape of Silvania, which fully deserves the name of mountain. It brings together, in one family of mountains, the Plopiş (Vf.Măgura Mare 917m) and Meseş Mountains (Măgura Pria 996m) and only comparatively Măgura Şimleului (597m) and Măgura Chilioarei (420 m), taking into account their high degree of erosion, and delimitates the vast Neogene Şimleu gulf from west to east and north-east. The territory presents a series of characteristics of the "Block Mountains", having an architectonics composed of horsts and grabens.

This tectogene, both Hercynian and Alpine, was submitted to an intense subaerial shaping, which led to a "palimpsestic morphology, unique within the Romanian territory".The dominant note of the landscape in the Silvania Mountains is the predominance of these crystalline and eruptive hummocks, with altitudes between 300-700 m, resulting from *the dislocation and sinking of a formerly unitary crystalline mas*s(see fig.1). The Silvania Mountains were formed as a reflex of a complex *endogenous and exogenous dynamics* against a background of a *strike-slip type tectonics,* respectivley of some distensive and compressive episodes which affected the crustal entity - Tisia-Dacia during the Cretaceous

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(Irimuș, Bogdan, 2017). They were submitted to the erosive action of a series of *endogenous and exogenous shaping agents* that favored the development of a complex denudation landscape, under the auspices of integration and multi-processual co-operation, through an infinite combination of processes, which brought the ancient Hercynian chain to the shape and aspect of some varistic remains, integrated into the Alpine nappes structure of the Apusenides.

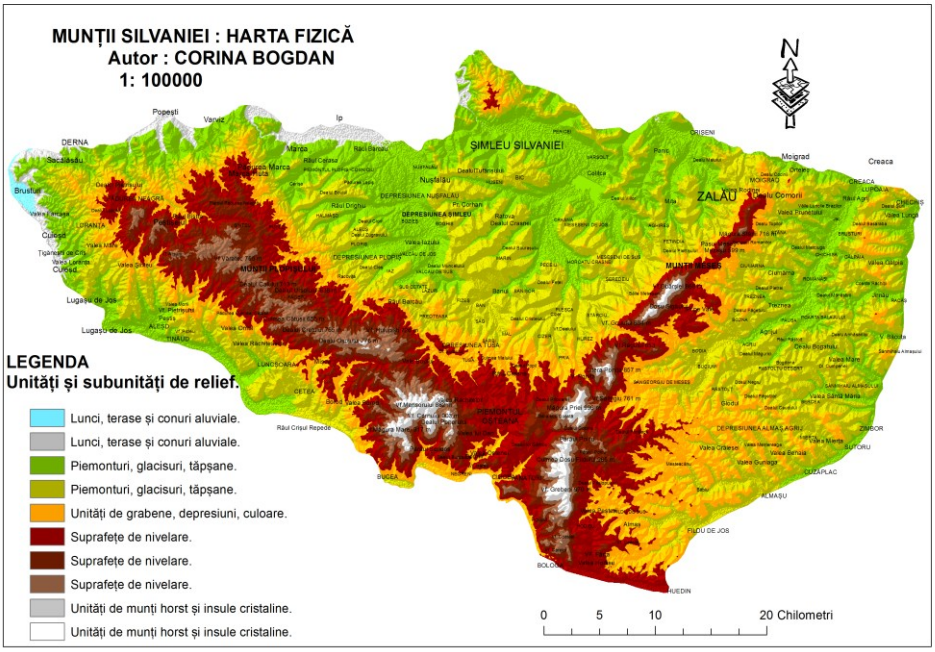

Fig.1. The hypsometric map of the Silvania Mountains

2. MATERIALS AND METHODS

In what concerns the methodology and the techniques used for outlining the present-day geomorphological processes and the associated risks, we took into account the topographic and geological databases, the *geomorphological mapping derived from terrain analysis* and we transposed to the topographic map these contemporary geomorphological processes.The geomorphological map was created using a mixed methodology: the geomorphology school from Cluj and Pisa. Thus, using the related topographic and geological base, both the lithology and the geomorphological processes specific to cover deposits from the Silvania Mountains were mapped and represented from a cartographic point of view. The final

geomorphological map confirms the dynamics and the evolution of processes in the Silvania Mountains. The final analysis imposed the use of the GIS techniques.

3. RESULTS AND DISCUSSION

The present-day geomorphological processes in the Silvania area outline a denudation landscape through two types of processes: *meteorisation processes* (elementary) and *complex processes* of landscape shaping (fluvial, cryonival, anthropic).

3.1. Elementary processes of landscape shaping in the Silvania Mountains

The discontinuity phenomena in the Silvania Mountains are materialized through extreme forms, as genuine "paroxysmal breaks" of rhythm and/or intensity in relation to the normal occurrence (Mac, Petrea, 2002), which is defined primarily by the average values determined due to statistical bases specific to hydrological, meteorological and climate phenomena, respectively discrete forms when the phenomena take place veiledly and are only perceptible through the induced effects. In the Silvania Mountains, the *meteorisation processes* determined the alteration and decomposition of their magmatic, metamorphic and sedimentary rocks. The main physical decomposition processes of rocks from the Silvania Mountains took place under the auspices of *termoclastism, hydroclastism, crioclastism, exfoliations, granular decompositions, chemical exfoliations, chemical alterations* and *oxidations*.

Based on these complex processes, the rocks from the Silvania Mountains were moved and transformed. The shaping of versants in the Silvania Mountains is achieved through *degradation* (destruction or erosion) and aggradation (construction or accumulation), therefore we are talking about two groups of distinct landforms in the Silvania landscape, respectively *erosion* forms and *accumulation* forms, in the present case, the denudation landscape. The agents and the geomorphogenetic processes acted in the Silvania area with a differentiated rate depending on: *lithology and structure*, *temperature*, *humidity*, *altitude*, *exposure*, *topographic configuration*, *type of vegetation cover* and *human exploitation* (Irimuş,2006*)*. The morphogenetic processes from Silvania are represented, in line with the above, as simple processes, *preceding erosion* (*meteorisation* and related forms) and complex processes, of erosion.

In the geomorphological landscape of the Silvania Mountains, we mention the surface erosion (areal or areolar) and *linear* erosion, the latter is identified with the in-depth erosion of rivers, accompanied by a lateral erosion of banks (Bogdan, Mac,2014). The previously mentioned *elementary* or *preceding erosion processes* represent a set of physical, mechanical and chemical actions, which have transformed

the initial nature of the rocks in the Silvania area, leading to their dislocation and small-distance transportation, under the auspices of *meteorisation processes* (which prepare the materials) and of *terrain movements* (areal and linear, which evacuate the materials). The geomorphological landscape of the Silvania Mountains is characterized by the *surface* erosion (areal or areolar) and *linear* or *section* erosion, the latter is identified with the in-depth erosion of rivers, accompanied by a lateral erosion of banks.The elementary processes have transformed the initial nature of the rocks in the Silvania area. Their dislocation and small-distance transportation were due to *meteorisation processes* and of *terrain movements.*

One of the recurring meteoric degradation processes encountered in the overall geomorphology of the Silvania Mountains is the *termoclastism.*In the Plopiş Mountains, the *termoclastism processes* are specific to the NE and SE sectors, in the Meseş they find optimal conditions to develop on both sides (see fig.2). We identified the most suggestive termoclastism processes in the Plopiş Mountains and Măgura Coşeiului (Dealul Viilor and Dealul Descoperit sector).

The hydroclastism processes have optimal conditions to develop as a result of the cyclic alternation of wet and dry periods and thus the predominantly argillaceous and marly deposits are water-logged and take the form of mud. *The exfoliations* are another attribute of the morphogenetic shaping of the Silvania Mountains and they affect mostly the massive rocks, originating from the depth and brought to the surface due to tectonic uplift and dismantling to which the ancient Tisia craton was submitted (Irimus, Bogdan,2017). The *granular decomposition* in the Silvania Mountains is represented by the disintegration of rocks in different parts and relatively big mineral granules, on the predominantly schistous and marly rocks.

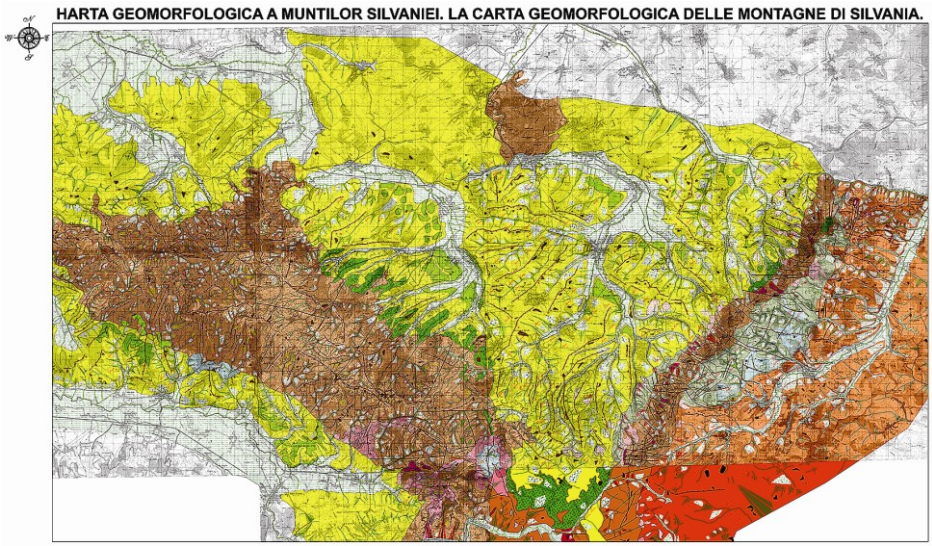

Fig.2. The geomorphologicals maps of the Silvania Mountains and their legend

Very often, this process is in close correlation with the processes of exfoliation. *The chemical alteration* in the Silvania Mountains is conditioned by the *processes of oxidation and hydrolysis*. *The hydrolysis processes* have as common denominator the running waters, which act as a solvent agent that dissolves the minerals from the rocks in the Silvania area under the auspices of the carbonation processes, which have mostly affected the calcareous rocks of the Silvania Mountains.Instead, the *oxidation* is specific to rocks rich in Fe and Mg, which will determine in certain climatic conditions the formation of oxides of various colors (red, orange, and yellow), specific to degraded soils.

3.2. Complex processes and forms of denudation of the versants in the Silvania Mountains

The complex shaping processes of the versants of the Silvania Mountains have a gravitational character, visible in the extensive or areal and linear erosion.

3.2.1. Gravitational forms, processes and deposits in the Silvania Mountains.

The versants of the Silvania Mountains are affected by *gravitational geomorphological processes,* such as *rocks falling, rocks rolling, debris flows, landslides* and *collapses(see fig.2)*, which create a series of particular forms both on the original rock, and on the detritus produced by meteorization. The versants' evolution in the Silvania Mountains was characterized by an *ascending phase,* marked through accumulations following collapses, landslides, solifluctions, respectively a *descending phase* (through the depression of the thalweg of the Silvania Mountains), due to the processes of rilling and ravination. The mass movements of the materials dislocated from the versants through erosion are mainly *clast or rocks flows*, under the following forms: through *mechanic causes, respectively forms related to debris flows* (rollings, landslides, the warping of the strata ends, the creep); *landslides* (slow movements - as a result of the soaking of the mass of materials - mudflows ; solifluctions) (Rădoane,Râdoane,2007). The accumulation forms refer to the accumulation of clastic materials with varying size as a result of the meteoric disintegration of the sloping versants without flora, particularly characteristic to the Meseş Mountains, to Măgura Şimleului and Măgura Coşeiului. Under the gravitation force the materials move down the slopes and accumulate at the base of the versants. As a result of the presence of some versants with smooth walls, following the meteoric disintegration, detritus nappes were formed in the Meseş Mountains , while on the sloping versants from the immediate vicinity of the main peaks alluvial-fans were formed.

Some detritus nappes in the Meseş Mountains also formed through the merging of alluvial-fans. The displacement of the materials on the slopes is

selective, and the materials accumulated at the base of the slopes in Măgura Şimleului, Coşeiului, Meseş take shape through debris, fans and detritus nappes, present in the central-northern part of the Meseş Mountains, respectively of Măgura Stânii, Vârful Obârşiei, Citera Ponița, Măgura Priei. More relevant in the general geomorphology are the landslides.West of Meseş, as a result of the dynamic processes, there are present fallings - rollings, which precede the ones the others and the other way round, starting with displacements from rock blocks, from the outcrops characteristic to large detachment steeps (Măgura Stânii, Dealul Gârsei). The Silvania Mountains, as a result of the advanced degree of erosion in the Tertiary sedimentary deposits and the adjacent crystalline, are affected by landslides too (see fig.2).

The versants adjacent to the valleys of Barcău, Crasna and Zalău are affected by landslides, respectively by sudden fallings of mass materials, consequence of the transcending of the limit slope and of the banks' undermining, as a result of the lateral erosion of the tributaries of Barcău and Crasna (Sorocovschi,2017). We add the excessive anthropic pression, the exploitation of useful mineral ressources, the massive deforestations, playing a key role in triggering possible extreme developmental discontinuities such as hazards and *geomorphological and technogene risk phenomena*. The Silvania Mountains are characterized by a moderate frequency of collapses/landslides as mass falls on the valleys' versants, in detachment and secondary steeps, landslides and blocks' collapses. The main *current geomorphological processes* with consequences on the quality of Silvania soils are : *hydric and aeolian erosion* (which lead to the loss of the layer of fertile soil from the surface, land strain, clogging and sedimentation); *compaction*; *landslides; water excess; soil exhaustion in organic matter* and nutrients; *salinization*; *acidification; pollution*.

3.2.2. Mass movements in the Silvania Mountains.

The mass movements from the Silvania Mountains represent more or less large *dislocations* of the *materials* which constitute the versants under the force of gravitation. These attract in displacement both the superficial alteration materials and the original rock. Regarding the *mass movements*, we distinguished two categories: *slow movements* (through solifluction processes) and *landslides. The slow movements* in the Silvania Mountains are characterized by *the presence of solifluction processes,* which mainly affect the superficial parts of the versants adjacent to the Valea Barcăului, Crasnei, Zalăului, mainly marly and loamy parts, including the versants of the immediate vicinity of the mountain frame of Plopiş, Meseş, Măgura Şimleului and Măgura Coşeiului. The solifluction is distinguished on the Silvania versants through ripples and typical terracing.

From the perspective of the *landslides* potential in Romania, the geomorphology research, classifies the Plopiș and Meseș Mountains, Măgura

Şimleului and Coşeiului as *areas of low potential for landslides,* in comparison with Şimleului Depression, with a high potential for landslides. The triggering of landslides in the Silvania Mountains is due to the breaking of the balance in the mass of rocks which constitute the versants because of climate modifications and anthropic activities (forest resources).The *anthropic factors*, in turn, are represented by: very frequent *deforestations* in the Silvania landscape (Josan,2004); any kind of digging; buildings on the slopes; the vibration produced by the passing of the means of transport; irrigations; the abandonment of the agricultural terrains from the mountain and hilly areas (see fig.3).The regeneration capacity of overexploited forest ecosystems, marked by profound unbalances, can lead to some hazards including the geomorphologic risk (landslides, soil erosion and ravination).

Fig.3. Deforestations on relatively large areas in the Plopiş Mountains (Platoul Negrenilor sector*)*.

At a *micro-scale level*, in the Silvania Mountains, *the landslides* are mainly fostered by the presence *of Pontian formations*, with a loamy upper horizon, superposed to the middle one, a marly one (Dealul Pripora, Zalău). The rainfalls in the area led to the soaking of these deposits displaced on the sloped versants of the western part of the Meseş Mountains and the east part of Măgura Priei.The typology of these landslides is diverse, according to the folowing criteria: consequent landslides west of Meseș, in West Zalău sector, Fetindia and subsequent landslides at Stârciu, plastic-suffosional landslides and mudflows, respectively the mudflows specific to the western part of Meseș, south of Fetindia, at Băile Meseşenii de Sus, Carpeni, south-east of Măgura Stânii, west of Vârful Obârşiei, on Valea Gropii, west of Dealul Pietrei and Măgura Priei, superficial landslides (Hurez; Dealul Malul, Panic, Zalău, Peste Vale, Viile Jacului, Vârful Dealului, Dealul Pietrei, Arini, Măgura Bodiei, Vf. Gorunel, Dealul Prislopului) and deep-rooted landslides (the inclined versants west of Măgura Priei, Dealul Omului, Dealul Plopişului, Dâmbu Teiului, Dealul Ciungi). Their triggering is conditioned by the incline degree of versants (Vârșolț, Boghiș, Tabla sub Coastă, Pria, Hurez) and the presence of argillaceous deposits (Bănişor, Recea, Dealul

Omului, Dealul Plopişului, Cizer), the over-moistening of soil during the periods with rich rainfall (Pericei) and the *fragmentation mode* and the *form* of the slipped mass led to the identification of landslides: in waves (Vârşolţ, Zalău, Dealu Omului, Dealu Satului), mixed (Boghiş, Zăuan), in the shape of mound (Dealul Pripora), in levels (Dealul Omului), in the shape of smaller nests (Dealul Hurez, Leordeasca, Măgura Bodiei, Dealul Corbului, Moigrad, Peste Vale, Viile Jacului, Stâna, Gorunel, Prislop). Most of the identified areas are characterized by active landslides (Munţii Meseşului) and passive landslides (in the southern part of the Şimleu Depression).

3.2.3. Fluvial forms and processes

The Silvania Mountains, throughout the phases of *fluvial shaping*, were involved by the disjunctive tectonic processes, in close connection with the flow processes of superficial waters, in complex cycles of post-tectogenetic evolution. The combined action of tectonic, morphological, climatic and hydrographic factors, due to complex interactions, created forms of *erosion* and *accumulation*, specific to the action of concentrated or linear flow of hydrographic networks (Barcău, Crasna, Zalău, Dioşod, Leşcuţ, Agrij) related to the Silvania Mountains (Morariu, Sorocovschi,1972). The erosive action of rain water in the Silvania area takes numerous forms (Tufescu,1966).

Thus, the torrential activity of flow on versant in the Silvania Mountains took place through various processes of flow due to *pluvio-denudation*, *pelicular or areolar denudation*, *ravines*, *torrential denudation* (through torrents, characterized by a temporary flow and high speed water) whose reflex in the sector geomorphology is a complex form of landscape: *the torrential organism.*The linear and areolar erosion is by far the most important factor that contributed to land degradation.The most common form of erosion is *surface flow*, having consequences so severe that the land is no longer used for agricultural purposes. At the level of Sălaj County, *torrential formations* were inventoried, respectively a number of 278 torrents (on a total length of 386.398 km) wherefrom 21 in Bihor and 257 in Bihor, Someş, Crasna. The *pluvio-denudation* within Silvania Mountains had favorable conditions for development as a result of torrential rain (triggering factor), accentuated *slope*, if we make reference to the mountainous area of Plopiş and Meseş, through the shaded versants, the discontinuous vegetation cover and last but not least the anthropic activity.The Plopiş Mountains are affected by diffuse flow processes on the versants near the hydrographic basin of Barcău and on the versants of the tributaries' subbasins within the village boundary and Marca, Vărzari, Piciorul Otoanilor, Bistra, Vărăsău, Valea Lupului, Loranţa, Gepiş, Valea Oştenei, Şerani, Luncşoara, Drighiu, Valea Cerăsei.

In the Meseş Mountains, we encounter phenomena of diffuse flow on the versants near Valea Poicului, Ragul, Valea Rodinei (Coasta Roşie), much smaller

from the point of view of surface. The Șimleu basin and Meseș Mountains are integrated into an area with average denudation potential, while the southern part of the depression and Plopiș Mountains, Valea Crișului, have a high pluvio-denudation potential. On the territory of the Silvania Mountains, the fluvial and torrential processes, periodically, become very active both in what concerns the lateral erosion and the depth, due to landfall and massive transportation of alluvial deposits. In this case, we talk about surfaces with *forms of concentrated flow* (ravines and torrents). The hydric erosion affected large surfaces of versants in the Silvania area, which is located on a crystalline basement and tertiary sedimentary covers, which amplified the erosion of ravines and torrents, specific to the eastern part of the Meseş Mountains, Măgura Şimleului, Măgura Coşeiului at the contact with the Almaş-Agrij Depression, where erosion has reached an advanced stage, as a result of an intense action of torrential shaping.In the Silvania Mountains, *the erosion and torrential accumulation* has different forms, with a high density of *ravines* and *torrents* that transform certain territories in real bad-lands. The detailed analysis of these forms of concentrated flow in the Plopiş and Meseş Mountains brings to the fore the majority of versants adjacent the Barcău Basin (the Nuşfalău Depression, Plopiş-Consiciu Piedmont, Plopiş Depression) and Crasna in the mountainous area (in particular, in the Eastern Meseş, at the contact between the crystalline and the dolomite and calcareous rocks). At a microscale level, we encounter concentrated flow in the following areas: on the versants near Valea Mare from Plopiş, with a highly developed watercourse, receiving numerous tributaries from the mountain area, on Iaz, in the Şimleu Depression, on the versants adjacent the Barcau and Crasna hydrographic basins (left and right tributaries).

The *linear torrential* erosion follows the ploughland, the paths, and the driveways and is mainly developed in the basins of Valea Sâgului and Malului, in Dealurile Meseşenilor and in the area of the spring of Valea Ragului and Poniței. Măgura Şimleului is deeply fragmented by right and left tributaries of Crasna, Valea Leşcuțului, in the form of diffuse flows, especially in the Poiana Măgura, Giurtelecu Şimleului, Câmpul de Sus sectors. Măgura Coşeiului, compared with the other subunits of the Silvania Mountains, has the highest degrees of erosion of the most advanced and the lowest altitudes. The areal erosion is widely represented on the versants near the tributaries from both sides of Valea Zalăului, Cusalul, Dioşodul. The action of superficial water is, most of the time, associated with a number of *gravitational processes* (slides, solifluction, mudflow), which affects the less consolidated versants and those consisting of sedimentary deposits. The versants will be submitted to a rapid morphogenetic development, which can create serious conditions of geomorphological risk, leading to the destruction of bridges, communication ways and isolated buildings.

4. CONCLUSIONS

In conclusion, in line with the above-mentioned aspects, the *elementary and complex processes of landscape shaping* in the Silvania Mountains take place under the auspices of freeze and thaw disintegration, the thaw and accumulation of the materials displaced in the form of eluvial, colluvial and deluvial deposits, landslides, rollings and collapses. Regarding the erosion and the torrential accumulation, we notice a high density of ravines and torrents, which transform some territories of the Silvania Mountains into real bad-lands, if we are to make reference to the *concentrated flow* from the versants adjacent to the basins of Barcău and Crasna from the mountain area. Hazards and inferentially geomorphological risk phenomena may be caused by these *current shaping processes,* fostered by the existent lithological structure, the morphological support and the climatic and hydric features specific to the Silvania land.

The landscape of the Silvania Mountains displays a high fragmentation, as a result of the alternation of permeable and impermeable formations, of the chaotic deforestations and the irrational use of the agricultural fields, which favoured these shaping processes in a variety of forms. In the area of the Silvania Mountains, the river Someş, alongside its three tributaries, Crasna,Vârşolţ and Zalău, are affected by bank erosion processes, landslides, collapses, floods, alluviations and meandering. In turn, the prevention of geomorphological risk phenomena implies a proper management of these phenomena, requiring the mapping of the areas affected by landslides and of unstable areas, setting out possible scenarios, mapping the areas prone to the triggering of these phenomena and the implementation of contingency plans in the event of floods, landslides, settlements, mudflows - an essential prerequisite for a sustainable and stable development of the areas within the Silvania Mountains.

REFERENCES

1. Ayala+ Alcantara Irasema and Goudie A.(2010), *Geomorphological Hazards and Disster Prevention, University Press, Cambridge*.
2. Bogdan,C.,Mac,I.,(2014),*Risk Phenomena in the Silvania Mountains, intuitive and genetic reflexes,* în Riscuri şi Catastrofe, nr.XIII,vol14,nr 1,Ed.Casa Cărţii de Ştiinţă, Cluj Napoca,pp.31-44.
3. Costea Mărioara (2012),*Degradarea terenurilor prin eroziune hidrică. Ghid metodologic.*Editura Universitţii "Lucian Blaga" din Sibiu.
4. Grecu, Florina (2009),*Hazarde şi riscuri naturale.ediţia a IV-a cu adăugiri,* Editura Universităţii Bucureşti.

5. Irimuş, I.A, Bogdan,C.,(2017), *Tectonic and structural relationship in Silvania Mountains*, Studia UBB, Seria Geografie,n.1.
6. Irimuş, I.A.(2006),*Hazarde şi riscuri asociate proceselor geomorfologice în aria cutelor diapire din Depresiunea Transilvaniei*,Ed.Casa Cărții de Ştiință, Cluj Napoca.
7. Irimuş,I.A.,(2006),*Hazarde şi riscuri asociate proceselor geomorfologice, în aria cutelor diapire din Depresiunea Transilvaniei,* Editura Casa Cărții de Ştiință, Cluj Napoca.
8. Josan,I.,(2009),*Ţara Silvaniei, studiu de geografie regională*,p.7-96,195-228.Editura Universității din Oradea.
9. Josan,N.,(2004),*Hazarde şi riscuri naturale şi antropice în Bazinul Barcăului*,Ed.Universității din Oradea,Oradea.
10. Mac, I.(1986), *Elemente de geomorfologie dinamică*, Editura Academiei, Bucureştii.
11. Mac, I., Petrea,D (2002), *Polisemia evenimentelor geografice extreme*, în Riscuri şi Catastrofe, nr.XIII,vol,nr. 1,Ed.Casa Cărții de Ştiință, Cluj Napoca.pp.1-13.
12. Morariu T., Sorocovski V., (1972)**,** *Judeţul Sălaj*, Editura Academiei Republicii România , Bucureşti.
13. Rădoane Mara, Rîdoane, N.(2007), *Gemorfologie aplicată*, Editura Universităţui din Suceava.
14. Sofronie,C.,Stoica,S.F.,Dulău,B.R.,Cocuţ,M.,Selagea,H.I.,Sârb,T.M.,Scuturici,D.Gh(.2 013),b,*Bazinul hidrografic Someş-Tisa,*U.T.Press,Cluj Napoca
15. Sorocovschi, V. (2016), *Riscurile naturale. Aspecte teoretice şi aplicative*., Editura Casa Cărții d Cluj-Napoca.
16. .Sorocoschi, V.(2017).*Fenomene şi procese hidrice de risc.Partea I. Domeniul continental*, Editura Casa Cărții de Ştiință, Cluj-Napoca.
17. Stângă, I. C. (2007), *Riscuri naturale. Noţiuni şi concepte*. Editura Universității "Alexandru Ioan Cuza", Iaşi.
18. Tufescu, V.(1966), *Modelarea natrală a reliefului şi eroziunea accelerată*, Editura Academiei , Bucureşti.