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EXOKARST PROCESSES AND FORMS AND AGRICULTURAL ARRANGEMENTS IN PLOPIȘ MOUNTAINS

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ABSTRACT. – Exokarst Processes and Forms and Agricultural Arrangements in Plopiş Mountains. The crystalline basement of Silvania Mountains and in particular of the Plopiş Mountains was brought to surface due to a "strike-slip type" tectonics (I. Balintoni, C. Balica, 2013) in the shape of *homoclinal structures* deposited in the Tertiary sedimentary cover of the Apusenides. Plopiş Mountains are a real *lithological synthesis*, because their structure consists of magmatic, metamorphic and sedimentary rocks and they represent an integration, cooperation and interaction between inorganic minerals and organic minerals. Plopiş Mountains cover the largest part of Silvania Mountains. The dominant note of the landscape in Plopiş Mountains is the high degree of erosion as a result of the close connection between *rock type* and the landscape imposed by the *Tertiary dynamics of the Tisia-Dacia microplate*. Therefore, the *rock type* is a key factor in the characterization of landforms. The lytotypes related to Plopiş Mountains conditioned the development of the karst landscape, which, according to endokarst and exokarst processes, created favorable conditions for the development of edaphic and biogeographic resources as the basis for agricultural, forest and pastoral arrangements in Plopiș Mountains.

Keywords: *strike-slip type tectonics, homoclinal structures, lithological synthesis, endokarst and exokarst processes, ecological reconversion, forest and pastoral arrangements.*

1. INTRODUCTION

Plopiş Mountains, also known as *Rez Mountains (de Aramă - Copper)* or *Șes* in the specialized literature, are the western part of Silvania Mountains. The toponym *Șes* ("Plain") *Mountains* is justified by the fact that a significant part of Plopiş Mountains has the form of a "plain" especially in Șinteu area. The toponym *Rez* refers to two areas of compact forest: Răzu Mare and Răzu Mic, from which

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the toponym *Rez* was derived, which means copper and which led to the name Copper Mountains (*Geografia României*, 1987). Plopiş Mountains have a uniform, unitary and leveled landscape, especially in the central parts, which represent a *large plateau* between Șerani, Făgetu, Valea Târnei, Șinteu and Socet (see fig. 2).

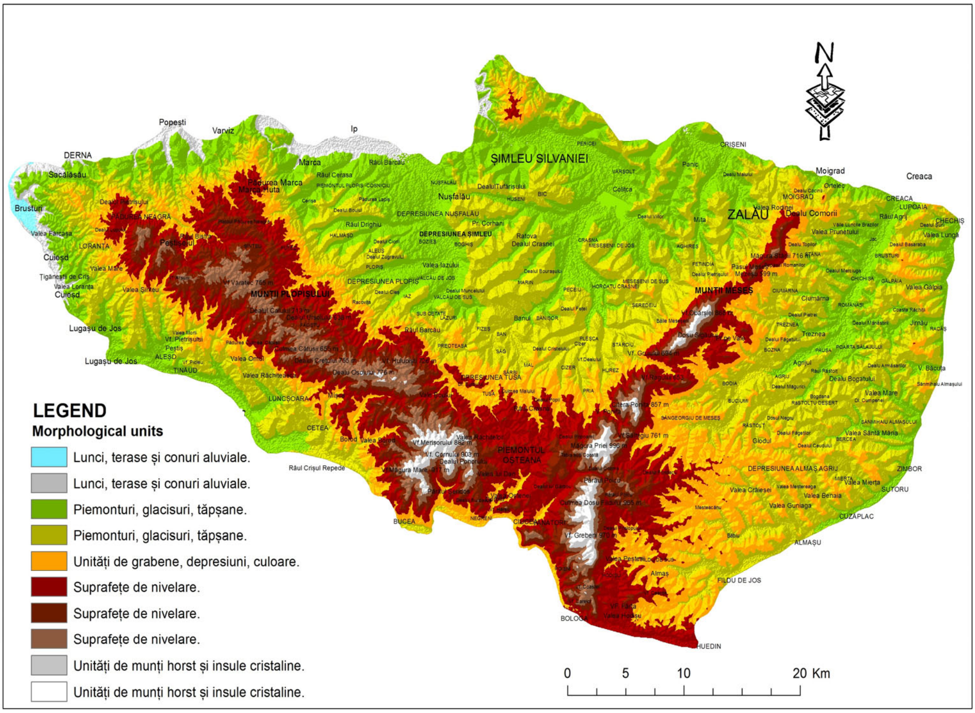

Fig. 1. Silvania Mountains, physical map (*source: the author*)

From the point of view of location, Plopiş Mountains share a border with Barcău Valley and Oradea – Borod Corridor to the West, which separates Plopiş Mountains and Crișana Hills, represented in this sector by *Plopiș Hills* (Bistra Hills, Derna Hills, Oradea Hills, Lugaș Hills), Barcău Valley and Toglaciu Hills to the North, which separates them from Silvania Hills, Şimleu Basin to the East and Crişul Repede to the South, which separates them from Pădurea Craiului Mountains. They are deeply fragmented by the tributaries of Crişul Repede and Barcău and have an asymmetric configuration on well individualized morphogenetic levels descending toward Şimleului Basin (see fig. 8). Between the neighboring mountains and the basin area, both in the western and the eastern part, a transitional strip is interposed, consisting of *morphological associations* of glacis-piedmont type and *shoreline-piedmont platform* in various stages of evolution.

The morphogenetic stages of landscape formation in Plopiş Mountains were complex and influenced by the structure of rocks. Thus, the efficiency of erosion processes was conditioned by *chemical and physical characteristics* of rocks, which have imposed the sector morphoselection in the Silvania Mountains. The *morphoselection* is conditioned by *tectonic, climatic and morphological factors*, variable in time and space. Through the *collaboration and interaction* of these factors along the contact surface, in this case the Silvania sublayer, subject to the modelling action of external factors, the landscape of Silvania Mountains is an *expression of the mobilization state of the sublayer*, at a given point in time and in a certain space (I. Mac, 1980). The stratified rocks in Silvania Mountains have different degrees of erodibility due to the orientation of these layers in relation to others.

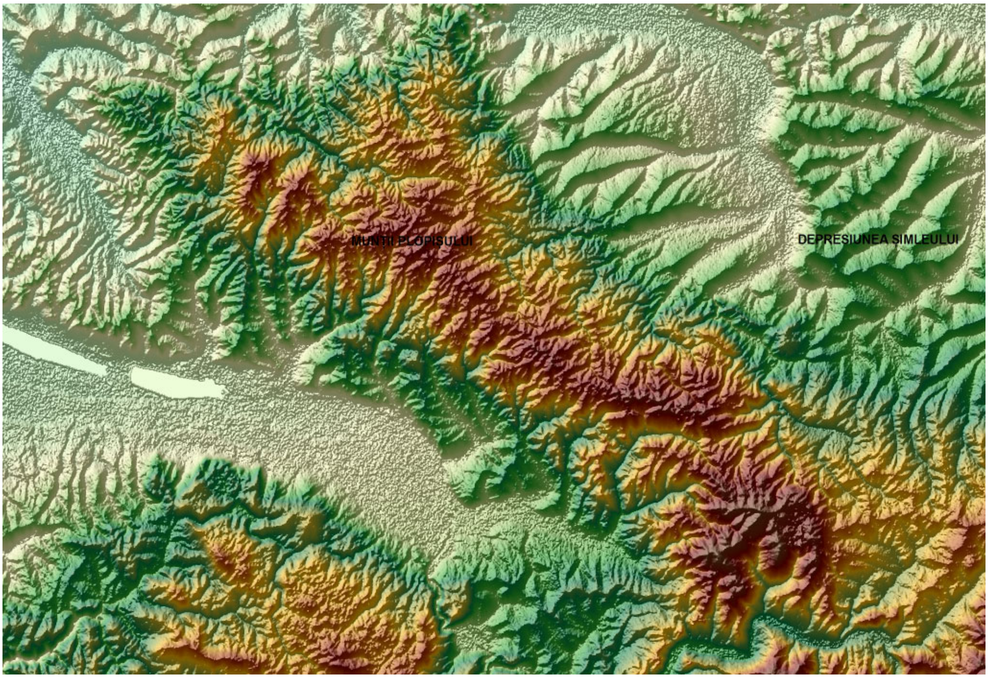

Fig. 2. DEM model of Plopiş Mountains and surrounding areas (*source: the author*)

The role of structure in the morphosculptural modeling of Silvania landscape is important because of the *layering of rocks*, *the degree of fracturing* (induced by water loss in the sedimentary rocks and the cooling in the case of magmatic rocks), *the cleavage* and *the presence of the areas of schistuosity* (specific to metamorphic rocks which contain lamellar–shaped minerals due to the efforts to which the rock was submitted during the phases of deformation). (I.A. Irimuș, C. Bogdan, 2017). We also mention that the *rock's response to differentiated shaping* in Silvania Mountains was a diverse and complex due to the following types of landscape, influenced by the lytotypes in the Silvania area: crystalline and metamorphic rock landscape, karst landscape, sandstone and conglomerate landscape, marl and clay landscape, periglacial landscape and anthropogenic landscape. Within this article, we will focus on the *karst landscape* and the agricultural arrangement from a pastoral and forest point of view in Plopiș Mountains.

2. MATERIALS AND METHODS

In what concerns the materials, the methodology and the techniques used for outlining the crionival processes and their effects on the types of agricultural use of Silvania land, we took into account the topographic and geological databases, while we used the geomorphological mapping as technique. In this respect, we transposed to the topographic map the morphology of these contemporary geomorphological processes as a reflex of a complex interaction between the crystalline sublayer, the sedimentary cover and the internal and external geodynamic agents. The geomorphological map was created using a methodology of the geomorphology school from Italy. Thus, using the related topographic and geological base, both the lithology of the sublayer and the main endogenous and exogenous processes, specific to Plopiș Mountains, were mapped and represented from a cartographic point of view. The main difference lies in the fact that on the final geomorphological map, the topographic base, which confirms the dynamics and the evolution of processes in the Silvania Mountains, is also visible. The methods and the techniques involved the cartographic method and the GIS analysis. In this article, we outlined five parts: introduction, materials and methods, the regional tectonic evolution and the geodynamic setting, the karst landscape of Plopiș Mountains, the resources and the forms of agricultural arrangements.

3. THE REGIONAL TECTONIC EVOLUTION AND THE GEODYNAMIC SETTING

Plopiş Mountains have the shape of a *crystalline Mesozoic peninsula* whose landscape is imposed by the sector dynamics of these systems of faults, which created favorable conditions for the intensive processing of the crystalline sublayer. The morphodynamic processes in Plopiş Mountains are conditioned by the *tectonic fragmentation in a horst-graben system*. Plopiş Mountains are delineated as a *supposed horst*, *homoclinal structure* or *rift shoulder*, bounded by faults with Carpathian direction (NW-SE) and faults with Pannonian direction

(NE-SW), to which we add secondary faults (N-S or W-E direction). Plopiş Mountains are differentiated from other units of Silvania Mountains by the *structure of the crystalline basement*, which spreads over very large areas in the central parts of the range and represents the most important area of the *Hercynian crystalline*.

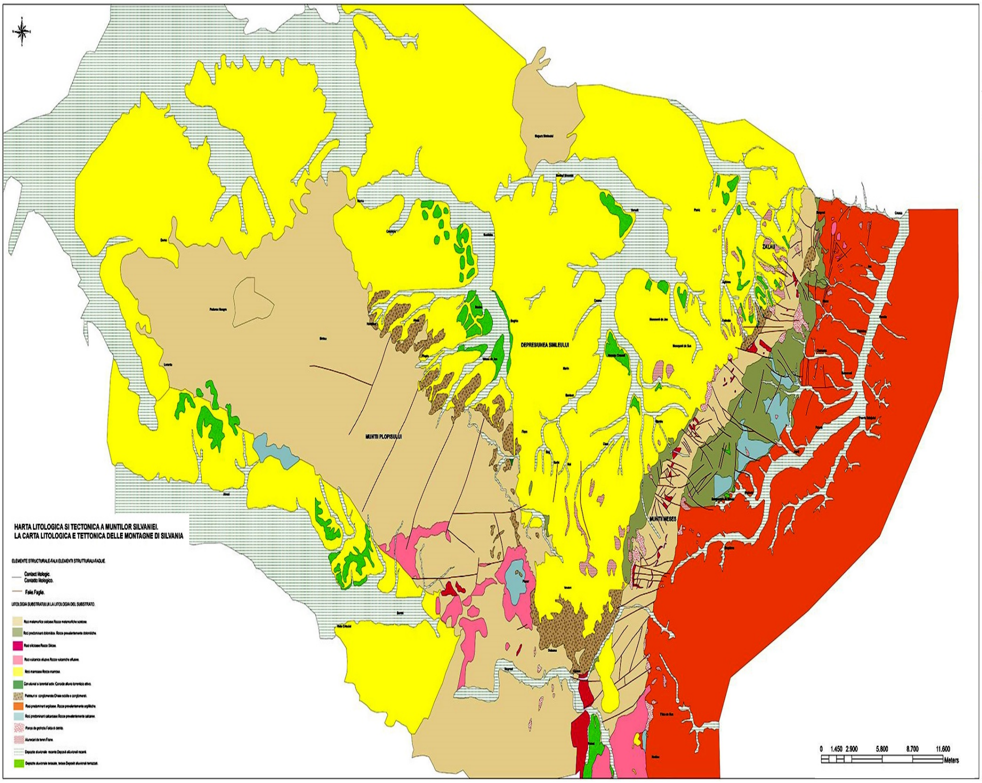

Fig. 3. The lithological and tectonic map of the Silvania Mountains (*source: the author*)

As in Meseş Mountains, in the southeastern part of the Plopiş Mountains there is a strong *tectonic fragmentation* outlined due to various *lithological units* which are constituted as a real petrographic synthesis supported by *magmatic rocks* (rhyolites in Vlădeasa), *metamorphic rocks* (mica-schists belonging to the complex of quartzofeldspathic rocks, quartz mica-schists, para-amphibolite rocks, ortoamphibolite rocks, nodular gneisses, paragneisses with muscovite and biotite of the Late Precambrian age) and *sedimentary rocks* (the Gosau Formation of Senonian age - conglomerates, sandstones, marls and limestones) (see fig. 3). The tectonic units related to this sector are represented by the *Bihor Autochtonous* – made of the crystalline basement (mica-schists of Precambrian age) and the Mesozoic cover (conglomerates and limestones), to which the *Gosau Formation* is added, while Paleogene magmatic rocks are interbedded. The reflex in geomorphology of these systems of faults on both sides of the Plopiş Range and their tectonic basement is the formation on the old shore line of Central Paratethys, especially on the northern side, of *a shoreline platform* made of piedmontal deposits (fig. 8).

The karst landscape in Silvania Mountains is the result of collaboration and integration between sedimentary cycles and episodes of transgression and regression from the Alpine Tethys, the Pannonian Sea, specific to the carbonaceous platform stage of the Tisia Craton. The basinal evolution of the Tisia Craton during the Ladinian, Senonian, Danian, Palaeocene and Badenian had a significant contribution to the completion of the karstic landscape in Silvania Mountains. The Ladenian was important due to the deposits of *ashen-grey dolomitic limestone* (fig. 4) with calcite

Fig. 4. Ashen-grey dolomitic limestone with calcite venules of Ladinian age in Plopiş Mountains (*source: the author*)

venules, and of *black limestones with fractures* (fig. 5) with calcite venules, of Guttenstein limestone type, widespread on the western and eastern slopes of Meseș and in the southern sector of Plopiș Mountains. The endokarst and exokarst phenomena in the Silvania area are connected to the Paleogene carbonaceous formations (Eocene and Oligocene), in the north-western part of Someșan Plateau.

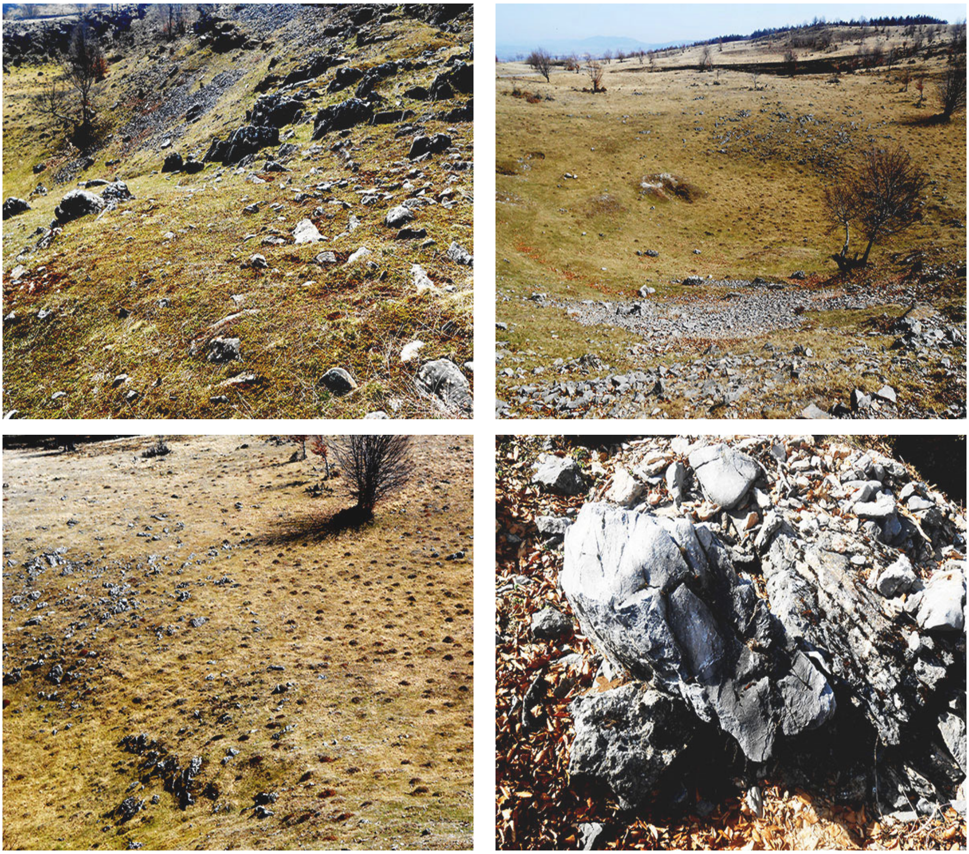

Fig. 5. Karst landscape in Plopiș Mountains: dolines within the Ponor karst plateau (upper row) and limestone with fissures (bottom row)

During the Neogene (Badenian), the unstable areas of the Șimleu Basin basement were the subject of intense sedimentation processes, thus *reefs of Leitha limestone type* were formed in the marine environment, identified at Pria, near Meseș, and Coșei, near Măgura Hăghișei. During the Sarmatian, near the Oștena Piedmont area, a *reef facies* was deposited, represented by limestones with Serpula, bryozoans, mollusks, foraminifera and algae. They were deposited during the Lower Volhinian due to a littoral zone close to the shore, brackish waters and warm temperatures, in other words, a biotope with real *limestone reefs* (bryozoans, worms, mollusks, foraminifera and calcareous algae), which developed on the hard sublayer of crystalline schists, in areas close to the shore and on the islands and crystalline summits, which were near the water surface. *The karst on the Miocene rocks* near Ragu Valley (Stârci) is linked to the existence of unstable areas within Șimleu Basin, which favored the emergence of several depositional facies (Clichici, 1973).

The Mesozoic sedimentary processes in Plopiș Mountains did not take place in the current expansion area, thus there are two hypotheses: in Late Triassic and Jurassic, Plopiș Mountains functioned as a horst only in a subaerial regime, although further South the Jurassic series is complete in Pădurea Craiului Mountains (a dry land located North of Bihor platform is mentioned in the geological literature); during the upper Triassic and Jurassic, the alternation of lifting and lowering on fault lines from the northern platform of Tethys is due to Eo-Cimmerian and Neo-Cimmerian phases, followed in the middle Cretaceous by the Austrian phase that determined the removal of the sediments of this age through erosion.

Fig. 6. Calcareous facies on the northern edge of Plopiș Mountains represented by Sarmatian limestones (*source: the author*)

The *calcareous facies* on the northern edge of *Plopiș Mountains,* in Halmăjd (fig. 6) has Sarmatian limestones (Păucă, 1954), in the form of patches, placed directly on the crystalline schists in the upper parts of the hill slopes, often forming real *garlands of calcareous islands*. The size of these patches is not particularly large; it ranges from a few tens of m^2 to 1000 m^2. The thickness of these limestones is variable. Their limits vary between 2-3 m and about 15 m. The calcareous patches are at the same levels on the hill slopes or summits. As indicated by Păucă (1954), these limestones appeared on *higher islands or crystalline summits*, while detritus deposits (sands and marls) were formed in the outside ditches. Clearly, the present limestone patches are only testimonies of a *calcareous area, marking the southern shore of the Şimleu Gulf during the lower Volhinian*. The shapes, the emergence, the lithological aspect (compact, white-grey) as well as the fauna indicate *the origin of these reef limestones* (fig. 7).

Fig. 7. Calcareous facies with reef origin in Ponor karst plateau (*source: the author*)

Such limestone formations are frequently found in the Euxinic basin and the Pannonian one. The reef limestones sometimes become oolitic limestones, which bordered the reef and which, with the increase in water depth, became in turn white calcareous sandstones, sands, calcareous conglomerates, and more rarely whitish marls. The geological positions as well as the lithological composition of these deposits indicate the reef origin.

4. THE KARST LANDSCAPE IN PLOPIŞ MOUNTAINS

The karst geomorphology in Plopiş Mountains is due to a *karst on Triassic rocks* because of the existence of dolomite deposits (dolomites, limestones, salt and plaster) (fig. 3), which created favorable conditions for the development of such landscape. In Plopiş Mountains, the karst landscape is mainly found in the calcareous plateau named Platoul Negrenilor or Platoul Ponor, as it is also known in the specialized literature, area where complex tectonic, lithological and structural units overlap, according to local geological data. *The karst on Triassic rocks* within the **Ponor karst Plateau**, in the south-eastern part of Plopiş Mountains, is located at an altitude of 750-800 m and represents the area of departure of a radial drainage network. The area is relatively small and has a rich karst landscape represented by endokarst and exokarst forms (N. Meszaros, 1957, 1997). It shares a limit with Borod Valley to the West, which collects its waters from under the peak of Măgura Mare (917 m), Șerani Valley to NW, Bou Valley to the North, the Răchite Valley to NE, which has its headwater in Dealul Mare, Criș Valley to the South and Dormir Valley to the East. The highest peaks in Plopiş Mountains are in this sector, Măgura Mare (917 m) and Cornu Peak (906 m), separated by Secătura Valley, tributary of Negrea River, to which one also adds Merișorul Peak (882 m), supported by black stratified limestones, dolomites, sandstones, conglomerates and siliceous sandstones of Campilian-Anisian age.

East of Făgădău Valley and Măgura Mare, there is a large structural surface and also Negrea River springs from below this peak, and is then collected by Crişul Repede at Bucea, where a very active torrential erosion is noticed, in the shape of detritus cones, active due to the heterogeneous lithological sublayer, supported by volcanic rocks (Dâmbu Roșu) and calcareous rocks (Măgura Mare Peak). NE of Cornu Peak, there are mostly calcareous rocks (the *Crișul Repede Formation* integrates in its structure Bucea limestones and inferior dolomites) over which *Bucea blackish limestones with Dadocrinus and Glomospira* are deposited. Based on this, the suggestive karst landscape on Ponorul Negrenilor or Negreni Plateau has developed, rich in endokarst and exokarst forms. Along Șoimu Valley there are stratified white dolomites, dark-colored limestones, arranged in plates, and marmoreal limestones. The *dolines* are widespread and are subject to dissolving processes associated with erosion and other processes, resulted in the shaping of distinctive karst morphology in the Silvania area. This happened because the limestones and the dolomites are the only category of karstifiable rocks, on which, in addition to landforms created under the current geomorphoclimatic conditions, *karst complexes* were preserved, belonging to different evolutionary stages, even from the Mesozoic. The underground karst is represented by small caves and sink holes. On the outskirts of the limestone area, at the contact with impermeable rocks, karst springs are encountered: Izbucul Mare from Izvorul Topliței, Izbucul Mic from Răchite Valley and Izbucul Negrenilor. Barcău River flows from a northern karst spring, on a thick travertin area, the karst spring waters forming a picturesque waterfall with a height of 10 m. A second karst spring, masked by a detritus mass, supplies water to Negrea Valley, a tributary of

Crișul Repede. Ponorul Negrenilor is a suspended synclinal, whose underground drainage is carried out in two opposite directions (toward Barcău and Criș), due to an eruptive transverse lamella, which has the role of watershed. Much smaller, but still a calcareous structural witness, is the cone-shaped peak of Picleu, in the area of Negreni.

Calcareous rock bodies in Plopiş Mountains were identified in the dolines within the Ponor karst Plateau in the south-eastern part. The limestones have different ages, but the Mesozoic limestones prevail, which, unlike the crystalline limestones (where the karstification is weaker), they are thick and intensively fissured, fact which allows an adequate water circulation that shapes endokarst and exokarst landforms. The analysis of the geomorphological map indicates the presence of dolines within the karst of Ponor Plateau: *Dealul Călin, Preoteasa, Dealul Osoi, Tusa, Ponor, Dealu Arsura and Dealul Ursoi,* in the south-eastern part of Plopiș Mountains (fig. 9). The Badenian and Sarmatian limestones on the southern border of Șimleu Basin (Tusa – Sâg area) have the shape of some erosion witnesses that rarely exceed 1 km^2. In what concerns the Șimleu Basin, the eastern sector of reef limestone is at Tusa.

Other limestone areas in this region are Dobra Hill, Dumbrava Hill, north of Tusa, on Peșterii runlet, where Litothamnium limestones appear. It is interesting that the Sarmatian limestone deposits on this runlet represent the only case in the region in which reef limestone is not in direct contact with the crystalline basement. In the area of Peșterii runlet, the local geology refers to the existence of a crystalline area with the *function of submerged island* (Late Badenian, Sarmatian), bounded by the deeper areas, which favored the accumulation of a *calcareous reef facies*. These limestones seem to be positioned over the crystalline formations of the basement, they only appear at the top of slopes and rarely exceed a thickness of 20 m. This calcareous reef facies allowed the development of exokarst forms, such as dolines, which do not exceed 15 -20 m in diameter, dry valleys and paleo-sinkholes.

During the *morphotectonic evolution* of Silvania Mountains, *an intense fragmentation of the calcareous areas* and a rapid evolution of the structural landscape took place (fig. 8), which prevented the emergence of major underground drainage, allowing the formation of notable karst networks. The exokarst in Silvania Mountains is a result of the Pliocene-Quaternary morphogenetic evolution, represented by a wide variety of forms: *karrens, doline fields, uvalas, poljes, lithological contact basins and doline valleys or valleys with dolines.*

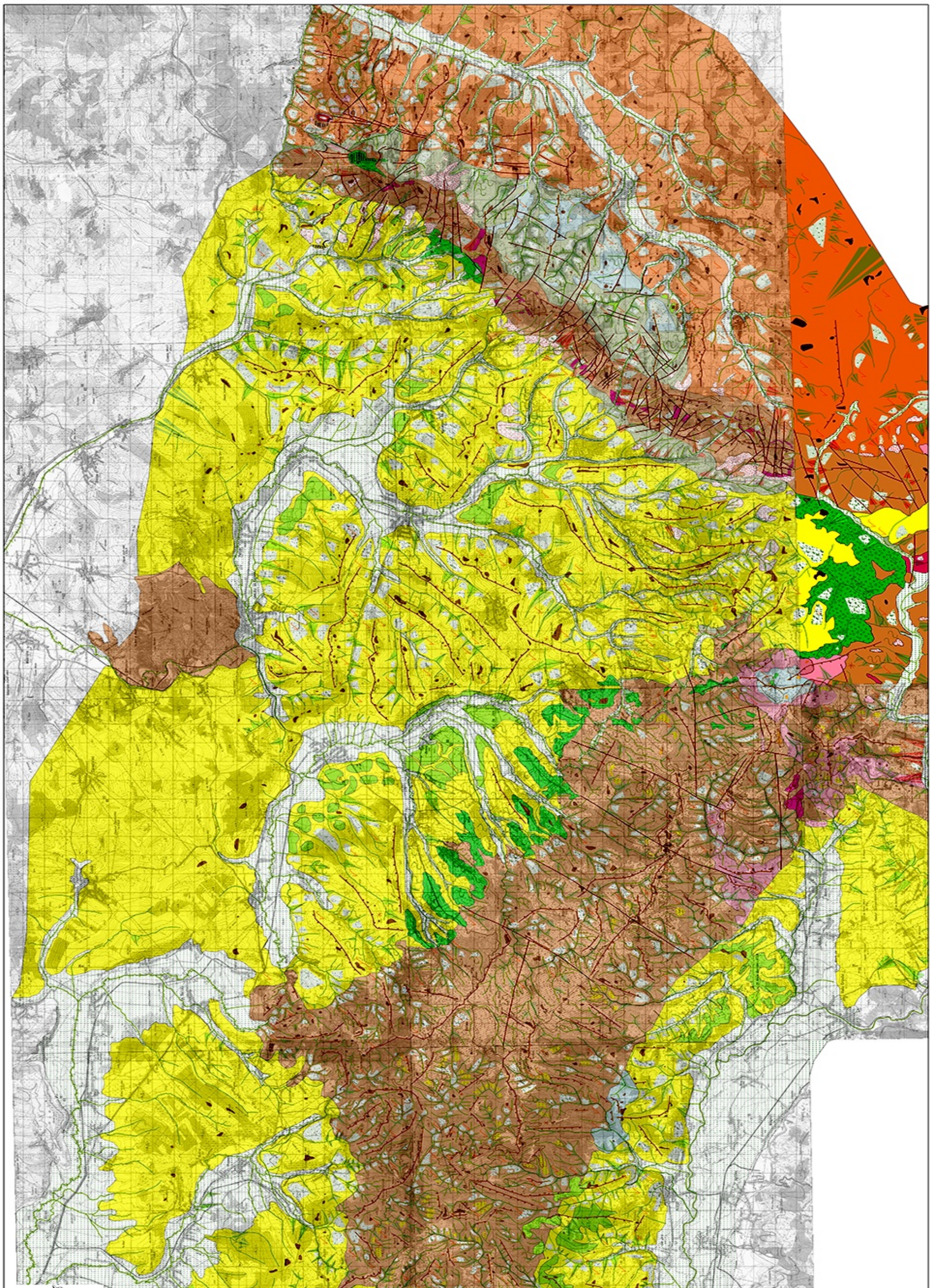

Fig. 8. The geological and geomorphological maps of Silvania Mountains and their legend (*source: the author*)

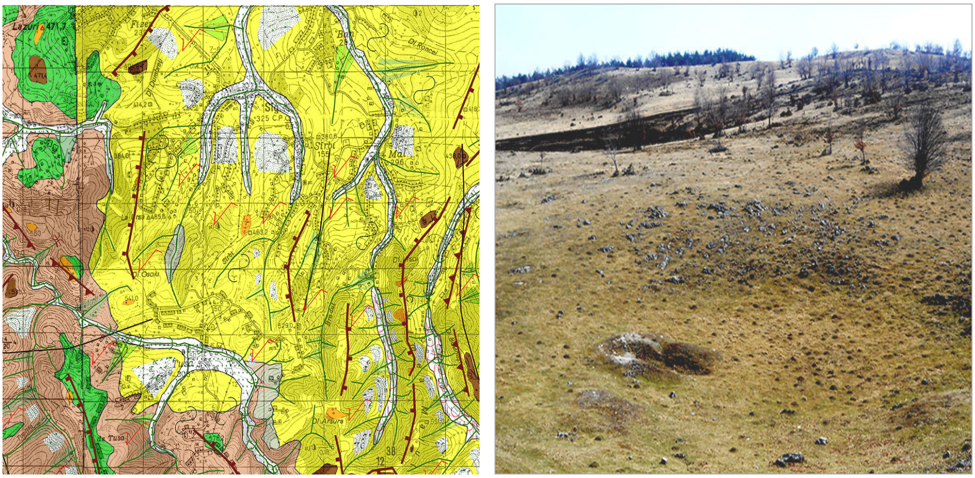

Fig. 9. Dolines within the Ponor karst plateau (*source: the author*)

As noticed from the analysis of the geomorphological map, these patches of *limestones and dolomites* represent the testimonies of the existence of this continuous calcareous limestone area, which marked the southern shore of Șimleu Gulf. The shape, the appearance and the white grey colour of these limestones indicate their reef origin, another attribute of the Hercynian chains of Central and Eastern Europe, where Silvania Mountains should be integrated by future geological and geomorphological research.

5. RESOURCES IN PLOPIŞ MOUNTAINS AND THE FORMS OF AGRICULTURAL ARRANGEMENT

Silvania Mountains and in particular Plopiş Mountains overlap the heterogeneous geological sublayer of the ancient Tisia craton, characterized by a peculiar *morpholithological and morphostructural* complexity. The formation of useful minerals in Silvania Mountains was linked to the basin stage of the Tisia Craton and to the variety of *source areas* related to this basin. Plopiş Mountains are characterized by the variety of natural resources, plants and animals that provide an integrated support in terms of human activities. These resources are capitalized and there are agricultural arrangements of different types, as well as forest and pastoral arrangements. From the point of view of typology, we distinguished the following categories of resources: *non-renewable* (minerals and fossil fuels); *renewable* (water, air, soil, flora and wild fauna); *permanent* (solar power, wind power, geothermal power).

5.1. Soil resources

In Plopiș Mountains, *cambisols and argiluvisols*, specific to the low mountains, prevail. With regard to the use of soil on *categories of use* in 2015 as the *primary base for agricultural development* in Plopiş Mountains, according to data provided by *Sălaj Office of Pedological and Agrochemical Studies* (*table 1*), we can notice an increase in the land covered by orchards, meadows and arable lands and a decrease in pasture lands and vineyards. The main geomorphological processes affecting the soil quality are represented by *water and wind erosion* (which causes the loss of fertile soil layer on the surface, the land deformation, clogging and sedimentation); *compaction*; *landslides*; *excess water*; *the low amount of organic matter and nutrients in the soil*; *salinization*; *acidification*; *pollution*.

The linear and areolar erosion is by far the most important factor in land degradation. Among the various forms of erosion, the most widespread is the *surface discharge*, having so severe consequences that the land can no longer be used from an agricultural point of view, so it must be removed from the agricultural circuit. At the level of Sălaj County, according to data provided by the *National Administration of Land Improvements, Someş-Tisa Branch*, the following phenomena were reported concerning the agricultural surface: strong surface erosion (10,375 ha), in depth erosion (4 657 ha), the modification of the geochemical composition (159 ha), landslides (8 343 ha), geological erosion (356 ha), bank erosion (109 ha), excessive humidity (8 961 ha), valueless vegetation (2 342), totaling an area of 35 700 ha. According to the *National Administration of Land Improvements Someş-Tisa Branch,* at the end of 2015, the area for land improvements of Sălaj County was 133,484 ha, structured as follows: *control of soil erosion* (119,161 ha, which represent 64% of the development potential) and *drainage* (14,323 ha, 56% of the development potential).

Table 1. The distribution of lands according to their use in Sălaj County, between 2011 and 2015 (*source: Sălaj Office of Pedological and Agrochemical Studies*)

No.	Year	Category of use					Agricultural lands total
		Arable lands	Grasslands	Meadows	Vineyards	Orchards	
1.	2011	120,588	74,672	36,781	2,500	4,425	**238,966**
2.	2012	120,586	74,671	36,780	2,500	4,425	**238,962**
3.	2013	120,428	74,521	36,604	2,533	4,827	**238,913**
4.	2014	120,428	74,521	36,604	2,533	4,827	**238,913**
5.	2015	120,559	74,340	36,659	2,529	4,863	**238,950**

Most of the agricultural lands (62%) have the incline between 6-14º and are covered by vineyards and orchards. 15% of lands have the incline under 6°, being used for grain crops and last but not least the pastoral arrangements specific to central summits of Plopiș Mountains, which have the form of some large plateaus.

5.2. Climate resources

Due to their position, Silvania Mountains are located in the temperate continental climate area, representative for the western and northwestern areas of Romania. The effects of the southern or southwestern circulation are felt through higher temperatures and rainfall in proportion of over 15%, as a result of warm air from the south-west, characteristic to north Mediterranean cyclone activity, in its movement towards north. The influence of climate is equally felt in the characteristics of flora and fauna. It can favor or restrict the anthropogenic activity. Particularly, it fosters the agricultural activity, through favorable periods for certain cereal and technical crops, fruit-growing, vegetable growing, farming (Josan, 2009).

Table 2. Average annual temperature, rainfall and winds in the Silvania Mountains, between 2011 and 2015 (*source: the National Administration of Meteorology*)

Year	Annual average temperature (°C)	Monthly rainfall (l/m^2)	Wind - main direction (m/s)
2011	10.5	389.6	NW/2.1
2012	11.2	568.7	NW/2.2
2013	11.2	693.4	NW/2.3
2014	12.4	649.3	SE/2.1
2015	11.7	626.1	SE.1.9

Between 2011 and 2015, the annual average air temperature in Silvania Mountains increased from 10.5°C to 11.7°C, influencing the dynamics of the Silvania ecosystems. Higher average annual precipitation amounts (800-900 mm and even exceeding 900 mm) were recorded in Meseș and Plopiș Mountains as a result of their higher altitudes as opposed to the surrounding regions and to their exposure to the Western circulation.

Between 2011 and 2015, the annual rainfall amount recorded oscillations with a rising trend from 389.6 l/m ^{2} to 626.1 l/m^2. The integration between the climate and the active surface in the Plopiș Mountains resulted in the formation of complex and elementary topoclimates depending on the characteristics of the active surface (altitude, aspect, slope, expressed in terms of the amount of received caloric energy, the duration of sunlight brightness and local air currents).

The topoclimate of Plopiş Mountains is imposed by their low height (less than 1000) and their position in front of the oceanic air masses (Josan, 2009). The climate of Plopiş Mountains is influenced by western air masses; therefore higher rainfall is recorded (700-900 mm/year) with average annual temperatures of 6-8º C in the central part and 8-9º C on the outskirts. In January, the values are between 2-4ºC while in July they are maintained around 16-19ºC. The integration between climate, landscape and human activity in the area of Plopiş Mountains led to permanent settlements of the "shelter" type on the cols between the main summits (Socet, Huta Voivozi, Valea Târnei, Șinteu, Făgetu, Șerani), favored by the moderate climate. The practicing of animal husbandry, as a pastoral development, attests the integrator character of the climate and of its influence, with a double purpose: *supporting landforms shaping* and last but not least the *development of human activities*.

5.3. Water resources

The hydrographic network of Silvania Mountains has a divergent character and was forced to adapt to tectonic structures in this area, draining from West towards East in the case of Crișul Repede and Barcău, near Plopiş Mountains. The *asymmetry* of major hydrographic basins is due to tectonic causes to which the network adapted (sinking movements, in the central part of Șimleu Basin, lifting movements in Plopiş Mountains, Măgura Şimleului and especially in Meseş Mountains).

5.4. Biogeographical resources

The pastoral and forest development in Plopiş Mountains is mainly based on edaphic and biogeographical resources. The types of habitat in Silvania area and in particular in Plopiş Mountains correspond to the characteristics of the continental biogeographical region: *forests*, *meadows* and *shrubs*, as well as *vegetation adapted to caves*, *waters*, *peats* and *marshes*. As regards the *distribution and composition of flora*, in Silvania area, a vertical zonality is noticed; the predominant landscape is given by the *interplay between the areas covered by woodland* (oak, beech, mixed forest) and the secondary and derivate meadows or agricultural land. The main share in Silvania Mounatins is held by *meadows and farmland* as a result of the introduction of crops in clearings by population in ancient times and of the deforestation of beech and common oak forests.

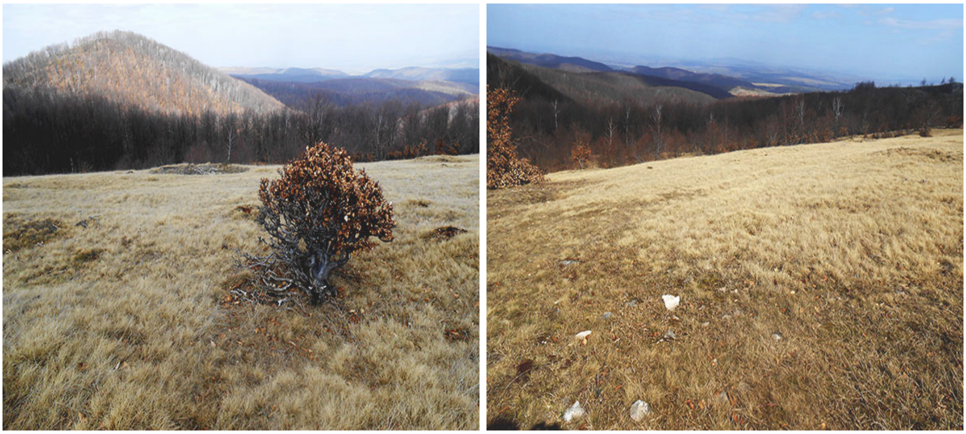

Fig. 10. Vegetal formations of meadow type in the Plopiş Mountains, Negreni Plateau sector (*source: the author*)

In Plopiş Mountains, the *coniferous forests*, in mixture with the *broadleaf forests*, cover large areas on Barcău Valley, Iaz Valley, Valea Mare and Marca – Huta, where the coniferous forests, represented by *spruce* (*Pices abies*), are accompanied by *broadleaf forests*, including *beech*, *hornbeam* (*Carpinus betulus*), ash (*Fraximus excelsior*) and sycamore maple (*Acer pseudoplatanus*). The beech sublayer, of *Fagus Silvatica,* is encountered in Plopiş Mountains.

Fig. 11. Deforestation of large areas in Plopiş Mountains (Negreni Plateau sector)

The current demands of wood as *main resource of the forest* are on a constant increase, leading to conflicting reports between the anthropogenic exploitation of this resource and the capacity of regeneration of overexploited forest ecosystems, marked by deep unbalances which can trigger geomorphological processes, controlled by this vegetal association (landslides, soil erosion and ravination). Against environmental reconversion schemes, the cleared areas in Silvania Mountains were replanted with varieties of deciduous trees (durmast) and coniferous trees (spruce, fir, pine). As a consequence of the massive deforestations in the land of Silvania, the forest area decreased from about 40% of the whole area of Silvania territory (fig. 11), in the 16th century, to 28% in the 19th century, to 26 % in 1970 and 22 % today (Josan, 2009). To the mentioned causes, one may add *the agricultural overproduction crisis* in 1873, when the exploitation of agricultural land was very poor, and the wood from forests was exploited in order to achieve the necessary revenues. The interaction between the anthropogenic factor and the forest ecosystem led to the creation of integrated forms of *runways and forest roads type* (road or rail tracks), such as railways for the transportation of timber between Nuşfalău and Valea Iazului (18.8 km), between 1926-1928 and on Boului, Starvinului and Blidarului valleys (48 km), built between 1927-1933. After the depletion of timber, railways were no longer used. The deforestation produced some modifications in the demographic structure, through the colonization of specialized workforce, comprised mostly of Slovaks in Plopiş Mountains. Due to the same circumstances, the *rural settlements of copse type appeared*. Their emergence was linked to the fact that people cleared the forests, then built their homes, and an eloquent example in this respect is the village of Marca-Huta.

In Plopiş Mountains, the forest on smooth surfaces (erosion platforms) were gradually replaced by pastures, therefore *sheep grazing* during summer was extended and *shelters* appeared as rudimentary forms of pastoral arrangement. The replacement of forests by agricultural lands reduced their hydrologic function, with serious consequences on the flow of the superficial water into rivers, which was then reflected in the frequent floods of Barcău. The forest roads, some of them temporary, fostered water erosion and led to the unbalance of the versants and the triggering of some specific slope processes (Irimuş, 2016). Due to its features, the forest has a high ecological value, it protects the soil, influences the local climate and the hydric regime, controls the cycle of the nutritious elements between the soil and the flora, constitutes the habitat of numerous varieties of plant and animal species, protects the human settlements and also has a production value through the wood, exploited alongside other forest products (according to the Environmental Protection Agency of Sălaj, 2012). Forests in Silvania area are in close connection to landforms, thus limiting the erosion processes and the landslides and affecting the climate, the vicinity of the forest and the evolution of forest soils. *The habitats of meadow and brushwood* type are mainly encountered in the hilly area of Silvania (fig. 10), on the site of the former forest of beech and durmast and along the valleys of the main rivers crossing the area. They are used as pastures and meadows consisting of mesophillic herbs (*Agrostis tenuis*, *Festuca rubra*, *Lolium perenne*, *Nardus stricta*, clover and dicotyledonous species). The fauna in Plopiş Mountains is sporadically represented by elements specific to the *Carpathians* (Carpathian stag, birch cock, bear, lynx). The cynegetic fauna instead is well represented by: boar (*Sus scrofa*), roe deer (*Capreolus capreolus*), Carphatian deer, bears, rabbits, badgers (*Meles meles*), squirrels (*Sciurus vulgaris*), wolves (*Canis lupus*), lynx, pheasants (*Phesianus colchicus*).

5.5. Forms of agricultural arrangement in the Plopiş Mountains

In Plopiş Mountains, the existing edaphic and biogeographical resources are mainly used for the forestry and pastoral arrangements.

5.5.1. Forest arrangements

The forest arrangements in Plopiş Mountains include the totality of the forests and the areas for afforestation, serving the needs of crops, production or forestry administration, the ponds, the riverbeds of the runlets near Plopiş, areas for forestry use and non-productive areas. All of these are part of the forestry development since 1st January 1990 or included in it later. From a legal point of view, they constitute, regardless of the nature of the property, the *National Forest Fund*: *the forests*; *areas in process of regeneration* and the *plantations* established for forestry purposes; *land used for afforestation* (degraded land and treeless land, in compliance with the law to be treed); *areas serving the needs of crops* (plant nurseries, plant crops); *areas that serve the needs of forestry production* (osiers, Christmas trees, ornamental trees and bushes and fruit trees); *areas that serve the needs of the forestry administration* (lands for ensuring game food and producing forage, temporarily used by the forestry staff); *areas covered by buildings and related fields* (administrative offices, cottages, pheasantry, trout farms, farmers, roads and forest paths for transport, industrial spaces, other technical facilities for the forestry sector); ponds, runlet riverbeds, as well as non-productive lands included in forestry development; wooded pasture with a consistency ≥ 0.4, calculated only for the actual area covered by forest vegetation. With regard to forest arrangements in Plopiș Mountains, the problems of regeneration of natural brushes require special attention from the part of foresters, because they constitute a small percentage, but they shelter rare plants, including species listed in the Red Book.

Fig. 12. Forest habitat in Plopiş Mountains

If one looks at the way in which the area covered by the *forest fund* in Sălaj County evolved during the last 5 years, one notices an increase of the *forest fund* from 95,847 ha, in 2010, to 95,876 ha at the end of 2015, but there is still a deficit in relation to taking possession of some lands, in particular degraded lands that need new forest plantations. Worth mentioning is the fact that in the case of the property structure of the National Forest Fund, at the level of Romania, the areas covered by state forests, under the *administration of R.A. Romsilva (Romanian National Forest Administration)*, continued to decrease from 4.3 million ha at the end of 2005 to 2.3 million ha in the following period. In Sălaj County, there was a significant change in the percentage ratio of private forest areas at the expense of those owned by the state, with the emergence of normative acts regulating the property regime. In particular under the Law no. 247/2005, large areas of forest were given back to their owners. From the point of view of the structure on forestry groups (coniferous-deciduous), the forest fund in Sălaj County consists of: *coniferous species* (6905 ha, 7%), *deciduous species* (87,778 ha, 92%) and other lands (1183 ha, 1%) (Environmental Protection Agency of Sălaj County, 2015). In order to ensure a sustainable forest management, a key factor is their regeneration. In this respect, between 2011 and 2015, by means of afforestation campaigns, the regeneration of forest areas was carried out as follows: *total regeneration*, *artificial regeneration* (afforestation) and *natural regeneration*, with a higher share of the *total regeneration* (141 ha and 107 ha), followed by *natural regeneration* (43 ha and 76 ha).

In order to keep the genepools of these brushes, it is recommended to use the natural regeneration. The forest fosters water infiltration into soil, maintains a favorable water regime for the soil, prevents or reduces the intensity of torrential phenomena and avalanches, with all the negative effects on the environment and the overall economy. Due to the leaves, the forest vegetation contributes to the purification of the atmosphere (reducing dust, smoke, toxic gases and microbes) and consumes at the same time a huge amount of carbon dioxide, continually renewing the oxygen stock. Another essential aspect is the landscape and recreational role of the forest, which, due to its aesthetics, is constituted as a haven and source of rejuvenation for the human population, affected by the technical progress and the industrial development (Environmental Protection Agency of Sălaj County, 2015). A natural risk that has to be taken into consideration within the forest ecosystems is represented by *forest fires* which depend on many factors, the most important of which would be: weather, vegetation (e.g. the amount and the type of vegetation), topography, forest management and other socio-economic factors.

Between 2011 and 2015, in Sălaj County, there were 11 forest fires recorded. They were small and affected a total area of 18 ha. The climate change has negative effects on forests through changes in the composition of brushes, the drying of brushes and trees, the exponential development of pathogens and the decline of biodiversity. The problems of sustainable forest management can be successfully solved only if the appropriate forest policies are promoted in order to meet the new requirements. In the *forestry policy* of the state, the primary forest function is the protection of the environment and the ecological balance. The *Forest Code* and other laws ban the reduction of the forest fund area, and cutting down trees is allowed only within the limits set by the forest arrangements. The sustainable forest management means the use of forests and wooded lands in a manner and at a pace which allow the maintenance of biological diversity, productivity, regeneration capacity, vitality and capacity to carry out, now and in the future, their ecological, economic and social functions, useful at local, national and global level, without prejudice to other ecosystems.

5.5.2. Pastoral arrangements

The pastoral arrangement represent the "documentation which includes technical, organizational and economic measures necessary for the improvements and exploitation of grasslands" referred to in the "Detailed rules for the application of the provisions of the Emergency Ordinance No. 34/2013 regarding the organization, management and exploitation of permanent grasslands". In Plopiş Mountains, the *grasslands* are frequent and near the human settlements as landscapes transformed as a result of deforestation in favor of agriculture. The forests became *fields* *with secondary grasslands,* with tickle grass (*Agrostis tenuis*) or *arable land.* Plopiş Mountains represent a *Site of Community Importance*, by order of the Ministry of Environment and Forestry No. 2387 from 2011 for the modification of the Order of the Ministry of Environment and Sustainable Development No. 1964/ 13.12.2008, concerning the establishment of the system of protected natural areas and of Sites of Community Importance, as an integral part of the European ecological network Natura 2000 in Romania. In Sălaj County, five Sites of Community Importance were established with a combined area of 45,474 ha (Peștera Măgurici, Racâș-Hida, Tusa-Barcău, Lozna, Muntele Șeș or Plopiș). *The Șes or Plopiș* Mountain (ROSCI 0322) cover an area of 34,880 ha and is located across the territory of the following communes: *Halmășd, Marca, Plopiș, Sâg, Valcăul de Jos* as well as communes in Bihor and Cluj counties.

The following *types of habitats* are to be mentioned*: Watercourses from the plain area to the mountainous level,* with *Ranunculion fluitantis* and Callitricho-Batrachion vegetation code – 3260; code – 3270 – *Rivers with muddy banks with Chenopodion rubri* p.p. and *Bidention* p.p vegetation; code - 40A0 – *peri-pannonian subcontinental shrubs*; code - 6240* - *subpanonnian steppic meadows*; code - 6430- *Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels*; code – 6510 *Lowland hay meadows* (*Alopecurus pratensis, Sanguisorba officinalis*); code - 7120 - *Degraded raised bogs still capable of natural regeneration;* code – 8210 - *Calcareous rocky slopes with chasmophytic vegetation;* code - 8220 - *Siliceous rocky slopes with chasmophytic vegetation;* code - 9110 - *Luzulo-Fagetum beech forests;* code - 9130 - *Asperulo-Fagetum beech forests,* code -9150 - *Medio-European limestone beech forests of the Cephalanthero-Fagion;* cod - 9170 - *Galio-Carpinetum oak-hornbeam forests,* code - 91E0 - Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, *Alnion incanae*, *Salicion albae*); code - 91M0 - *Pannonian-Balkanic turkey oak- sessile oak forests;* cod - 91Y0 - *Dacian oak & hornbeam forests.*

The second Site of Community Importance in the territory of Plopiş Mountains is *Tusa-Barcău* (ROSCI 0257), which covers an area of 13 ha, situated in the territory of the commune of Sâg, near the village of Tusa. The site includes a Community habitat of Asperulo-Fagetum beech forests (code 9130), to which one should add its fauna and landscape character, as the karst springs of Barcău River are located here. The natural qualities of the Land Fund constitute the fundamental premise of agricultural activities and in particular of the pastoral arrangements. The degradation of characteristics and functions of soils in Plopiş Mountains, as well as their bioproductive capacity, led to restrictions of their use, determined either by natural factors (climate, landforms, soil characteristics) or anthropogenic, agricultural and industrial actions. The main restrictions regarding *soil quality* in Sălaj County and in Plopiș Mountains are: the average annual temperature, the average annual rainfall, the gleyzation of soils, the stagnogleyzation of soils, the salinization/ alkalinization of soil, the texture of soils, the degree of pollution, the slope, the landslides, the groundwater depth, the flooding through overflow, the total porosity, the calcium carbonate content, the soil reaction, the edaphic volume, the hummus, the excess moisture at the surface. In order to prevent the decrease of soil productivity due to chemisation, it is recommended to use an association of mineral fertilizers with organic ones or the alternation of their administration, so that organic fertilizers are administered at least once every 3-4 years. Both *natural* (low altitude grasslands, subpanonnian steppic grasslands) and *secondary* grasslands (resulting from the massive deforestation) in the communes within Plopiș Mountains can be included in the category of "pastoral arrangements" depending on the landform on which they are located, their position on the slope, the shape, the altitude and the exposure of the slope (C. Bârliba, 2011).

Fig. 13. Free pasturage in Silvania Mountains (*source: the author*)

Karst landforms are important from this point of view, because they favor a chasmophytic vegetation that finds the best growth conditions on the rocks across the calcareous slopes of Negreni Plateau and the northern parts of Plopiş Mountains. Obviously, the assessments of their grazing capacity, as well as the optimal livestock, are important. Animal waste is used since the earliest times to increase fertility, but the improper use, the uncontrolled storage or discharge of these products can produce negative effects on the soil and implicitly on the quality of these grasslands. Due to the high variability of elements contained, animal waste can lead to unbalances of micro- and macro-elements in the soil structure and can contaminate the groundwater and surface waters. Each grassland must have a driveway; we mention here the existence of some runways and forest roads in Plopiş Mountains, which still need restoration works. In the activity of pastoral arrangement, the livestock (sheep and cattle) is important, as well as the drinking sources and places. The best water sources are the natural ones (the river of Barcău and its tributaries from the mountain region of Plopiş, its waterhead, the wells), because the quality of animal origin products is highly influenced by the water quantity and quality. The pastoral activity implies more workforce for the *improvement of grasslands* (A. Lăpușan, K. Niedermaier, 1975) and for their exploitation (harvesting hay, animal care) and can be a valid alternative of *ecological* reconversion of the area after the end of mining and massive deforestation activities. The cowherd or the shepherd has a special role within the pastoral activity; this is the reason why he needs proper living conditions in the form of zoo-pastoral buildings, sheepfolds, stables, summer camps, storehouses, and special-purpose shelters.

The grazing methods are classified into two categories: *free grazing* (continuous or irrational, which involves directing the herd on particular modifiable route, intensive and in front grazing within the two parcels) and *rational grazing* (rotational grazing, which requires the establishment of the number of parcels in which the grassland is divided, their area and the length of time the animals stay there). Both methods have variations for the intensive and extensive exploitation. The delineation of parcels is carried out by natural landforms (rivers, valleys), the woody vegetation (borders, clumps of trees), roads, conventional signs, fixed and electric fences. The limit of parcels in Plopiș Mountains consists of hedges of broad-leaved trees. The advantages of the rational system are numerous: the time spent by animals on a given territory is limited, the production of grassland increases, as the plants have time to grow again; the removal of selective grazing and will force animals to consume all of the valuable species; the uniform use of the whole area of grazing; the possibility of grassland improvement works including fertilization and irrigation; higher production of animal meat and milk. The works to increase soil fertility involve the use of chemical fertilizers (nitrogen and potassium fertilization), organic matter (farmyard manure) and mixed. The works of annual and long-term improvement of grasslands involve weed control, destruction of anthills and leveling, removal of stones, gnarls, overseeding and removal of excessive humidity (draining through open channels, drains and biological ways). The technical works and installations related to grassland are those enclosures in the form of fences needed to better exploit the grassy carpet. The rules of use and management of grasslands are included in the "pastoral arrangement" in the form of "pastoral investigation" which must be concise and use accessible language with regard to the timing of work on the pasture in accordance with the legislation in force.

6. CONCLUSIONS

The lytotypes related to Plopiş Mountains, conditioned by the carbonaceous platform stage of the Tisia Craton, allowed the development of a *karst landscape on Triassic rocks,* placed directly on crystalline schists in the form of *garlands of calcareous islands* in the shape of dolomitic rocks which were submitted to an intense fragmentation together with a rapid evolution that prevented major underground drainage which allowed the formation of an important karst network. The exokarst in Plopiş Mountains is a result of the Pliocene-Quaternary morphogenetic evolution, represented by a wide variety of forms: *karrens, doline fields, uvalas, poljes, lithological contact basins and valleys with dolines.* According to the endokarst and exokarst processes, these forms created favorable conditions for the development of edaphic and biogeographic resources as the basis for agricultural, forest and pastoral land use in Plopiş Mountains.

The formation of useful minerals in Plopiş Mountains was linked to the basin stage of Tisia Craton and to the variety of *source areas* related to this basin, either non-renewable or renewable (water, air, soil, flora and wild fauna), which are important for permanent and agricultural arrangements. In Plopiș Mountains, *cambisols and argiluvisols* prevail, on which develop numerous habitats, specific to the continental biogeographic region: *forests*, *meadows* and *shrubs*, as well as habitats related to *caves*, *waters*, *peats* and *marshes* as the basis for agricultural and pastoral arrangements. The forest arrangements in Plopiş Mountains integrate the totality of forests (coniferous and deciduous species) and other lands that require sustainable management allowing the maintenance of biological diversity, productivity, regeneration capacity. Natural regrowth is preferred rather than the artificial one as a result of their many ecological, economic and social functions. In the *forestry policy* of the Romanian state, the primary forest function is the protection of the environment and the ecological balance.

Both *natural* (low altitude grasslands, subpanonnian steppic grasslands) and *secondary* grasslands (resulting from the massive deforestation in Plopiș Mountains, in places where grasslands are now found) in the communes within Plopiș Mountains can be included in the category of "pastoral arrangements" depending on the landform on which they are located, their position on the slope, the shape, the altitude and the aspect of the slope. The pastoral activity implies more workforce for the *improvement of grasslands* and for their *exploitation* (harvesting hay, animal care) and may be a valid alternative including the *ecological* reconversion of the area after the end of mining and massive deforestation activities. The pastoral arrangements are a valid alternative for the promotion of sustainable economic development in these areas, based on a type of agriculture in agreement with the regeneration capacity of the Silvania ecosystems.

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