
IMPACT OF TECTODYNAMIC AND MORPHODYNAMIC FACTORS ON THE SUSTAINABLE DEVELOPMENT OF THE SHPAT MOUNTAINOUS RIDGE

Andri HoxhaUniversity of Tirana, Faculty History-Philology, Department of Geography, andri_ti@yahoo.com

Abstract: Shpat mountainous ridge represents a morphological unit with extremely prominent natural borders and rich natural resources. This abstract presents the natural potentials of Shpat mountainous ridge and a synthesized analysis of key aspects of tourism, mineral and water resources, forests and pastures management, etc. Shpat unit, is integral part of Bukanik ultrabasic massive, where are explored cooper resources. The geological content of this mountain, contributes the mesozoic ultrabasic and flysch, calcareous rocks and quaternary deposition are also present. The morphologic and morphogenetic complex of the relief was created during the tectogenic period, especially during the tecto-orogenesis, where as consequence diverse magmatic, terrigenous and carbonates rocks were created. Structural relief landforms, are structural benches, flat surfaces formed in the acinal structure, structural surfaces, denudational surfaces and concave fragment of front of the cuestas. The karstic surface forms were developed on limestones of different age and character. There is a conspicuously small number of dolines on the surface of the hardly dissolvable crystalline limestone, and the debris covering the surface is high enough for agriculture. The water infiltrating on the plateau surfaces in the karst springs. The knowledge of present morphodynamics implies features concerning the positive and restrictive role of each factor, which, by association, defines the potential of some groups of processes and state of morphologic hazards in certain area. Such analyses multiplied in the last couple of years, when the occurrence of some mass wastings determined many geomorphologic risk situations all over Shpat mountainous ridge. The climate by regional and local differences of the weathering elements favorable to the development of morphological processes. In periglacial environments solifluction frequently occurs in association with permafrost or seasonally frozen ground, and under these circumstances it is more specifically described as gelifluction. Snow provides both and as ground insulation. The erosional potential of nivation is controlled primarily snow thickness or absence underlying permafrost. Cryoplanation terraces (also known as altiplanation terraces) are level or gently sloping surfaces found in the periglacial zone which are cut into bedrock on hill summits or upper peaks. The natural potentials of Shpat mountainous ridge have been analyzed as key elements of this area for sustainable development. The effects of the use of the natural resources and their influence on the economic structure have been analyzed defining the directions of the development on perspective of the rural area. The current developments at the agricultural rural area have produced changes to the physical-geographical elements, accelerating the pace of slope processes, where the predominant part of the settlements is established on the terrace levels, causing environmental degradation.

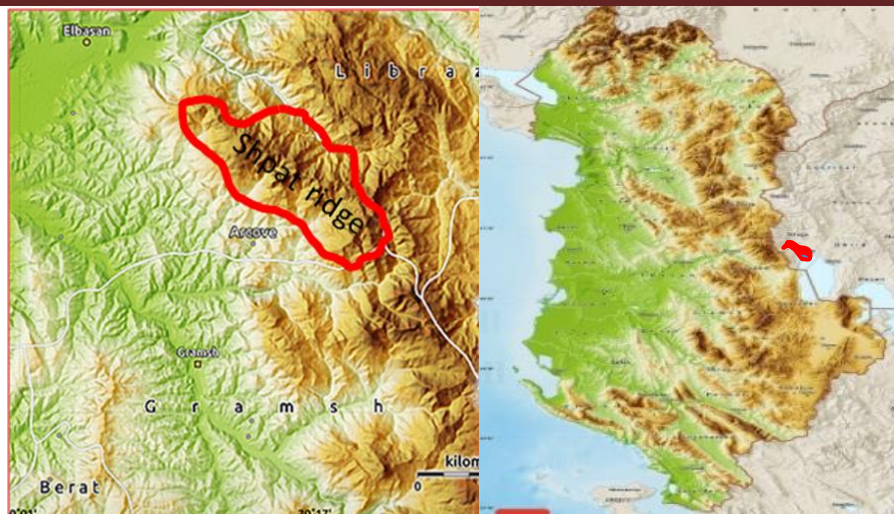
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1. WORKING METHODS

The first phase of the article preparation work is the collection and research of the necessary scientific literature and the use and collection of the nearest geographical information. The method of comparison has been used in the analysis of all natural and human components of the mountain slope of the slope, which has helped us to clearly present the dynamics of relief development during morphotectonic and morphoclimatic evolution, as well as current and prospective phenomena.

2. INTRODUCTION

The mountain slope of the Shpat has a surface around 190 km² and is distinguished by a rugged and fragmented relief and is formed on the anticlinal structure of the Shpat, which lies at the center of this ridge. The ridge of the Shpat has the large size with characteristic morphological features, which are directly related to the morphotectonic evolution and the actual tectodynamic regime of the structural basement. In general, its boundaries are mainly morphotectonic and morphological, with marked differences with other neighboring subunits. Continuous morphological changes are related to its extension into the central part of the anticlinal structure, representing the large-sized mountain ridge, which retains a little change in absolute height relative to the Guri i zi ridge. Morphogenetic significance is the morphotectonic boundaries, its size and position relative to the limiting morphologic subunits.



Map 1. Map of geographic position of Shpat mountainous ridge in territory of Republic of Albania.¹

3. CLIMATIC ELEMENTS

The mountain range is part of the Mediterranean climate zone, with cold and humid winters and hot and dry summers generally reflecting the daily, monthly and annual performance of various climate elements. Climatic conditions are of importance for the development of active morphogenesis, reflected in the ongoing modeling of current relief patterns. Among the main factors influencing climate formation are cyclonic and anticyclonic activity, position, altitude, shape, size and degree of relief. The position of this range as the connecting sector between the central and southeastern part of the country, near the crossroads of some air masses, has given climatic conditions, a low-temperature mountainous character, with frequent inversions, relatively long periods of frost and average values of the temperature amplitude. Various forms of relief such as undulated crests, deep valleys, depressions and pass that interrupt them have affected the characteristics of climatic elements. This mountain ridge includes several climatic subzones.² Climatic conditions of this range have been influenced by local factors, such as hipsometric values, exposure and inclination of slopes, direction of extension of mountainous crests and river valleys, etc. The main factor is relief, which, with its predominantly northwest-southeast direction, influences the circulation of air masses, emphasizing highly the fluctuations of climate elements. High elevation values of the mountainous ridge of Shpat, partially impede the eastward entry of warm, humid winds coming from the west. Whereas from the northern sector the valley of Gostima allows the penetration of warm and humid winds. High necks, gorges and other valleys allow their penetration into the interior of the ridge. Differences of meteorological elements between western and eastern exposure slopes are clearly evident, leading to the formation of local microclimate type. The northwest-southeast direction in most of the Gostima valley creates conditions for a free meridional wind circulation, complicating the regime of climatic elements within the mountain range. Physical properties of bare carbonate rocks and vegetation which is poor in some sectors, affecting the values of temperature amplitude and air humidity. Complex relationships between landforms and the external environment were indicated. Geomorphic systems are often affected by episodic large events such as volcanic eruptions, glaciation, and megafloods which lead to a disturbance of system adjustment, sometimes in a catastrophic way. Also, responses of geomorphic systems to external changes tend to be nonlinear, including lag time, relaxation time, and thresholds.³

4. TECTODYNAMIC AND MORPHODYNAMIC ELEMENTS OF THE RELIEF

Tectonic setting is the primary control on the regional physiography and landscape character. The regional tectonic settings of active plate margins, passive continental margins, and continental interiors strongly influence landforms through styles of tectonic deformation and uplift, differences in dominant lithologies, and changes in the degree of

¹ <http://www.maphill.com/albania/3d-maps/physical-map/>

² Collective authors. *Climatic zones map of Albania*, Tirana (1981).

³ Oguchi.T. Butler.D. *The International Encyclopedia of Geography. Chapter Geomorphic systems*. © 2017 John Wiley & Sons, Ltd. Published (2017).

fracturing (which affects erosion resistance).⁴ In the eastern and central part of Albania, the relief is also formed on magmatic mountainous massives and in structures, which have been subjected to horizontal displacement or tectonic thrusting with high value of the amplitude of displacement, as well as in the grabens system with old age and those of the Plio-Quaternary age with north-south direction.⁵

Tectonic setting and structural geology influence landforms through the direct action of faulting and through the indirect influences of spatial variability in erosion resistance generated by folding, faulting, and offset of rocks of differing lithology.⁶ The tectonic lines that cross the Elbasan district surface are quite and clearly delineated by line contours and earthquake configurations creating unstable areas over wide areas; instability that results from the uneven movement of different blocks of land in these NE-SW directions and consequently different landings occur. Although these movements are very slow, they can become very threatening in the event of earthquakes.⁷ The dominant values

of hipsometry fluctuate from 500-1000m to the west and from 1200-1500m to the east. This is related to the high intensity of differential neotectonic movements. The morphological differentiation of the ridge of the Shpat is related to the geological position, that is, the inclusion in three tectonic zones such as that of Mirdita, Krasta and Kruja, with diverse lithological construction and highly active tectonic development reflected in prominent relief forms. Alpine tecto-orogenesis is reflected in the NW-SE longitudinal structures, accompanied by thrust fault to the west and SW. The rate and direction of morphotectonic evolution has been determined by differential neotectonic movements and the great variety of lithological content of ridge. These movements have led to the formation of major structures, which are clearly reflected in the general characteristics of the actual relief, having a very active morphological development. In the structural context, tectonics appears to be highly developed with longitudinal and transverse faults. New and actual tecto-orogenesis has caused on the mountain ridge, very prominent morphologic features, which in large part have concordance with the dominant anticlinal structure of the Shpat unit. Thrust faults along the Dërstila-Zavalina sector has given secondary synclinal structures the shape of monoclinical, as in Pashtresh, Joronisht, Dragullara and Xibresh. The widespread phenomenon of thrust faults has simultaneously determined the presence of monoclinical structures, along the flysch, which are directly reflected in the modeling of monoclinical crests of varying sizes and morphological features. The rapid development of the actual relief is a consequence of the hydrographic network of the streams of Stan, Pashtresh and Zavalina, which with deep erosion have caused an intensification of the values of density of fragmentation in the sandstones. Its lithological content includes ultrabasic deposits that are often reflected through the flat with rounded peaks, such as in Bukanik, Zeleshnja, Valç and Studio etc. Limestones appear in the form of fragmentated blocks, such as in Zavalina and Deda Stan, while the flysch lie on the Dragullara peak and are reflected in the gentle hilly relief. The Pashtresh-Gjinar sector with sandstones and alevrolites, appears partially folded and contained in many fragments massive slides and falls. Significant morphogenic role is played by normal longitudinal and transverse tectonic faults that have brought changes in altitude dimensions and major morphological features between hills and confining valleys. The generally smooth flysch rocks have a wide extension west of the ridge. Due to the dense tectonic faults rate and their poor permeability, appears average values of the depth of fragmentation and high values of density of fragmentation of relief. The tectonic faults that cross the rocks of varying hardness are associated with the dense presence of structural, fluvial, mass wasting and less glacial relief. The presence of ultrabasic rocks has conditioned the dense development of periglacial and glacial phenomena, especially at altitudes of 1750-1850m. Morphological evolution is closely related to the base local level of erosion, while regressive erosion of the river network has advanced to varying degrees, creating disorder forms of watershed ridge and increasing values of density and depth fragmentation of relief, depending on the degree of the hardness and permeability of ultrabasic, calcareous and flysch rocks. Flysch structures are distinguished for smaller amplitude values of tectonic uplifts.⁸ Superficial morphogenic processes, especially fluvial processes, have formed a high fragmentation of relief, reflected by the extensive network of deep ravines and gorges that border irregular aquifers, that limit by pass of varying sizes with tectonic-erosive origin.

⁴ Bierman.P. Montgomery.D. *Key concepts in Geomorphology*. U.S.A.(2014)

⁵ Aliaj.Sh. Kondo.A. *Bul. i U.Sh.T. Ser.Shk.Nat-Nr.3*. Tirana, (1971)

⁶ Collective authors. *Geological map of the Republic of Albania*, Tirana, (2002)

⁷ Municipality of Elbasan. *Document of the final environmental strategic assesment report of the general territorial plan of the municipality of Elbasan*. (2016)

⁸ Collective authors. *Geologic Map of Republic of Albania*. (2002)



Photo 1. Mass wasting in central part of Shpat mountainous ridge

In the morphological complex of the mountainous ridge an important place has the fluvial relief, as the surface waters represent the main external modeling factor. Tectodynamic conditions throughout the period of morphotectonic evolution of the mountain ridge have promoted the activity of regressive erosion in the depths of the watercourses, creating conditions less favorable for the full development of the river terraces, although they generally occur along ultrabasic sectors. The relief presents prominent contrasts that are more pronounced along the valleys, which have different directions, while the latter confined to disordered watersheds, giving the relief a much fragmented shape. Part of the valleys retains consequent features in relation to the direction of monoclinical inclination of the flysch layers, constituting the main morphogenic element of the relief, in addition to the mass wasting phenomena. The central and eastern part of the ridge differs sharply from the western and southwestern one, as it is here that the immediate passage transition from hilly relief with different morphological features to a highly fragmented and complex mountainous relief, in the tectonic and morphological context. The peak part of the Bukanik crest, in contrast to the limiting slopes, appears soft almost throughout the stretch and characterized by minor relative elevation changes (30-40m). It is interrupted by an erosive pass at both edges of the Gostra peak, which connects the settlements of Gjinar and Dërstila with Zavalina. Due to the highly developed tectonics, variety of lithological composition and numerous rainfall, the values of relief fragmentation fluctuate from 1-2km/km² in restricted sectors, south of Rrafshi i Bukanikut, while average values up to 2-3km/km², extend mainly in the central part. The highest values of fragmentation appear in the hills of Gjinar, Valesh and Zavalina. These values reach their maximum in the valley of Joronisht and Pashtresh. Depth of relief fragmentation is generally distinguished for high values and this is due to the prevalence of mainly ultrabasic deposits, the greater intensity of tectonic uplifts relative to its periphery, the tectonic scarps formed by this differentiation, mass wasting processes along the flysch rocks and the large amount of rainfall. Maximum values of 500-700m/km² occur mainly in the Gurra e Arra, while values of 400-500m/km² appear in the eastern and central parts of the ridge. Exposure of slope is characterized by a large variety, with slopes with more exposure to the north, southwest and west. The inclination of the slopes retains very high values and this phenomenon is explained by very active faulting tectonics, ultrabasic deposition and erosive activity of streams. Mainly dominated by values of 15-20° which lie in the central part of the ridge, in the hills of Gjinar and Vala. Maximum values reach up to 30° at the crest of Çika, sector near Bukanik and in the valley of Gostra, while values below 10° appears in the western and southeastern part of the ridge. In the relief of the Shpat ridge, the particular morphological importance is the thrust tectonic fault, which has divided the latter into 2 prominent sectors with significant changes, in the size and diversity of morphological elements, depending on the tectonic differentiation, between them and the widespread occurrence of southwest and west flyschs and ultrabasics in the center and east of the ridge.⁹

The hilly western sector extends from the Mulen River to the Holta Valley and the eastern high mountain sector extends from Dërstila to the Zavalina-Joronisht segment. In the western part of the ridge, the hilly section of Valesh-Kabash is characterized by small morphological contrasts. The predominantly flysch composition has also determined the gradual decrease in east-west of altitude values on relief. Genetic types are fluvial and mass wasting relief, where their widespread distribution, has led to the formation of many erosive sites. The small ridges between the streams that cross the hills of Xibresh, Joronisht and Selta represent the flysch relief with very fragmented shapes. This sector is characterized by a mostly hilly relief, where altitudes between 450-500m occupy about 65-70% of the surface. The features of the following hills have no marked variation along their slopes, due to their approximately identical flysch content. The tops of the hills are undulate to round in shape and generally, the slopes have inclination with average values. The villages are mainly built on flat sectors, while fragmentation density

⁹ Collective authors. *Tectonic map of the Republic of Albania*, Tirana, (2002).

values increase in the river basins of the Pashtresh, and Selta streams. The crest of Dragullara hill is rounded and separated by low pass. The morphological features of the hills to the west of the ridge are related to the deepening of the river beds of the Pashtresh, Joronisht and Selta streams to a large extent of flysch rocks. In some of their segments, the cuesta landforms have been formed, where the little inclination of the flysch layers is clearly visible with generally low-thickness of flysch. Gravity, flowing water, and temperature changes are the main forces behind hillslope processes, with the action of animals and plants being important in some situations. In some parts of the world, similar features have been built to protect infrastructure from other types of mass wasting. Weathering on hillslopes, as elsewhere, includes the in situ conversion of bedrock into regolith and the subsequent chemical and mechanical transformation of regolith. Several hillslope processes serve to transport regolith and other weathering products. They range from slow and continual processes to rapid and intermittent processes. Splash processes into three categories: leaching, soil creep, and rainsplash and sheet wash. Rocks are subject to stress and gravitation.¹⁰ The mass movement types, distribution and shapes are strongly controlled by both the lithological characteristics and the multi history structural setting. Active slow-moving landslides, commonly characterized by multiple and superimposed landslide bodies, confirming that the spatial distribution of the recent landslides is frequently influenced by the presence of older landslides. New mass movement of the river catchment represents a useful tool for territorial planning, and engineering-geological and environmental purposes in the study area. It is, also, the starting point for both quantitative landslide risk analyses and the design of the most appropriate risk mitigation measures.¹¹ The morphological contrasts of their relief appear near the tectonic thrust of the Krasta tectonic subzone over that of the Kruja tectonic zone forming several fault scarps, that limit the valleys of the main streams, though with entirely flysch composition and limited tectonization. Some local tectonic faults have defined the southwest extension of the right affluents of the Holta River.

5. HUMAN IMPACT ON THE MOUNTAIN SLOPE OF THE SLOPE

Human intervention, through the development of industry, urban, rural, agricultural and tourist infrastructure, requires the application of scientific criteria, particularly by utilizing basic knowledge in the field of applied geomorphology. Human activity has had negative consequences on the natural environment and on the migration of the rural population. The mountainous ridge environment carries scientific, educational, tourist, recreational and spiritual elements. where the participation of the rural community in the management of nature monuments is still in its initial Nature monuments lie on the oak, beech and alpine pastures floor. On the mountain ridge there are some representatives of trees of scientific and historical value and endemic and rare plants with limited area.

Monuments of Nature are:

- The Lleshan Oak is located in the village of Lleshan, near the road to Gjinar, at an altitude of about 1,000 meters above sea level.
- Fushë Kuqe Pine is located in Gjinar village of Gjinar administrative unit, at 920-1,000 m above sea level.
- The Oak Church is located near the village church of Gjinar, 900 meters above sea level.
- The Pashtresh oaks are located in the east-southeast part of the village of Pashtresh, near Gjinar.
- Zeleshnja Pine is located near the village of Zeleshnja, near Gjinar, at an altitude of 1,650-1,700 m above sea level.
- The Zavalina Birch is located near the village of Zavalina 1,000-1,170 m above sea level.
- Joronisht Black Mulberry is located in the center of the village of Joronisht in Zavalina administrative unit, which is a secluded mulberry tree.¹²

In the development of the agricultural structure, have played a role, natural, economic and social factors. The predominantly mountainous relief has created conditions for planting potato crops, beans and a partial feed base for livestock. The forest economy has played an important role in the villages of Gjinar, Zavalina, Pashtresh and Xibresh. The management of timber is managed by the exploitation enterprises, through the sawmill sector and the opening of forest roads, at the relevant facilities. The rich forest fund led to the creation of road infrastructure for timber utilization and its transportation from the high mountain sectors to the urban centers of Elbasan, Tirana and Librazhd, where until 1990, the timber industry facilities were in operation, producing timber and construction materials, furniture, etc.

¹⁰ Hugget.R. *Foundamentals of Geomorphology*. U.S.A (2017).

¹¹ Borrelli.L. Muto.F. Geology and mass movements of the Licetto River catchment (Calabrian Coastal Range, Southern Italy) *Journal of Maps. Volume 13, - Issue 2*. (2016).

¹² Municipality of Elbasan. *Development strategy for the territory of Elbasan Municipality*. (2015)

RECOMMENDATIONS

Prior to developing rural and urban infrastructure, undertake geomorphological and geo-engineering studies.

By studying karst phenomena, one can determine the hydrological conditions and localization of the groundwater horizon.

Construction of some hydro-technical and economic works should be carried out in sectors where there are no empty underground spaces, as they create serious problems for the extraction and exploitation of mineral resources, depending on their stratification, permeability, cracking and orientation.

In order to avoid floods, protective canals and embankments should be built, along with the prohibition of inert materials from the rivers Gostima and Joronisht, etc.

Geological research should be intensified in the near future to discover the reserves of raw materials for construction and metal minerals and to precisely determine lithologo-tectonic conditions in view of hydro-technical works and exploitation of copper and chrome minerals.

All physico-geographical elements must be assessed and adapted to the human environment in view of tourism development.

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