GeoJournal of Tourism and Geosites Year **V** no.**1**, vol. **9**, **May 2012**
ISSN **2065-0817**, E-ISSN **2065-1198** Article no. **09107-108**

THE IMPORTANCE OF MORPHOMETRIC ANALYSIS IN HIGHLIGHTING THE TOURISTIC ATTRACTIVENESS OF NORTH – WEST DOBROGEA LANDSCAPE

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Abstract: Our study area is situated in the North-Western part of Dobrogea Plateau, respectively in the South-East of Romania. The purpose of this paper is to perform an interpretative analysis of the morphometric parameters of the Măcin Mountains, Niculiţel Hills and Nalbant Basin landscape for highlighting areas with touristic potential. To achieve our goal we generate the digital elevation model (DEM) by interpolating the contour lines taken from topographical maps (1: 25,000). Then, we derived the primary (hypsometry, slope gradient and orientation) and the secondary (fragmentation depth) morphological indicators. The area covered by each class has also been derived, therefore establishing the weight of every one of them by types of indicators. Data obtained from the morphometric analysis reflects the areas with touristic attractiveness and the areas suitable for placing the touristic infrastructure within the study area.

Key words: morphometry, tourism, North-West Dobrogea

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INTRODUCTION

The morphometric features of Măcin Mountains, Niculiţel Hills and Nalbant Basin are reflected by the genesis and the evolution of the Northern Dobrogea landscape. Our study area knows a long geological evolution, being the result of Hercynic and Early Alpine orogenesis (Ionesi, 1994). The formation of structural and tectonic features since the Upper Cretaceous has led to the submission of our study area to a long erosion cycle. The prolonged action of shaping agents determined the slopes withdrawal by weathering processes leading to the formation of an uniform peneplain (Popescu, 1988). The planation surfaces spread widely in the north-west, west and east of the study area, being situated at the contact of Măcin Mountains and Niculiţel Hills with basin areas.

The long evolution of the study area is reflected in the overall morphology, as well as in the current values of the morphometric parameters. Therefore, the prolonged action of the erosion processes made that, in the present time, the high altitudinal level do not exceed 500 m. The wide spread of planation surfaces is reflected in terms of morphometry, in low values of hypsomety and declivity. The contact between mountain

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area (hard rocks) and planation surfaces is made through "*knik*" slopes (Vespremeanu, 1973), so in this areas the declivity and fragmentation depth reach higher values.

Beside the paleoevolution, the geological frame is also an important factor that have determined the morphometrical features of our study area. The variety of the genetic types of rocks (with different composition, age and hardness gradient) and the prolonged action of external agents (over 300 million years) is reflected in the distribution of morphometric parameters values. Therefore, the declivity and depth fragmentation reflects the lithological composition, while the hypsometry and the slope orientation reflects the main geological and tectonic features of the study area. So, in achieving the morphometric analysis which is the objective of our study, it is necessary to know the geological frame (especially the lithologic features) of our study area. This will be analyzed in a later chapter.

From touristic viewpoint, the analysis of morphometric parameters have a particular importance in establishing the areas with touristic attractiveness and the basis for development of territorial tourism planning strategies. Knowing the morphometric values of the study area is very important because are mainly reveal the way in which the touristic territorial planning of Măcin Mountains, Niculiţel Hills and Nalbant Basin should be done. Therefore, their values allows the identification of possible landforms with touristic potential, likewise areas for placing the touristic infrastructure, such as accomodation and leisure bases, trails (length, the highest and lower point reached by the route), campsites, viewpoints ans so on.

Therefore, in this paper we performed an interpretation of morphometric indicators in order to highlight the attractiveness of North – Dobrogea landscape and it pretability for territorial tourism planning. Our study is a preliminary one. In the future we aim to realize a quantitative multi – criteria analysis of morphometric parameters in order to achieve the touristic potential of our study area.

STUDY AREA

The study area is developed on a surface of 1326 square kilometers and is situated in the North-Western part of Dobrogea Plateau (South-East of Romania) (Figure 1).

Măcin Mountains, Niculiţel Hills and Nalbant Basin are the main morphological units analyzed in our study. The area is delineated on the West and North by the Danube River (which separates on the West the Măcin Mountains of Balta Brăilei and on the North the Măcin Mountains of Danube Ponds), on the East by the Isaccea – Teliţa – Trestenic – Izvoarele basins and on the South by the Babadag Plateau.

From lithological viewpoint, Măcin Mountains belong to the Măcin Nap. It is made up of Alpine foreland formations being represented by mezometamorphic (amphibolites, gneiss, micaschists, quartzite, limestone) and epimetamorphic (quartzite, quartzitic and muscovitic schists, phyllite) crystalline schists (Nedelcu & Dragomirescu, 1965). In terms of regional geostructural frame, Ianovici et al. (1961) consider that mezometamorphic crystalline Eoproterozoic ground that were reactivated in instabile areas after Eoproterozoic age.

Wider areas within Măcin Nap are occupied by Paleozoic sedimentary deposists represented by sandstones, clays, limestones, marls of Silurian and Devonian age and arenites, tuffs, diabases of Lower Carbonifer age (Mutihac, 1990; Mutihac et al., 2007).

Crystalline schists and Paleozoic sedimentary rocks are pierced by intrusive rocks bodies represented mainly by granite and granodiorite placed before and after Paleozoic age. The Paleozoic intrusions have been taken place both before (Hamcearca leucogranites, Coşlugea granites) and after (Greci, Pricopan, Cetate granites) the sedimentation of Carapelit Formation (Mirăuţă et al., 1962). From morphologic viewpoint it often appear in the territory under the form of isolated imposing massifs (Iacobdeal, Piatra Roşie).

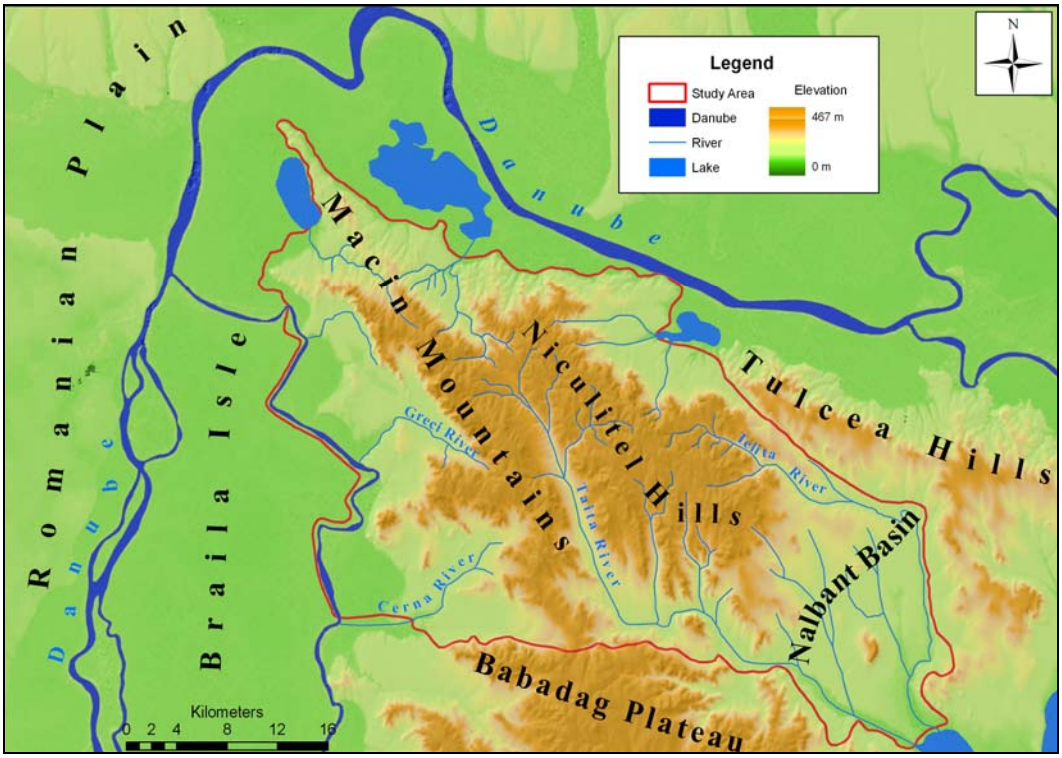

Figure 1. Geographical position of the study area

Niculiţel Hills belong to Niculiţel Nap and are mainly made of alpine sedimentary formations and igneous rocks of Triassic age (Rădulescu et al., 1976; Săndulescu, 1980). In the Niculiţel Nap area are often occur Alpine foreland formations represented by mezometamorphic (micaschists) and epimetamorphic crystalline schists (sandstones, greywacke sandstones). The Paleozoic sedimentary deposits are represented by silicolite with limestones intercalation, black and greyish schists of Silurian age, likewise limestones and clays of Devonian age (Săndulescu, 1984). The Alpin sedimentary deposists include limestones of Triasic and Jurasic age (Mutihac et al., 2007).

In terms of geology, Nalbant Basin belong to Nalbant formation being considered a rhythmic flysch which consists of quartzo- and quartzo-feldspathic sandstones and gray-blackih silite of Lower Jurassic age (Liasic) (Ionesi, 1994).

From morphologic viewpoint, Măcin Mountains unfolds in form of parallel ridges oriented north-west – south-east. They represent the highest and the most massive part of North Dobrogea Plateau, reaching a maxim altitude of 467 m in Ţuţuiatu Peak. Although of their relatively low altitude and the predominantly hilly appearance, Măcin Mountains present especially in the hard rock areas (granite, quartzite) an spectacular ruiniphorm landscape (represented by imposing ridges, pyramidal peaks, steep slopes, a wide variety of weird rock forms) resulted from the weathering processes. In the areas developed on rocks higher succeptible to erosion, the landscape is characterized by rounded peaks and lower altitudes. At the mountain base are developing large basins, being resulted by the slopes withdrawal caused by the action of weathering processes. Within basin areas, inselbergs are often occur (Posea, 2005 b). Niculiţel Hills is an extended plateau, highly fragmentated by the Taiţa and Teliţa valley and their affluents

and separated in rounded erosion witnesses, such as inselbergs (Popovici et al., 1984). Beside rounded peaks, in Niculiţel Hills are rarely occur proeminent peaks with altitudes higher than 200 meters (Denistepe - 266 m, Beştepe – 242 m).

Nalbant basin is an typical pediplain (Posea, 1983), resulted by the merge of several planation surfaces. Within Nalbant basin the landscape is almost cvasi-horizontal, being interrupted sometimes by erosional witnesses of different altitudes. This proves that the denudation processes have differently auctioned (Popescu, Ielenicz, 2003).

METHODOLOGY

The morphometric indicators (hypsometry, terrain energy, slope gradient and orientation) have been determined using GIS techniques. Initially, we created the digital model of the land based on the contour lines taken from topographic maps at the 1: 25 000 (1978 edition) scale. The next stage of our study, consisted in generating the areas covered by classes of indicators and in establishing the weight of everyone of them (using the geostatistical method).

The quantitative data obtained this way have been correlated with the results of photointerpretation (ortophotoplans - 2006 edition, satellite images) and field observations in order to obtain information regarding the touristic attractiveness of the Nort-Western part of Dobrogea landscape, likewise the landscape pretability for territorial tourism planning.

RESULTS AND DISCUSSIONS

Hypsometry

The spatial distribution of the main hypsometric levels is determined both by the main tectonic features (anticlines, synclines) and secondary tectonic features expressed by the leaving or lifting of the anticlines and synclines axles. Therefore, the arrangement of the elevation levels in Măcin Mountains is influenced both by the existence of two anticlines (Megina and Taiţa) and two synclines structures (Blasova – Sacar Dere and Greci - Carapelit), while in Niculiţel Hills is determined by the existence of an anticline (Sarica – Cilic) and a syncline (Teliţa) structure (Posea, 2005 a).

In our study area were identified five morphometric levels with unequal distribution and weight across the territory. The morphometric levels decrease from Măcin Mountains to Niculiţel Hills (4 morphometric levels) and Nalbant Basin (3 morphometric levels).

The upper hypsometric level (above 400 m) has the lowest weight in the territory (0.10 %) and it is characteristic only for the Măcin Mountains (Figure 2). The low values of hypsometry are explained by the long action of erosion processes that have acted in the North Dobrogea Plateau, which have led in the end, to its peneplanation (Coteţ, 1969).

The peaks belonging to this height are located in the central part of the mountain space (Ţuţuiatu – 467 m, Ghinaltu – 443m, Piscu Înalt – 442 m, Căpuşa – 433 m etc) and are important landmarks in the North Dobrogea landscape by their dominant appearance. Also, heights above 400 metres occur in isolated points to the West of the main range, in Priopcea Range (Priopcea Peak - 410 m) and South-East of it (Boclugea Range - 411 m). From the tourism viewpoint, they provide a large perspective on the surrounding morphology, therefore constituting natural panorama points. They facilitate the horizon tours and the panoramic reception of the neighbouring landscape, increasing the attractiveness of the study area. At the present, the identified peaks are not appointed as viewpoints by placing touristic panels for describing the surrounding morphology. Between peaks mentioned above, only those situated in the central part of the Greci ridge are coverd by touristic trails.

The altitudinal level comprised between 301 and 400 m is also developed on a small area (4.60 % from total area) in Măcin Mountains and Niculiţel Hills. In Nalbant Basin this altitudinal level is rarely being identified in areas where inselbergs occur.

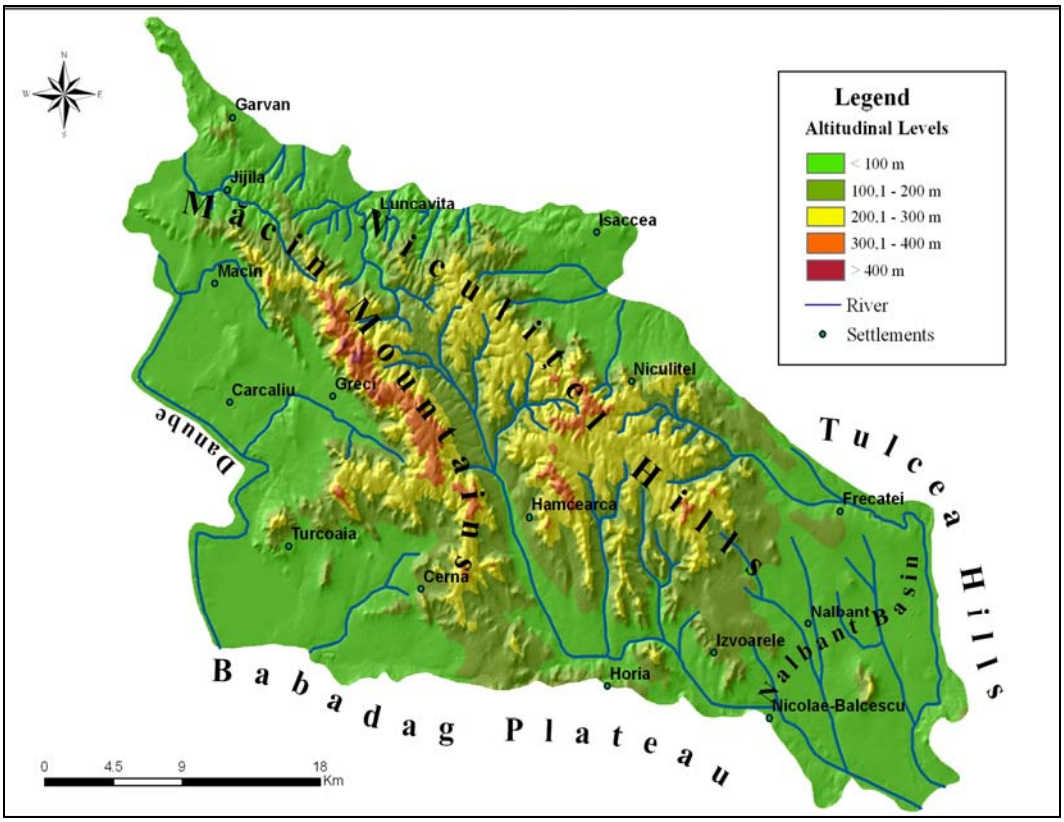

Figure 2. Hypsometry map

Therefore, in this level, one remarks the Pricopan Range (Măcin Mountains), both by the prominent peaks (Sulucu Mare - 370 m, Piatra Râioasa – 346 m, Sulucu Mic – 316 m, Căprariei – 312 m) and its unique ruinphorm morphology resulted from weathering processes. The morphological features of Pricopan Ridge have been capitalized through the implementation of a touristic route that starts from Măcin city and reach it highest peaks (Albotă, 1987). The broad perspective given by the Pricopanul highest peaks over the Danube and basins from the north-western part of Măcin Mountains is currently not valued through viewpoints.

Heights above 300 metres are also found predominantly along the main range of Măcin Mountains (Cartalu Peak – 393 m, Piatra Mare Peak – 381 m, etc), in Iacobdeal (Victoria Peak – 341 m), Bujoarele Hill (380 m), in Priopcea and Crapcea ranges and on smaller areas in Niculiţel Hills (Dumitru Hill – 356 m, Mare Hill - 349 m etc).

Althought of their apparently lower altitudes, the peaks comprised in this hypsometric level are invidualized in relation with adjacent units and provide the visual perception of a broad area (including Măcin Branch of the Danube; the main ridge of Măcin Mountains; Taiţa basin; Greci, Nalbant, Jijilla depressions; Babadag Plateau, Niculiţel Hills and so on), being favourable areas for the establishment of natural panorama points.

A significant weight (40,59 %) within the study area is represented by the hypsometric level comprised between 100 and 300 meters. This altitudinal level is characteristic for tablelands with different shapes and extensions that occurs both in Măcin Mountains and Niculiţel Hills, as well as in isolated places within the basins

neighbouring the mountain space (Chervant Peak – 204 m, Bujorul Românesc – 223 m). However, the most frequent and most extended are the areas which do not exceed 100 m in height (56.75%) and they are characteristic for Nalbant Basin and the valley corridors. In this altitudinal level, remarkable from touristic viewpoint are the isolated massifs - inselbergs (Carcaliu Peak – 95 m, Şcolii Hill – 92 m, Piatra Râioasă Peak – 98 m etc) which interrupt the monotonous landscape and diversifies the phisiognomy of the basins landscape (Ciangă et al., 2007).

The erosion witnesses within study area basins are not currently capitalized form touristic viewpoint. They can constitute viewpoints over the broad peneplain surfaces within Măcin Mountain and Niculițel Hills; likewise over the pediplain of Nalbant basin. Also, the most representative of them can constitute the subject of a touristic trail with real scientific and educational valences.

Fragmentation depth

The distribution of landscape energy values within the analyzed area is influenced mainly by lithology and by the intensity of erosion processes. Knowing of fragmentation depth values is necessary to identify the spectacular areas with high degree of attractiveness and the favourable sectors for establishment the touristic infrastructure (access roads, trails, accommodation bases, recreation bases etc).

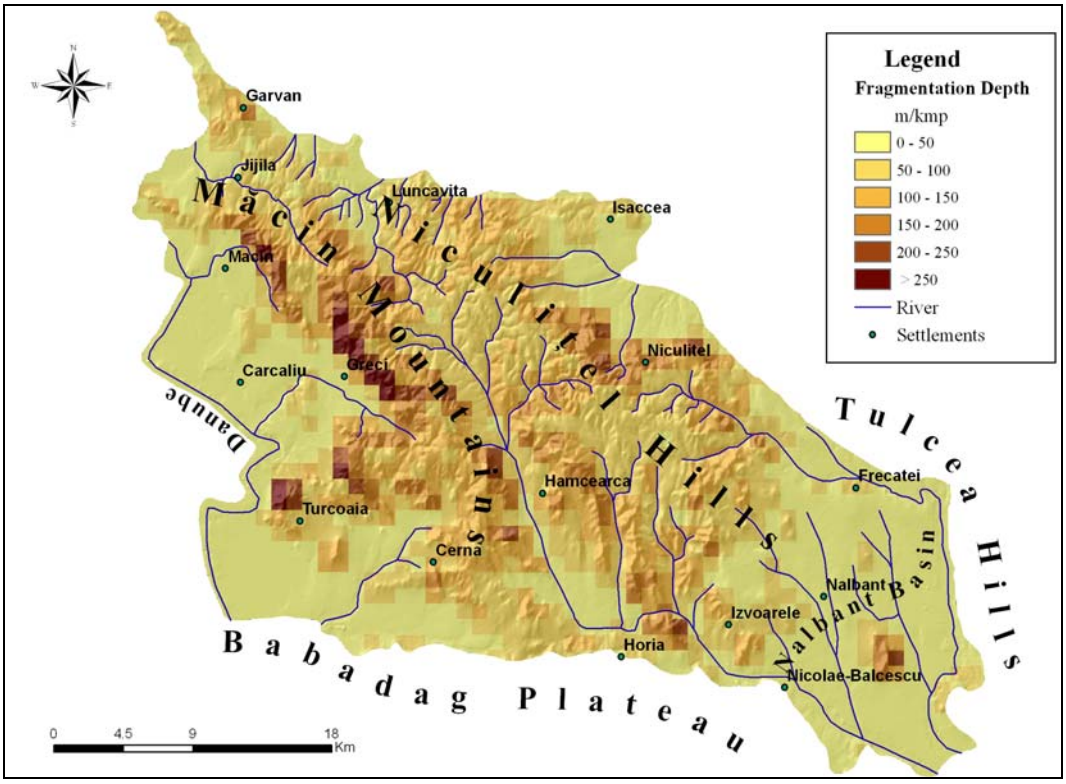

Figure 3. The map of depth fragmentation

By analyzing the map of depth fragmentation we noticed that the highest values of landscape energy, over 250 meters, are developed on a small area (just 0,91 % of total area). This values are registered in areas made of granite, granodiorite, quartzite rocks, lower susceptible to erosion. They are characteristic for the higher parts of central Măcin

Mountains (Ţuţuiatu, Moroianu, Cavalu, Negoiu, Tăpşanu, Călcata and so on) which are in the same time, one of the most attractive within the analyzed space from the viewpoint of landscape aesthetics. The existing touristic trails are partially reach the areas with high values of fragmentation depth (Ţuţuiatu, Cavalu, Negoiu), but most of them are not capitalized from touristic viewpoint.

Also, on a small area (7,2% of total area) are developed the values of landscape energy comprised between 150 – 250 meters (Figure 3). They correspond to areas with elevations above 300 metres within Măcin Mountains and Niculiţel Hills. However, the most frequent are the areas with lower landscape energy (under 100 meters) specifics for basins (Nalbant, Jijila, Măcin, Greci, Cerna, and so on) and valley corridors composed mainly of rocks highly susceptible to erosion (loess deposits).

In certain points within the basin areas higher values of landscape energy, exceeding 100 – 200 meters, may occur due to the presence of the erosion witnesses such as Carcaliu Hill, Piatra Râioasă Hill, Şcolii Hill etc (Table 1).

The large spatial extension of the areas with lower values of landscape energy represents a favorable factor for territory touristic planning. In the present, the areas with low values of landscape energy are partially capitalized. We notice in this areas the presence of acommodation basis, rest areas, information center of Măcin Mountains National Park (Măcin), riding center (Cerna), memorial houses (Panait Cerna), monasteries (Cocoş, Şaon), Niculiţel basilica and so on. We also notice that the touristic facilities are fewer in comparison with the great scientific, educational and touristic potential of North Dobrogea.

Table 1. Depth fragmentation values

No.	Depth fragmentation(m)	Values (%)
1.	0 – 50	41.42
2	51 – 100	30.21
3.	100 – 150	18.71
4.	150 – 200	7.02
5.	200 - 250	1.66
6.	over 250	0.91

Some of the areas with values of landscape energy that exceed 150 meters represents areas favorable for the establishment of panorama viewpoints, due to their perspective under the surrounding morphology. In the present they are not capitalized.

Declivity

The declivity of morphological surfaces is closely linked with lithology, tectonics and geomorphological processes of the study area. The analysis of declivity map reveals some accordings between slope distribution and hypsometric levels identified.

Table 2. Declivity values

No.	Slopes (°)	Values (%)
1.	0 - 5	66.11
2	5 - 15	30.02
3.	15 - 25	3.71
4.	Over 25	0.16

The highest weight in the territory (66,11 %) (Table 2) is represented by the moderately inclined surfaces (below 5°) comprised in the altitudinal level under 100

meters and frequently made by limestones, marls, clays, loess deposits, etc. They are specific for basins, valley corridors (Telița, Taița) and structural watersheds.

Slopes with values comprised between 5° - 15° has also a significant weight in the territory (30.02%) being reported at the contact between the ridges and basins in Măcin Mountains (Vespremeanu, 2003). They are also frequent in Niculițel Hills too.

Areas with low values of declivity are currently valorised by the implementation of a cyclotouristic route that starts from Măcin basin and comprises Greci – Cerna – Mircea Vodă basins - Carapelit pass - Taița Valley – Jijila basin. Also, in this areas were placed the main accommodation bases, restaurants (Angelo), rest areas (Căprioara), etc. The cyclotouristic route can be combined with visits at the religious sites (Leac Fountain monastery), archaeological sites (Troesmis, Arrubium, Dinogetia fortresses), etc that are also placed in the basins areas and valley corridors within the study area.

The smallest weight in the territory (3,87 %) is represented both by the steep slopes comprised between 15° and 25° and slopes which exceed 25° values .They are signaled in the massifs composed of hard rocks, lower susceptible to erosion (granite, granodiorite, quartzite, basalts), characteristics for the upper sector of Sulucul Mare and Sulucul Mic, Piatra Râioasă, Vraju (Pricopan Ridge); the main ridge of Măcin Mountains (Țuțuiatu, Ghinaltu, Moroianu, Căpușa, Priopcea, David massifs), likewise for the slopes of Trestenic, Mare, Episcopiei, Dumitru hills within Niculițel Hills. Higher declivity values and even vertical walls are also registered on quarries where construction rocks are exploited, especially granites.

The determination of the slope gradient presents a high importance in highlighting the tourism potential of our study area. Thus, remarkable from touristic viewpoint are steep slopes (Sulucu Mare, Moroianu, Priopcea) and highly inclined surfaces (the left slope of the Racova valley) both due to their spectacularity note induced to the landscape and for the possibilities of practicing climbing (Erdeli et al., 2006). The existence of vertical walls within the granite quarries is also favors the practice of this type of leisure activity.

The touristic potential of both natural (Piatra Râioasă, Turnul Crăpat, Gemenii within Pricopan ridge) and anthropic vertical walls were capitalized by establishing of climbing routes with different difficulty degree, various insurance types (fixed, mobile, mixed) and lengths comprised between 5 and 30 meters. Routes with low difficulty degree are also used for teaching purpose, such as climbing courses.

No.	Orientation	Values (%)
1.	Quasi-horizontal	1.04328
2	NE	12.86885
3.	E	15.41307
4.	SE	11.50735
5.	S	11.43955
6.	SV	15.5611
7.	V	14.33166
8.	NV	9.09617
9.	N	8.73897

Table 3. Slope orientation values

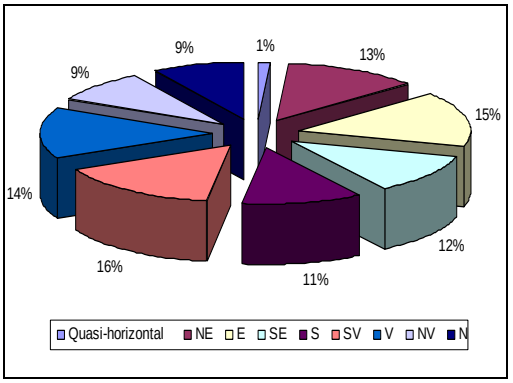

Figure 4. Histogram of Slope orientation

Thus, the surfaces with declivity values which not exceed 5° where used for placing the touristic infrastructure (accommodation bases, rest areas), while the surfaces which

exceed 25° for placing the infrastructure for climbing activities. Also, the slopes values where used in tracing all the touristic trails from our study area, especially for determining the length, the degree of difficulty and the travel time of the route, as well as the categories of tourists that they can perform it.

After we created the slope orientation map we have determined the weight of each class of values using GIS analysis. For a better interpretation of each class of values we created also the histogram of slope orientation (Figure 4). By analyzing it one remarks the relatively uniform repartition of all types of exposure. The slopes oriented towards South-West (15.5%) and East (15.4%) have the highest weight within the area (Table 3).

Slope orientation

The landforms configuration and the orientation of slopes play a significant part in the placing of tourism structures. Thus, the sunny slopes oriented towards South and South - West where used for the planning of camping sites and rest areas, but also as a support for determining the direction and orientation in crossing the touristic trails within Măcin Mountains and Niculiţel Hills.

CONCLUSIONS

The determination of quantitative (hypsometry, slope gradient, terrain energy) and qualitative (slope orientation) morphometric parameters was made using GIS tehnics and has been performed in order to assess the areas of touristic attractiveness within Măcin Mountains, Niculiţel Hills and Nalbant Basin landscape and it suitability to territorial tourism planning.

The altitudinal levels identified were the starting point in analyzing the attractiveness of the study area landscape. The increased frequency of low altitudinal levels is determining for defining the Măcin Mountains as being an accessible mountain area for performing touristic routes of medium and low difficult degree, in comparison with other mountainous areas from our country. The low values of fragmentation depth are also determining for establishment the accommodation structures and touristic trails within Măcin Mountains and Niculiţel Hills.

The high differences between the altitudinal levels recorded in certain spaces from our study area represents points of interest within the touristic trails. The isolated massifs are attractive from on aesthetic viewpoint both due to the interruption of the monotonous landscape and to the diversification of landscape. The areas with isolated massifs are easily identified in our study area by using the values of fragmentation depth. Thus, the isolated peaks overlap of areas where the highest values of the fragmentation depth (over 250 m) are registered.

The orientation and position of the isolated massifs allow the visual perception of the morphological adjacent units, thereby constituting natural panorama viewpoints with potential for touristic exploitation.

Declivity represents an important factor regarding the establishment of touristic infrastructure. This is due to the easy representation in GIS of the quasi-horiyzontal and unfragmented areas which can be favourable zones for building accommodation resorts. Thus, the high extension of the slopes below 5° represent a favourable factor for placing touristic infrastructure (accommodation structures, restaurants, leisure structures, campings, touristic trails and so on). The declivity defines also steep - slope areas within Măcin Mountains. From touristic viewpoint, steep slopes are increasing the attractiveness of our study area due to their aesthetic values and also give the possibility of practicing climbing activities.

Therefore, the assessment of morphometric parameters such as hypsometry, fragmentation depth, declitivity and slope orientation facilitates the determination of

the attractiveness of North – West Dobrogea landscape and can constitute the basis for achieving a global territorial tourism planning strategy of our study area. Also, this preliminary morphometric analysis will be the starting point in developing a quantitative multi-criteria analysis in order to establish the tourism potential of North – West Dobrogea landscape.

Currently, the touristic infrastructure is in an early stage or is completely missing in some places within the study area. In Măcin Mountains the touristic infrastructure is the most spread. Therefore, in Măcin Mountains were implemented six touristic routes, a thematic trail, an equestrian route and a cyclotouristic route. These trails are taking into account the values of the morphometric parameters and are frequently reaching the most important areas form a touristic viewpoint (Pricopan ridge, central part of Greci ridge).

Slopes with high declivity values and vertical walls, with wide level differences were equipped in order to practice climbing activities. Also, in five of the existing abandoned quarries were equipped with an adequate infrastructure for practicing climbing. In areas with low difficulty degree were implemented particular routes that are used for teaching purpose (climbing school).

In the areas with declivity comprised between 5° - 15° from the southern side of Măcin Mountains was established an equestrian trail. In the areas where declivity does not exceed 5° was created a cyclotouristic route.

In Niculiţel Hills the touristic infrastructure is currently in an incipient stage and focuses for the most part on the religious tourism. In Nalbant Basin the touristic infrastructure is totally missing.

Ackowledgements

This paper was possible with financial support of project Ph.D. scholarship, Project co-financed by the Sectoral Operational Program For Human Resources Development, 2007 – 2013**,** Priority Axis 1 "*Education and training in support for growth and development of a knowledge based society*"**,** Key area of intervention 1.5**:** Doctoral and post-doctoral programs in support of research, Contract no: Posdru/88/1.5/s/60185 – "*Innovative doctoral studies in a knowledge based society*"**,** Babeş-Bolyai University, Cluj-Napoca, Romania.

The authors acknowledge to anonymous reviewer for their thoughtful suggestions and comments.

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Submitted:	Revised:	Accepted and published online
07.11.2011	10.02.2012	14.02.2012