
THE ROLE OF THE GEOLOGICAL COMPOSITION IN THE STRUCTURAL MORPHOLOGY OF THE TERRITORY OF ALBANIA

Andri Hoxha

University of Tirana, Faculty History-Philology, Department of Geography, Tirana, Albania

andri_ti@yahoo.com

Abstract: In the context of geological composition, the territory of Albania closely depends on the geographic position. The presence of our country in the alpine-Mediterranean fold belt and the geological structures, called Albanide, have determined the intense development of the internal tectonic processes, as well as the external processes. The tectonic regime of the geological structures during the Miocene epoch to the Quaternary period, was accompanied by reverse faults and thrust faults one over the other of the tectonic areas of Albania. The morphologic and morphogenetic complex of the relief was created during the tectogenic period, especially during the tectogenesis, where as consequence diverse magmatic, terrigenous and carbonate rocks were created. The highly pronounced character of the differential tectonic movements during morphotectonic evolution, especially during the plio-quaternary period, has created the actual morphological features of the relief of Albania.

The migration of orogenesis from east to west is conditioned by the dominance of mountainous ranges and ridges in the eastern and central parts, as well as in the fields and lowlands of the western part of Albania. The relief is distinguished by its diversified morphogenetic traits, due to the highly complex morphotectonic evolution, a large number of carbonate, terrigenous and magmatic rocks, as well as the significant influence of the outward processes. Due to the existence of composition of the large number of tectonic faults as well as the high values of tectonic uplift and downlift, the genetic composition of the structural relief was also created. Each of the sub-types within the structural relief is closely related to the presence of complex geological structures such as anticlinal, synclinal, monoclinal and aclinal structures. An important role have the structural landforms formed in the structures of faulting type, thus in the horst and graben structures, which are associated with very large morphological contrasts of the relief.

A part of the horst and graben structures during the last period of pliocene and during the quaternary was involved by intense tectonic lifting movements, resulting to a fragmentation of flat bottom of ex-former depressions, and consequently they were transformed into depressions with fragmented bottom. A large part of structural relief landforms, such as structural benches, flat surfaces formed in the aclinal structure, structural surfaces, denudational surfaces and concave fragment of front of the cuestas, have been used for the construction of rural and urban settlements, for the road infrastructure network, the construction of human buildings, as well farmlands for the country's economy. The detailed analysis of the structural relief features, based on the characteristics of geological construction, enables prospects for taking measures against geomorphological, seismic and hydrological hazards.

Keywords: relief, geological structure, geomorphology.

1. WORKING METHODS

Due to geological information, the characteristics of structures, morphotectonic and morphoclimatic evolution, as well as their influence in function of the assessment of relief and other physico-geographical elements have been utilized. Among the geomorphologic problems to be solved are the reflection to the relief of diverse rocks and the geological structures. During Plio-Quaternary morphotectonic evolution in the territory of Albania multiple coluvial, proluvial and alluvial materials were deposited, being considered as the main source of arable agricultural land and building materials. The activity of natural hazards is related to the active tectonics, especially during intense diagonal reverse fault from the most northwestern point of the country to the southeastern edge of Gramozi mountain. Special importance is given to the phenomena of morphotectonic and morphological evolution of the relief, which are closely related to the morphogenic role of climate, hydrography, soil and vegetation. This has enabled to draw important conclusions regarding the orientation of morphological evolution in the perspective of the territory. In the frame of the structural relief, have been addressed the respective forms, the relationship between the faults and folds geological structures and the role of the neotectonic uplifting movements to the significant fragmentation of the territory. By recognizing the components of the geological structures, the direction, intensity and duration of the modeling factors of the relief has been defined. An important aspect represents the analysis of the relationship between the direction of river flows with those of geological structures, thus the type of valleys in

relation to the structure, their fragmentation in the respective sectors, the causes of formation, the dynamics of development and the polygenetic character of the gorges, and their depth.

2. GEOGRAPHICAL POSITION

In the physical and geographical context, the territory of our country is situated in the western part of the Balkan Peninsula and respectively in Southeastern Europe, while in the west of the southwest is bordered by the Adriatic Sea and the Ionian Sea. Albania is positioned in the belt of alpine orogenesis and the geological structures that construct the relief are built up of sedimentary and magmatic rocks. During alpine orogenesis, folds and faults structures are involved in intense uplifting tectonic movements, especially during the last stage of Pliocene and generally during the Quaternary. The active fold and fault deformations have also conditioned the features of the relief, mainly of the hilly and mountainous relief. The prominent hipsometric and morphological contrasts have produced major changes in the zonality of climatic conditions, soil and vegetation coverage. The geographic position between the southeastern and central parts of the country and the high altitude above sea level have significantly influenced to the climatic, hydrographic and vegetation characteristics, enabling high precipitation rates in rain and snow, with a long period of frost, especially at the mountainous ridges in the northern and central part of the country. From the climatic point of view, the territory of this paper is part of the Mediterranean area.¹ As altitude increases, the values of temperature and the amount of precipitation change, precipitation in snow, where the layer and the length of which grow towards high level of the mountainous ridges. The hydrographic network is part of the river basins of Drin, Mat, Erzen, Shkumbin, Seman, Vjosa, etc, which with their respective branches represent one of the most significant external morphogenetic phenomena in the modeling of the relief. The reciprocal influence between climatic and topographic factors has created favorable conditions for the intensive development of the hydrographic network, conditioned by a very dense distribution of the river drainage and the respective streams. The torrential character of many of the river network has led to the activation of the mass wastings, especially of the slope wash, creeps, heaves and slides, mainly in the sectors composed of molasse and flysch rocks. The geographical position, along with favorable natural conditions, has created opportunities for the development of the most important civilizations during the different periods of historical evolution. Being in direct contact with the waters of the Adriatic Sea, particularly near the strait of Otranto and Ionian Sea, the area of Western Lowland has had a close connection with the main corridors of the river valleys, such as the Drin, Shkumbin and Vjosa. The dense network of river gorges created by the hydrographic drainage, as well as the presence of several mountainous cols have created favorable conditions regarding the connections of Albania with neighboring countries. The presence of the Egnatia road transformed Albania into a very strategic area connected with the central part of the Balkans. Corridor VIII is of great importance for road transport and beyond. Geological, geomorphological, climatic, hydrographic, pedogenetic and forestry assets represent considerable economic resources for the country. The general layout of the territory extension is typical meridional north-south, and with a generally irregular character, which is distinguished by the intersection of the mountainous ridges with river valleys and gorges. This favorable geographic position is related to the extension to some tectonic areas, such as Korab, Alpe, Mirdita, Krasta-Cukal, Kruja and Ultesira Pranadriatike², as well as to the lithological composition, fold and fault structures, abundant waters and rich forest vegetation. The geological position has determined the development of genetic types of the relief and the development of fluvial, carstic and mass wasting.



Map. 1. The Physical Map of Republic of Albania.³

¹ Collective authors. Climatic zones map of Albania, Tirana (1981).

² Collective authors. Tectonic Map of Albania, Tirana (2002).

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



Photo.1. Landform of structural relief in Gjinar village in middle part of Albania

3. GEOLOGICAL COMPOSITION

In general, the geological structures are characterized by the variety of rocks where prevail sedimentary and magmatic rocks and very small parts are represented by metamorphic rocks. Terrigenous rocks, mainly flysch and molasse, account of about 60% of the territory, carbonate rocks about 24% and magmatic rocks slightly over 10%. Terrigenous rocks, such as the molasse and flysch, mainly compose the sectors of Western Lowland, of Delvina depression, as well as the depressions located over the sinclinal and graben structures situated in the southeastern part of Albania. Molasse rocks of Neogen build up the synclinal and graben structures over which the upper sections of Shkumbin and Mat river valleys are created and the graben structures over which the depressions of Korca, Devoll, Kolonja, Ohrid, Kukës and Tropoja are created, as well as in the middle and lower sectors of the river valleys Erzen, Devoll, Osum and Vjosa.⁴ Molasses are built up of soft deposits of clays and alevrolites, as well as depositions of sandstones and conglomerates, clearly displaying the influence of the selective character of the superficial modeling activity of the relief. Magmatic rocks build up geological structures over which mountainous ridges of massif type are created, such as in Shpat, Valamara, Morava, Lura, Shebenik and Krrab. Magmatic rocks lie mainly in the tectonic zone of Mirdita, which reverse over the tectonic zone of Krasta-Cukal, where as consequence during the tectonic contact of reverse type of magmatic over the limestone and flysch rocks, the fault line scarps with a relative height of several hundred meters are created. In the eastern and central part of Albania, the relief is also created on magmatic mountainous massives and in structures, which have been subject to horizontal displacement or tectonic thrusting with high value of the amplitude of displacement, as well as in the grabens system of old and new age of Plio-Quaternary age with north-south direction.⁵ The lithologic and structural composition of the ofiolitic belt and morphotectonic evolution, in a close relation to the erosive activity, have created mountainous ridges with a high value of absolute altitude and with slopes of type of scarps such as in Tropoja, Bulqiza, Shebenik, Scanderbeg, Kutërmán and Shpat ultrabasic massives.⁶ Along the geological structures composed of limestone rocks, which are characterised by the massive type and the great thickness, have been created morphological traits, with significant morphological contrasts with a large degree of vertical fragmentation of the relief, accompanied by crests and scarps, such as in Tomor, Polis, those of Skënderbeg and Mali me Gropa mountainous ridges. The presence of marble limestone rocks has led to the formation of a fragmented relief, characterized by high mountainous crests and deep valleys. Quaternary Deposits are located in suburbs of Ulëtësira Perëndimore, which are subject to tectonic downward movements during the Quaternary age, mainly in the western coast and along synclinal structures of Miocene and Pliocene age. In the coastal part of Ulëtësira Perëndimore appear marine-lagoon deposits, which in the interior part of Albania, are transformed to alluvial deposits. Marine-lagoon deposits of Quaternary age are composed of sand and clays.⁷ The remains of marine terraces of Quaternary age, appear in Zvernec, Kryevídh, Shkëmbi i Kavajes, Durrës etc, over the sectors of Miocene and Pliocene molasses, with tendency towards tectonic lifting movements during Quaternary age.⁸

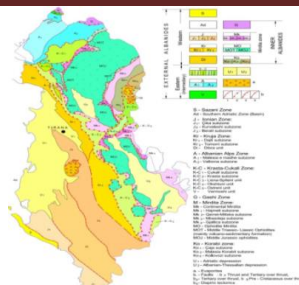
⁴ Collective authors. Geological map of the Republic of Albania, Tirana, (2002).

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

⁶ Melo.V. Geographical Studies. No.1, pp. 77-81. Tirana (1985).

⁷ Konomi.N, Kero.J, Goga.K. Bul.Shk.Gjeol.Nr.3. Tirana, (1984).

⁸ Aliaj.Sh. Neotectonic of Albania. (1th ed) Monography Tirana (2012).



Map 2. Tectonic Map of Republic of Albania.⁹

4. RELATIONSHIPS BETWEEN OF STRUCTURAL MORPHOLOGY AND GEOLOGICAL STRUCTURES

The genetic type of the structural relief is widespread in Albania. Landforms of structural relief have been created in structures of folding, faulting, reverse and thrusting type, which are composed by diverse rocks, subject to the development of the morphological features of these respective forms. In Albania, fold and fault structures are more common, which are involved in a dense number of tectonic faults with different values of amplitudes.

Many of the normal tectonic faults or reverse faults type have created deformation to the fold structures, producing rupture of the other side of the limb of structure, until they take the shape of the monoclinical structure. Some of the fold anticlinal and synclinal structures during the Plio-Quaternary age, were subject to new uplift and downlift tectonic movements, where as resul horst-anticlinal, horst-synclinal structures were created, etc. Due to highly heterogeneous composition of the rocks that construct the geological structures, favorable conditions have been created for the development of the selective erosion process, through which varied shapes of structural relief have been formed, such as fault line scarps, complex scarps and lithological scarps with their respective subtypes, some types of structural benches, structural nickpoints, as well as river valleys, closely related to lithologic composition and tectonic conditions. The tectonic composition of the internal and external Albanide zone, as well as the lithological composition in relation to the erosive processes and neotectonic, have generated important consequences to the characteristics of the Albanian relief. During Pliocene-Quaternary neo-tectonic period, the early structure within Albania was fragmented by normal tectonic faults, due to the tectonic regime of the movements to expansion, resulting in the formation of horst and graben structures. While on the outer coastal part of Albania, fold structures and reverse type structures were created.¹⁰ In the Central Mountain Range, are present the fault structures such as horst and grabens and fold anticline and syncline structures intertwined to each other, leading to the formation of a very irregular relief with depressions and high massives as well, while the forms of a more fragmented relief are reflected in the formation of the mountainous ranges with parallel stretching, bounded by river valleys.¹¹ The new Plio-Quaternary orogenesis of the differentiating character has given to the structures of Pukë-Mirdita highland, new block features, that appear in its central part, being clearly reflected in the highest value of the absolute altitude of Munella's ridge, in relation to Tërbun-Kuzhnen and Krab-Kunora-Dardha mountainous ridges.¹² The mountainous ranges with the morphological features of the block type, such as those of Polis, Zepa, Deja and Munella, are mainly formed over the syncline structures which, due to the new tectonic uplifting movements during the quaternary age, have reached the values of the absolute height of 1850- 2200 m. Inversion of the relief with the geological structures occurs as result of their composition of limestone rocks of the Cretaceous period, such as in the mountain ridges of Zepa, Deja, Munella and Polis. River valleys within the territory of Albania, such as those of the upper sector of Shkumbin and Mat valleys, as well as Black Drin valley, or depression of Kukës and Tropoja, are composed of rocks of Miocene and Pliocene molasses, which are created over the synclinal and grabens structures, that were subject to new tectonic uplifting movements during the Quaternary. While the graben structures over which were created the depressions with younger age such as that of Korça and Ohrid, have suffered downlifting tectonic movement during the Quaternary period and during the current period, leading to an intensive development of the accumulation process of Quaternary deposits.¹³ Livadhas-Bukmirë nickpoint is completely composed of magmatic

⁹ Collective authors. Tectonic Map of Republic of Albania. Tirana (2002).

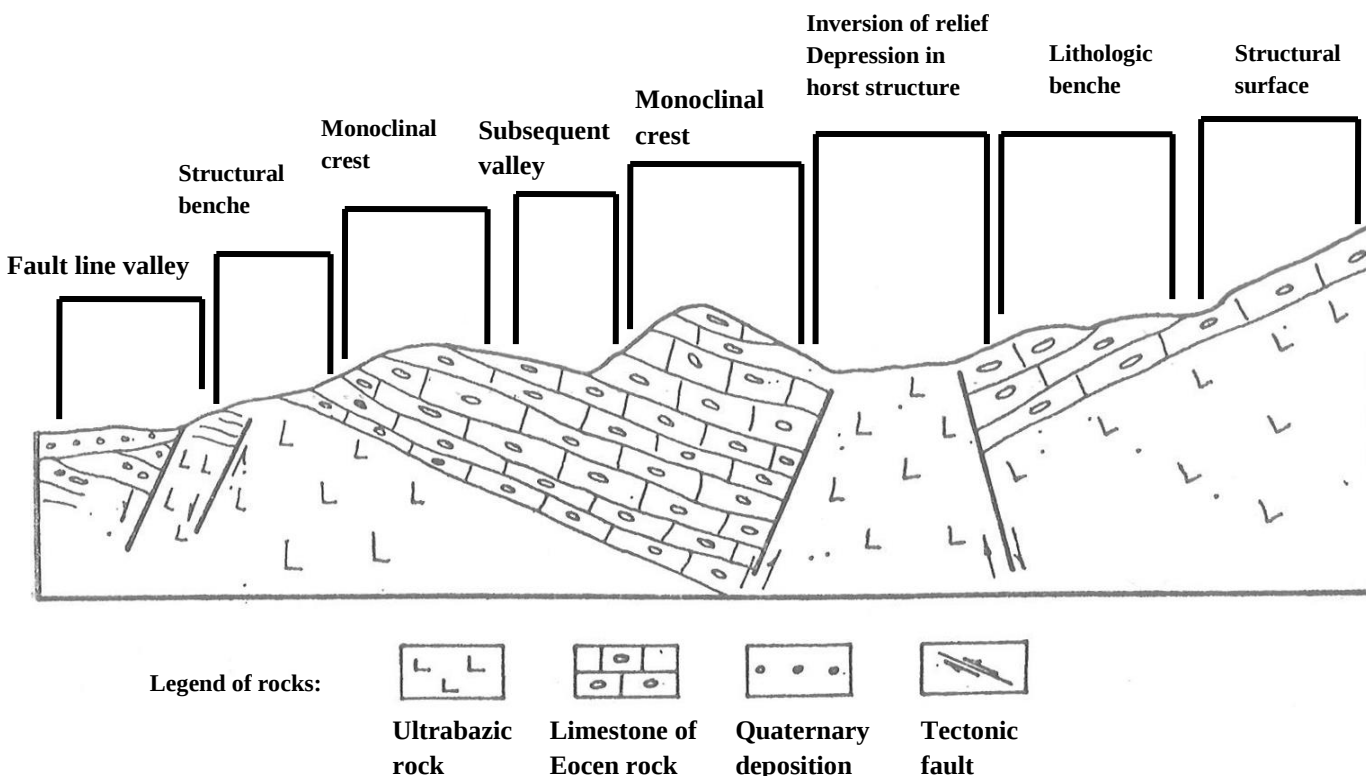
¹⁰ Aliaj.Sh. The Journal of Natural and Technical Sciences, No. 4. Tirana, (1988).

¹¹ Qiriazl.P. Physical Geography of Albania. Vol.No.2. Tirana, (1990).

¹² Ziu.T. Physical Geography of Albania. Vol.2. Tirana.(1990).

¹³ Melo.V. Geographical Studies.No.1. Tirana, (1985).

rocks, and it is displayed in the form of horst, lying between the depression of Rrëshen and that of Kalivaç.¹⁴ In the mountainous ridges of Martanesh, Çermenika and Golloborda, the uplifting tectonic and pushing movements have complicated the geological structures, especially during their western limbs. The tectonic faults, related to the phenomenon of inversion and displacement of the axes of the main geological structures towards the west, have defined the asymmetry of slopes of mountainous ridges. The typical structural characteristics and the lithologic diversity determine the changes in vertical and horizontal fragmentation values of the relief.¹⁵



Profile No.1. Geomorphologic profile in sector Devoll Valley – Vërnik¹⁶ – Worked : Andri Hoxha

The fold structures are transversally interrupted by tectonic faults, where as consequence surface waters have used them to create fluvial transversal gorges. Due to normal tectonic faults and reverse faults, tectonic scarps of various types have been created, by intensively increasing the contrasts of the relief, especially the vertical fragmentation rate. The Reverse of the fold structures from northeast towards the west has led to the phenomenon of the structural asymmetry and the asymmetry of the slopes of mountainous ridges, where as consequence the western slopes are generally destroyed, displaying in the form of coastal scarps with very high-altitude, in front of Ionian Sea waters.¹⁷ In Albania, the forms of monoclinical crests are distinguished and they are created over the structures of reverse type of tectonic zones. The presence of these monoclinical crests is explained by the fact that the anticlinal structures are tectonically deformed, because their eastern limb has reversed over the western limb, by completely destroying the latter, and as consequence these structures have acquired the features of monoclinals, over which the respective ridges culminate. While their western bording slopes represent fault scarps of reverse type, such as in the mountainous ridge of Dajt, Scanderbeg, Shpat, Griba, Valamara, Ostrovica, Gramoz, Çika etc. Cuestas are forms of relief created over monoclinical structures, that are composed of soft and instable molasse and flysch rocks, as well as

¹⁴ Sala S. Physical Geography of Albania. Vol. 2. Monography Tirana. (1990).

¹⁵ Krutaj.F. Physical Geography of Albania. Vol.2. Monography Tirana.(1990).

¹⁶ Qiriazhi.P. Physical Geography of Albania. Vol.2.(1990). Monography Geology from Collective authors: Geologic Map of Albania, (1983)

¹⁷ Kabo.M. Physical Geography of Albania. Vol.No.2. Monography, Tirana,(1990)

in the fold structures, that are interrupted by tectonic faults, as a result they are of tectonic origin. Cuestas with the most obvious morphological features are created on the synclinal structures, over which the hilly ridges in Vora, Rodon, Mallakastra and Kërraba are created, of the hilly ridges in the western part of the upper section of Shkumbin and Mat valleys. Cuestas have been created due to the contact of strong sandstones and conglomerate layers with clays and marls. Because of the small value of the thickness of the sandstone and conglomerate layers, some cuestas appear quite close to each other, such as in Kërraba hills that limit Tirana plain, or Bërzeshta hills in Librazhd etc. Their lithological composition of generally soft molassis and flysch rocks, has led to the considerable presence of the hydrographic drainage, represented by some branches of main rivers. These water streams have created valleys of subsequent type, where one slope is limited by the back side of one cuesta, while the other slope is limited with the front of the other cuesta. During the Pliocene and Quaternary period, the hydrographic network of Albania was gradually created. In Pliocene age, the river flows that circulated along the bottom of wide valleys with a little depth, almost consolidated their actual directions, transporting massive solid flows towards the lakes basin of Pliocene age, extending into the interior part of the Albanian territory and in the Pliocenic Pranadriatic marine basin. The presence of the Pliocene marine basin in the Ultesiren Perendimore conditioned the withdrawal towards the west side of the rivers of our country, while the curve of these rivers was realized towards the west, along the lower sectors of river flows.¹⁸

RECOMMENDATIONS

- The diverse and complex character of the relief of Albania requires further deepening studies for full acknowledgement of chronological problems of morphotectonic evolution of relief.
- The wide and complicated extent of genetic complex of structural relief requires a particular study related to the stages of its morphotectonic and morphological evolution, and especially in relation to actual and new tectodynamic.
- The complete descriptions of tectonic scarps in all complex forms of their appearance in actual relief, would be fundamental to this evolution.
- Prior to the development of the infrastructure of construction, geomorphological and geologic-engineering studies should be undertaken and it should be determined the geographical distribution of the sectors destroyed by fault tectonics, especially the itineraries and their respective dimensions, along with the construction of some protective barriers.
- In sectors with high seismic hazard, studies related to the construction of road infrastructure must be performed.
- In the framework of the structural relief, studies related to the development of mass wasting must be planned and strategies for the construction of hydro-technical works in these sectors should be preceded by detailed studies.

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¹⁸Aliaj.Sh. Neotectonic of Albania. Monography, Tirana 2012.