THE BÂSCA ROZILEI RIVER DRAINAGE MODEL, ROMANIAN CARPATHIAN BELT

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Abstract. This paper presents the interpretation of the field investigations carried out in the southern part of the Eastern Carpathians, aiming to obtain a drainage model of the Bâsca Rozilei, the left tributary of the Buzău River. For achieving the drainage pattern, we have correlated the geomorphological, topographical and geological features of the studied area. We found that Bâsca Rozilei is a 6th order stream, being a young basin, which shows a high degree of branching of the hydrographic network and a torrential character.

Key words: geomorphology, hypsometry, drainage system, Buzău basin, Eastern Carpathians.

1. INTRODUCTION

The drainage morphometric model is achieved by using a mathematical procedure analysis of a hydrographic basin which quantifies the drainage system, highlights its degree of development and outlines the future directions of evolution for the basin (Grecu & Palmentola, 2003). The morphometric analysis of a basin can provide essential information regarding a river evolution. The values of these parameters are closely related to the physical and geographical aspects and their continuous dynamics are imposed by certain variables, such as: geological substrate, precipitation conditions, leakage regime, as well as the anthropogenic impact, especially for the events caused by deforestation, pasturage and the riverbed arrangement. The interpretation of the river drainage is very important in hydrological outlines and lead to a realistic management of water resources (O'Callaghan & Mark, 1984). As a result, substantial information occur, pointing out various events which affect a river basin, including natural, i.e., landslides, erosion, flows (Agarwal *et al.*, 1996) and anthropogenic ones.

In this paper, the hydrographic system of the Bâsca Rozilei basin was generated by the numerical model of the field and classified after the Horton-Strahler system (Horton, 1945; Strahler, 1952, 1957). With an important role in the formation and distribution of the river runoff elements, various morphometrical components related to the hydrographic system were analyzed, useful for elaborating the calculation methods of the hydrological parameters.

2. STUDIED AREA

The Bâsca Rozilei morpho-hydrographic basin is part of the upper Buzău Valley, which occupies the central-eastern position of the country (Ielenicz & Comănescu, 2003), overlapping several units in the Buzău Mountains, such as the Penteleu Mt. at the confluence between Bâsca Mare and Bâsca Mică, Podu Calului Mt. and Ivănețu Peak (Figs. 1 and 2). The Bâsca Rozilei Valley, with a longitudinal flow, crosses the main massifs, flanked by the Ivănețu Peak towards East and Podu Calului Mt. at West. The Penteleu Mt. is formed by a north-to-south oriented ridge where all the peaks exceed 1,500 m (Posea & Badea, 1984).

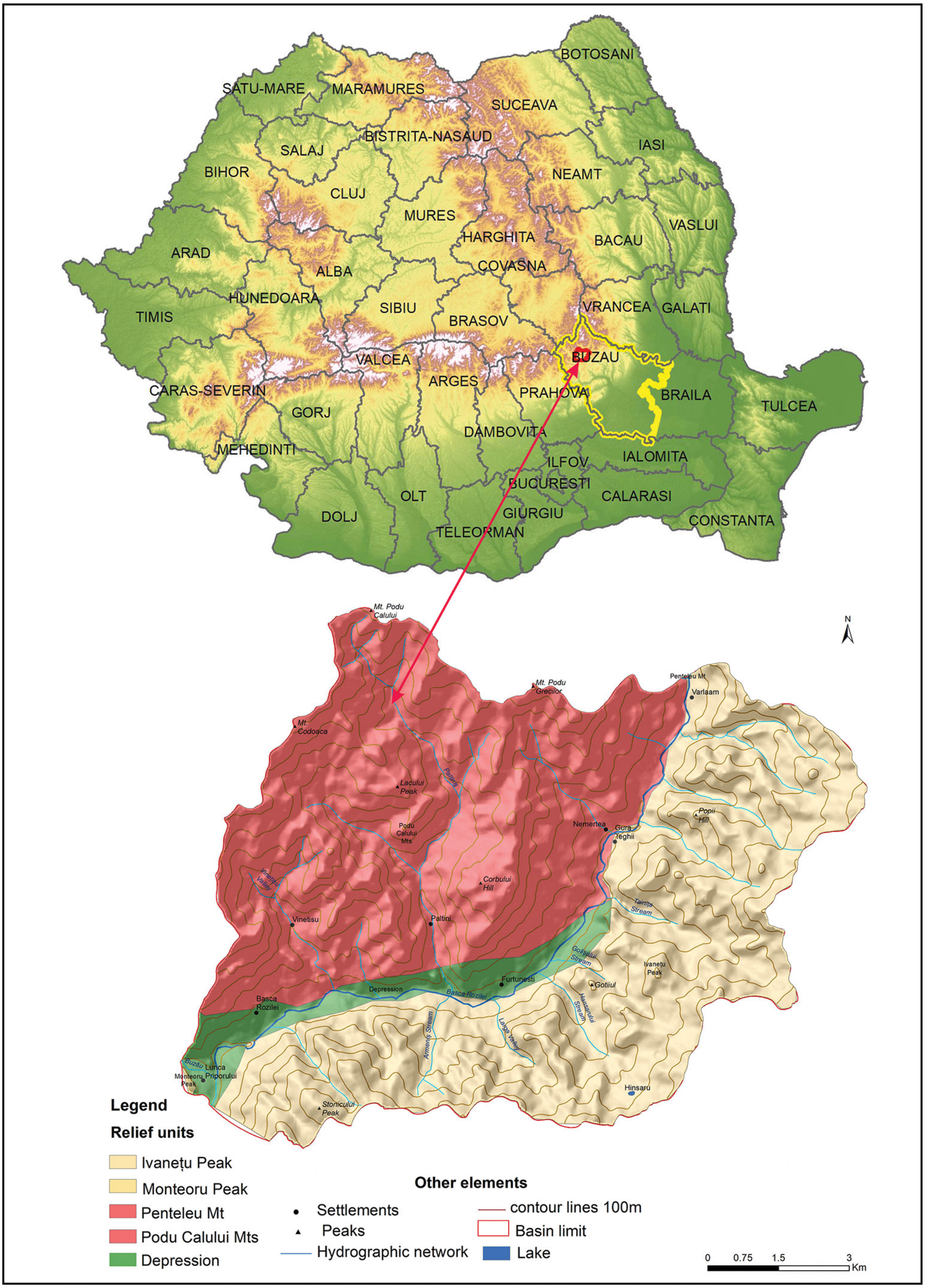

Fig. 1. Location of the studied area in the Romanian Carpathians bend area (up) and the development of Bâsca Rozilei basin (down).

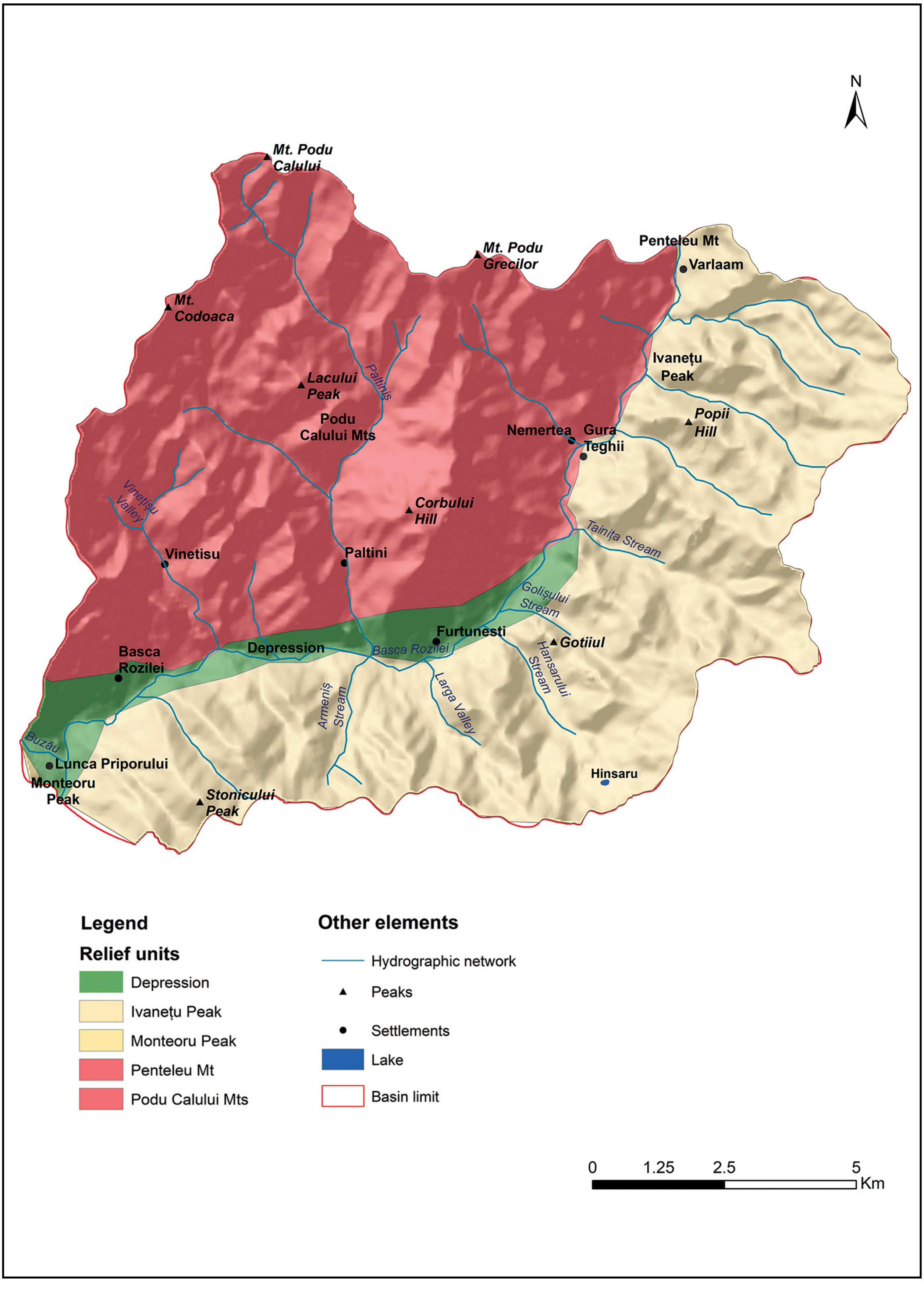

Fig. 2. Bâsca Rozilei Basin and the main geomorphological surrounding units.

Unlike other massifs, Podu Calului Mt. is intensively fragmented, especially on the Buzău affluents. In consequence, there are no central peaks but bundles of interfluves, west and south oriented and several hills, which are detached from three higher peaks. This type of relief unfolds between the Caşoca and Bâsca Rozilei valleys, having the Podu Calului Mt. in its center (Ielenicz, 1984). The reception basins of the valleys suggest the appearance of large natural amphitheaters, located behind the small gorges crossing through the Paleogene lithological units, such as the Tarcău Eocene and Kliwa Oligocene massive sandstones.

The north-east to south-west oriented Ivănețu peak upholds at approximately 1,000 m. A few more peaks made of sandstones exceed this value (Ivănețu 1,191 m, Arsenie 1,115 m, Oii 1,038 m and Zboiu 1,114 m), while in the saddles between them the height varies between 800 m and 950 m (Ielenicz & Comănescu, 2003). On the slopes of all the valleys, due to the rock type that are cropping out, i.e., mostly pelites, landslides have a remarkable development. Landslide "tongues" are imposed in the landscape, covering almost completely the riverbed and the main source sector, and showing large circle shapes. Waterfalls and gorges occur where the valleys have deepened into massive sandstones.

The Bâsca Rozilei river or Bâsca Roziliei (named in the past Bâsca Rosiliei or Bâsca Rusilei, after Rusila Mountain), is a tributary watercourse of the Buzău River. It starts at the confluence between Bâsca Mică (to the East) and Bâsca Mare (to the West), located in a place known as Piatra lui Vișan, downstream of the Varlaam village, and ends at the confluence with the Buzău River, in the vicinity of Nehoiașu village. On this sector, the riverbed increases in width and the tributaries show a NS orientation with lengths between 5-10 km (Fig. 1). The main left-side tributaries of the Bâsca Rozilei Valley are Bâsca Mică, Varlaam, Tigva, Fulgeriș, Tainița, Gotiș, Hânsaru, Valea Largă, Aniniș; the right-side tributaries are Bâsca Mare, Tega, Păltiniș and Vineţişu (Ielenicz, 1984).

The Buzău Mts. consist of various rocks belonging to the external units of the Eastern Carpathians, respectively the Moldavides (Săndulescu, 1984, 1995). The successions crossed by the Bâsca Rozilei river are located in the Tarcău Nappe, unit consisting mostly of Eocene and Oligocene turbidites on the lower course. The traversed rocks predominantly consist in rhythmic alternations of sandstones, clays and marls. Subordinately, microconglomerates, menilite-type siliceous rocks and bituminous rocks (clays and marls) of Oligocene age are added. The thickness of the beds varies from a few centimeters to 2 m. The differences which occur from one unit to another are based on the rock types, layer thicknesses, but also on tectonic elements, such as anticlines, synclines, digitations, reverse faults and normal faults (Ştefănescu *et al.*, 1993; Melinte-Dobrinescu *et al.*, 2017).

Several sectors are distinguished in which the arenite layers are thinner and alternates with pelites in the Penteleu, Podu Calului and Ivănețu Mts. Due to the great erosion resistance, often the valleys show canyon-type characters (Frunzescu & Brănoiu, 2004). At the confluence with Buzău Valley, as well as on several Bâsca Rozilei tributaries, Quaternary terrace deposits were identified.

The development of local communities located in the Bâsca Rozilei basin has been favored by the general economic progress of the surrounding regions, especially due to the existence of important forest reserves. From an administrative point of view, the settlements located in the Bâsca Rozilei basin, situated between the confluence of the Bâsca Mică and Bâsca Mare rivers and the confluence with the Buzău River, belong to the Buzău County. The villages Varlaam, Gura Teghii, Nemertea and Furtunești belong to Gura Teghii commune, while Bâsca Rozilei village belongs to Nehoiu city. The main populated areas like Varlaam, Gura Teghii, Nemertea, Furtunești and Bâsca Rozilei are located at the confluence with important tributaries, such as Tega and Tainița (Ielenicz, 1984; Gherghe *et al.*, 2020).

The population activities in the region are sustained by natural factors, which play an important role for the economic progress. The existence of pastures and meadows favored the growth of animal husbandry. Rich forest resources of the region led the orientation of a significant number of inhabitants towards activities related to exploitation and wood processing. Because of the high altitude and the accentuated slopes, farming cereal crops is not feasible, most of the area being hard to use from this point of view.

In the Bâsca Rozilei Basin, landslides have extremely varied shapes, with steep sandstone walls appearing on most of the slopes. Occasionally, landslides reach the riverbed where they create natural dams leading to the formation of lakes. Thus, in 1969, two natural dam lakes were formed on the Caşoca Valley (located outside our study area, northwest of the Podu Calului Mts), one of which being still preserved today (Frunzescu & Brănoiu, 2004).

3. METHODOLOGY

The geographical analysis was realized by using GIS techniques. The cartographic model presented in this paper is based on geographical data processing methods by integrating the maps and their components into algebraically equations. Subsequently, maps were transformed or combined, producing new ones using specific space operations (Chendeş, 2011). Cartographic algebra was used for the cartographic modelling (local-type, focal-type, zonal-type operations and progressive-type ones). The representation for the geomorphological characteristics was generated through a complex selective process and by retaining the essential morphodynamical elements for mapping, such as floodplain and channel configurations, the superficial deposits which cover the slopes and outcrops, the characteristics of the gravitational process given by active and inactive scarps, flow networks and the alluvial fans.

A large number of primary data were vectorized. The isohypses were generated by vectorizing topographic maps at 1:25,000 scale, tectonics and lithology were determined using 1:200,000 and 1:50,000 geological maps, and villages and geomorphological elements have been marked in accordance with the geographical map of Romania.

For elaborating the drainage model, we have calculated the number of river segments, the total length of the river segments and the average length of the river segments (N_1, N_2, N_3), using the Horton-Strahler hierarchy; the order was established by counting each segment. The number of successive ascending river segments tends to form a decreasing progression in which the first element (N_1), is the number of first-rate course segments and the ration is given by the confluence ratio (R_c).

$$Rc = \frac{Nx}{Nx} + 1 \quad (01)$$

A confluence ratio can also be determined for each pair of segments:

$$R_{c1} = \frac{N_1}{N_2} ; R_{c2} = \frac{N_2}{N_3} \quad (02)$$

In this case:

$$R_c = \frac{R_c + R_c + R_c}{n} \quad or \quad R_c = \frac{\sum_{i=1}^{n} R_{ci}}{n} \quad (03)$$

Through the partial confluence ratios (R_{c1}, … R_{cn}) comparisons between confluences from different hydrographic basins and in different sectors of the basins (upper, middle, lower) can be made. The data were graphically represented in semilogarithmic coordinates. For the river segments, the length was measured for each order; the sum of lengths for the river segments with successive increasing order tend to form a decreasing geometric progression, in which the first term is given by the sum of the first-order segments length. The ratio (R_L) is given by the summed length ratio:

$$R_L = \frac{L_x}{L_{x+1}} \quad (04)$$

The calculation of the average length of each river segment for each order was performed by dividing the total length to the number of river segments:

$$l_1 = \frac{\sum L_1}{N_1} ; \quad l_2 = \frac{\sum L_2}{N_2} \quad (05)$$

The average length of successively increasing river segments tends to form an increasing geometric progression, in which the first term is given by the average length of first-order courses (l_1). The ratio (R_L) is given by the ratio of the successive average lengths or by the ratio of the river segments strings and the average lengths:

$$N = \frac{R_C}{R_L} \quad (06)$$

The graphic representation has been realized using semilogarithmic coordinates, *x* – axis with orders of magnitude, as independent variables and *y* – axis with dependent variables: number of river segments (*N*), length (*L*) and average length of river segments (*l*). The line defining each parameter has been drawn in order to determine as many points (values) as possible. The values that deviate from the right were influenced according to the morphogenetic conditions of the relief and its stage of evolution. The measured values are represented on the graph.

The water balance development coefficient (Cebotarev, 1957) was calculated using the formula:

$$M = \frac{0.28 \text{ x P}}{\sqrt{\text{F}}} \quad (07)$$

where *P* – perimeter; *F* – surface, and highlights the water balance and the hydrographic basin evolution over time. The sinuosity of the water balance was determined by using the formula:

$$K_s = \frac{L_c}{L_p} \quad (08)$$

where L_c – length of the balance; L_p – the distance on the balance between the spring and the discharge. It was calculated either for the whole basin or for the left and right banks, providing important data related to the evolution of the studied hydrographic basin. The asymmetrical coefficient of water balance is given by the formula:

$$K_{as} = \frac{\frac{(L_{st} - L_{dr})}{L_c}}{2} \quad (09)$$

where L_c – length of the balance, L_{st} – the length of the balance on the left side of the basin relative to the drainage axis, L_{dr} – the length of the balance on the right side of the basin relative to the drainage axis. In order to express the shape of the basin a form factor is being used which is calculated according to the formula:

$$R_f = \frac{F}{L_m{}^2} \quad (10)$$

where *F* – surface and L_m – maximum length of the basin (*fide* Zăvoianu, 1978). The value 1 indicates a shape close to a square where the value decreases for elongated basins. The asymmetry coefficient of the hydrographic basin was calculated according to the formula:

$$K_a = \frac{2(F_{st} - F_{dr})}{F} \quad (11)$$

where F_{st} – the left side area of the main drainage axis, F_{dr} – the right-side area of the main drainage axis, *F* – total surface (Morariu *et al.*, 1962).

The sinuous length of the river represents the real length of the watercourse, which can be calculated by digitizing in ArcGIS the trough of the topographic map. The straight-line length of the river is the line joining the elevations of point A and point B, these representing the highest point (A) and the lowest (B) of the Bâsca Rozilei riverbed. The sinuosity coefficient of the river is:

$$K_s = \frac{L_s}{L_d} \quad (12)$$

where L_s is the actual length of the river (sinuous) and L_d is the straight-line length of the river. The sinuosity coefficient is calculated as the ratio between the sinuous length of the river and its length in a straight line. This coefficient is always higher than 1, and if it exceeds 1.5 then the riverbed is considered to be meandered (Zăvoianu, 1978).

In order to generate the drainage model, a morphometric parameter was also calculated, as indicator of the depth degree of the valleys in relation to the level of interfluves, known as the relief energy. This indicator is the numerical expression of the capacity to deepen the denotative processes in opposition to the tendency of the Earth's crust to rise, being in fact the ratio between external and internal agents (Posea and Cioacă, 2003). The calculation method we used is based on the statistical calculation for the surroundings. A square with side of 1 km was considered our calculated area. Based on the MDT, two new grids were created containing the maximum altitude and the minimum altitude. Each cell is assigned the highest altimetric value, respectively the lowest, from the set of values found in the surrounding area of 1km^2. The difference between the two grids (according to the methodology described by Chendeş, 2011) generates a new map which represents the relief energy.

The hypsometric curve is represented graphically in a two-coordinate system, where the vertical axis indicates the altitude and depth of the relief and the horizontal axis shows the land surface, calculated in km^2 or percent, indicating the areas between the cumulative level curves decreasing from the highest altitudes to the lowest. This type of representation allows us to determine the basin surface located above a certain elevation, ex., $S.cum\ (n+2) = S\ (n+1) + S_n$. Hypsometry was represented in the form of hypsometric steps with fixed intervals at 200m obtaining 7 classes, visually delimited by level curves from 100 to 100m.

4. RESULTS

4.1. Hypsometry

The hypsometry of the studied area reveals altitudes between 378 and 1,433 m (Fig. 3). The highest value is recorded in the Podu Calului Mts., and the minimum altitude is given at the confluence with the Buzău River. The hypsometric steps with altitudes between 600-1,000m are typical for the Bâsca Rozilei Basin, occupying approximately 71.4 km^2 and representing 66% of the basin surface (Fig. 4, Table 1). In the Bâsca Rozilei basin, the most illustrative hypsometric step is at 800-1,000m, which occupies approximately 36.72 km^2 and 34% of the surface of the area, while the last altitudinal step is covering 0.07% of the total area. Along with the riverbed, the altitude steps 381-600 m represent the dominant areas that occupy 6.26 km^2; on Culmea Ivăneţu the dominant altitude steps are located at 600-1,000m, covering 39.10 km^2 of the total surface (Table 1). Due to the fact that the studied perimeter is located in a mountainous area, there is a development of the surfaces up to the altitude of 800m, followed by a reduction of the surfaces up to 400 m (Fig. 5).

4.2. Geology

The Bâsca Rozilei basin, situated on the lower course of the Buzău River, crosses the tectonic units of the outer Eastern Carpathians, mainly represented by turbidite successions (Dumitrescu *et al.*, 1968; Săndulescu, 1984). The traversed sediments belong to the Tarcău Nappe (Ştefănescu *et al.*, 1993; Melinte-Dobrinescu *et al.*, 2017) mainly composed of Eocene and Oligocene deposits (Fig. 6).

From a lithological point of view, the predominant units are the Paleogene sandstone turbidites, sharing 58.92% of the total surface and a 27.48 km^2 cover of the area, followed by Paleogene and Lower Miocene shally turbidites, composed of pelites and subordinate sandstones (28.89% and 13.48 km^2); the Pliocene-Pleistocene deposits of clays, marls, sands and loess represent 8.56% and 3.99 km^2. The smallest area is occupied by the Quaternary sands and clays located along the river (3.62% and 1.69 km^2).

Table 1. Areas occupied by hypsometric steps in the Basca Rozilei basin.

Relief units	381-400 m	400-600 m	600-800 m	800-1000 m	1000-1200 m	1200-1400 m	1400-1450 m
Depression	0.50	5.76	0.44	0.00	0.00	0.00	0.00
Ivăneţu Peak	0.00	7.13	19.82	19.28	2.71	0.00	0.00
Mt. Penteleu	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Mts. Podu Calului	0.00	6.75	14.40	17.37	10.40	3.20	0.06
Monteoru Peak	0.00	0.06	0.00	0.00	0.00	0.00	0.00

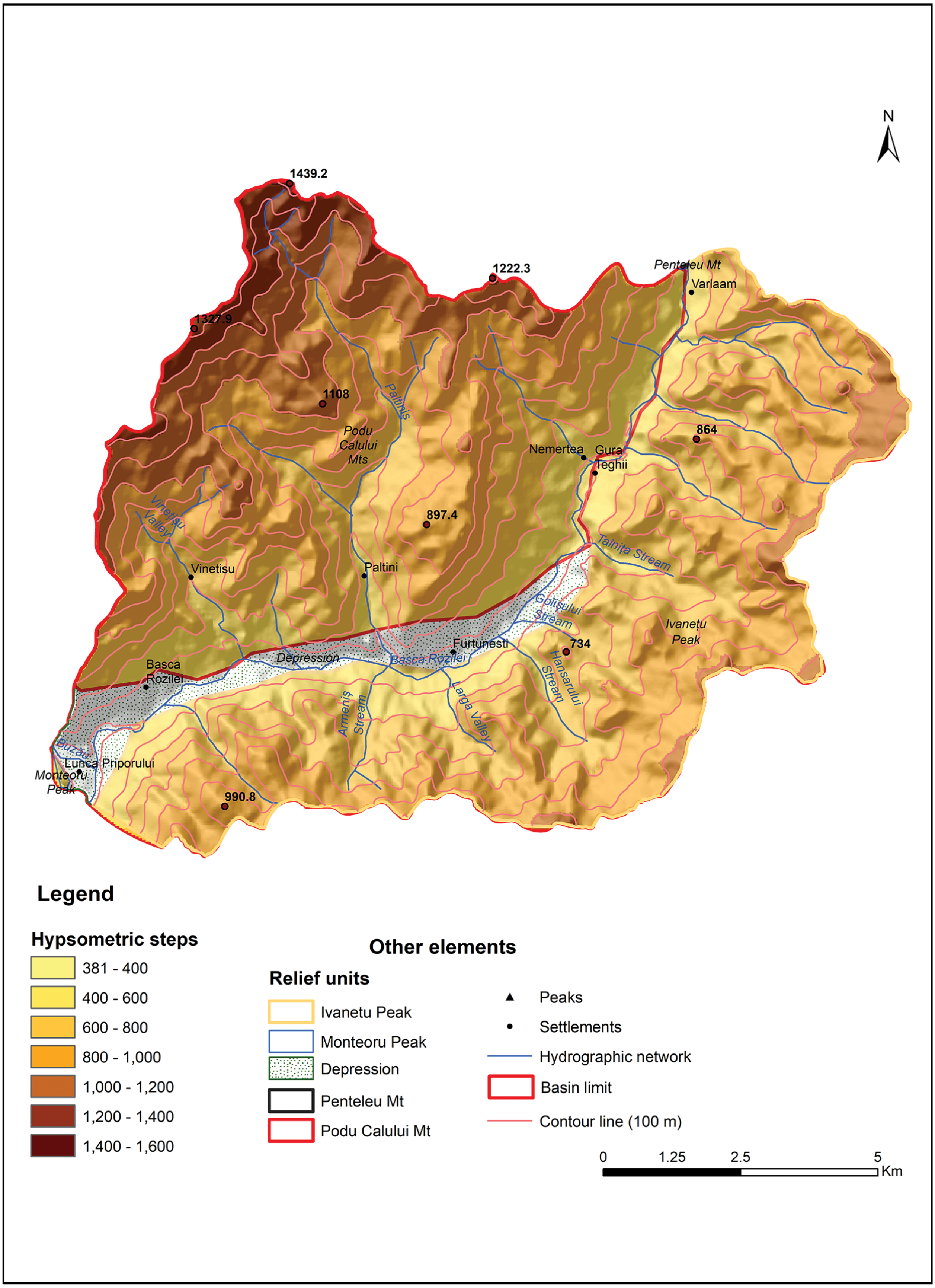

Fig. 3. Hypsometric map of the Bâsca Rozilei basin.

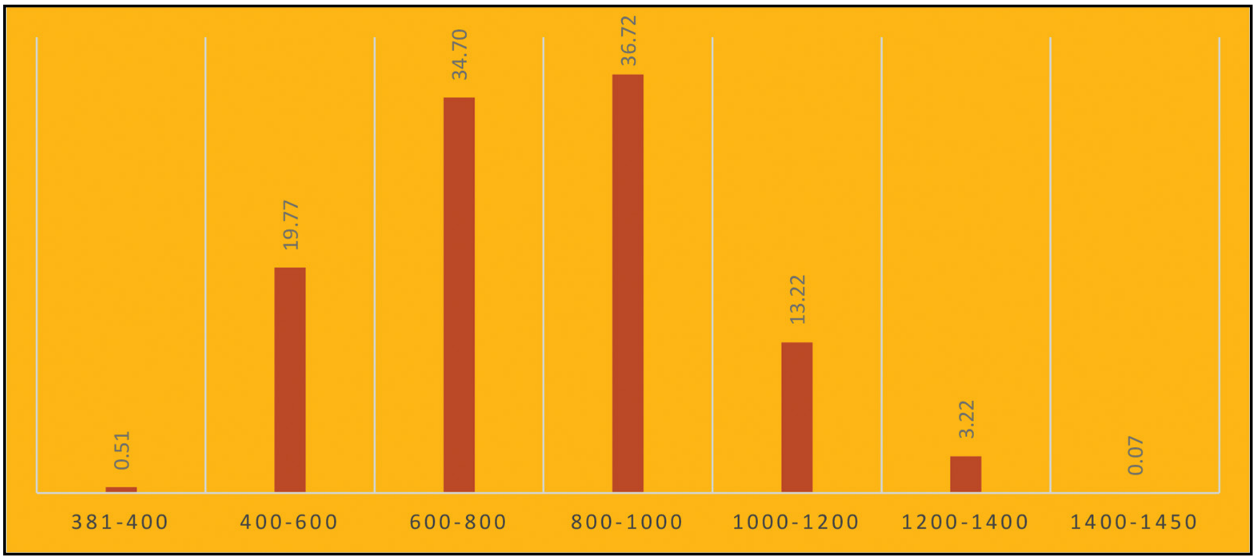

Fig. 4. Areas occupied by the hypsometric steps in the Basca Rozilei basin (km^2).

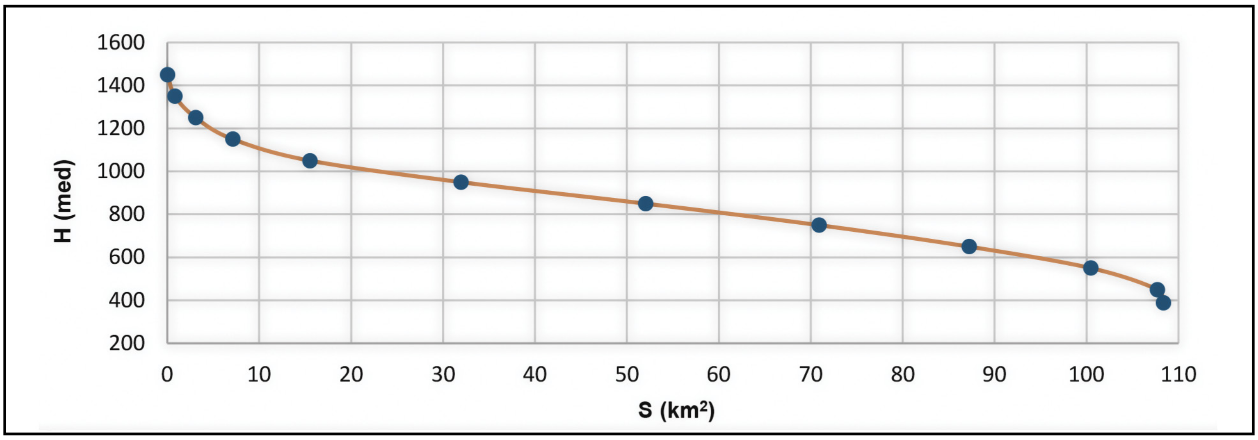

Fig. 5. Cumulative histographic curve; H - altitude; S - surface.

4.3. Geography

In regards with the geographical features, the relief is one of the outstanding factors that contribute to the modifications of the geomorphological processes. Through its quantitative components (slopes, fragmentation, as well as the length and exposure of the slopes) the relief imposes the intensity and efficiency of the current geomorphological processes (Popescu, 1990 *in* Ene, 2004).

The slope is an important indicator in geomorphological analysis. The choice of slope classes is related to the object in view and the studied relief units. It represents one of the main determining parameters in the development of geomorphological processes for slopes and riverbeds. Slopes with an inclination between 0-3^0 (quasi-horizontal and slightly inclined) share 1.63% and cover 1.76 km^2 of the total surface of the Bâsca Rozilei basin, characterizing the river crossing area which is identified with the Bâsca Rozilei riverbed. Since it represents the smallest percentage of the whole area, the conclusion is that it is quasi-horizontal. The slope interval corresponding to the 3-7^0 interval is generally found in the surrounding riverbeds of the tributaries of Bâsca Rozilei river, with a percentage of 5.94% and 6.41 km^2 of the total area. The surfaces, with inclinations of 7-15^0 and a significant share (37.16% and 40.12 km^2) of the total surface, are frequently located on the slopes surrounding the Bâsca Rozilei Valley and its tributaries, illustrating the manifestation of present geomorphological processes. The most common phenomena which characterize these surfaces are rainfall and moderate surface erosion, shallow landslides, less intense runoff and drainage, except for areas where the vegetation cover has a low consistency. The surfaces with inclinations of 15-25^0 have the largest coverage (41.53% and 44.84 km^2), particularly characterizing a part of the slopes in the area. The main geomorphological current processes that influence these surfaces are erosion, ravines, strong torrentiality and landslides. Surfaces with slopes of over 25^0 have a lower coverage of 13.74% and 14.84 km^2

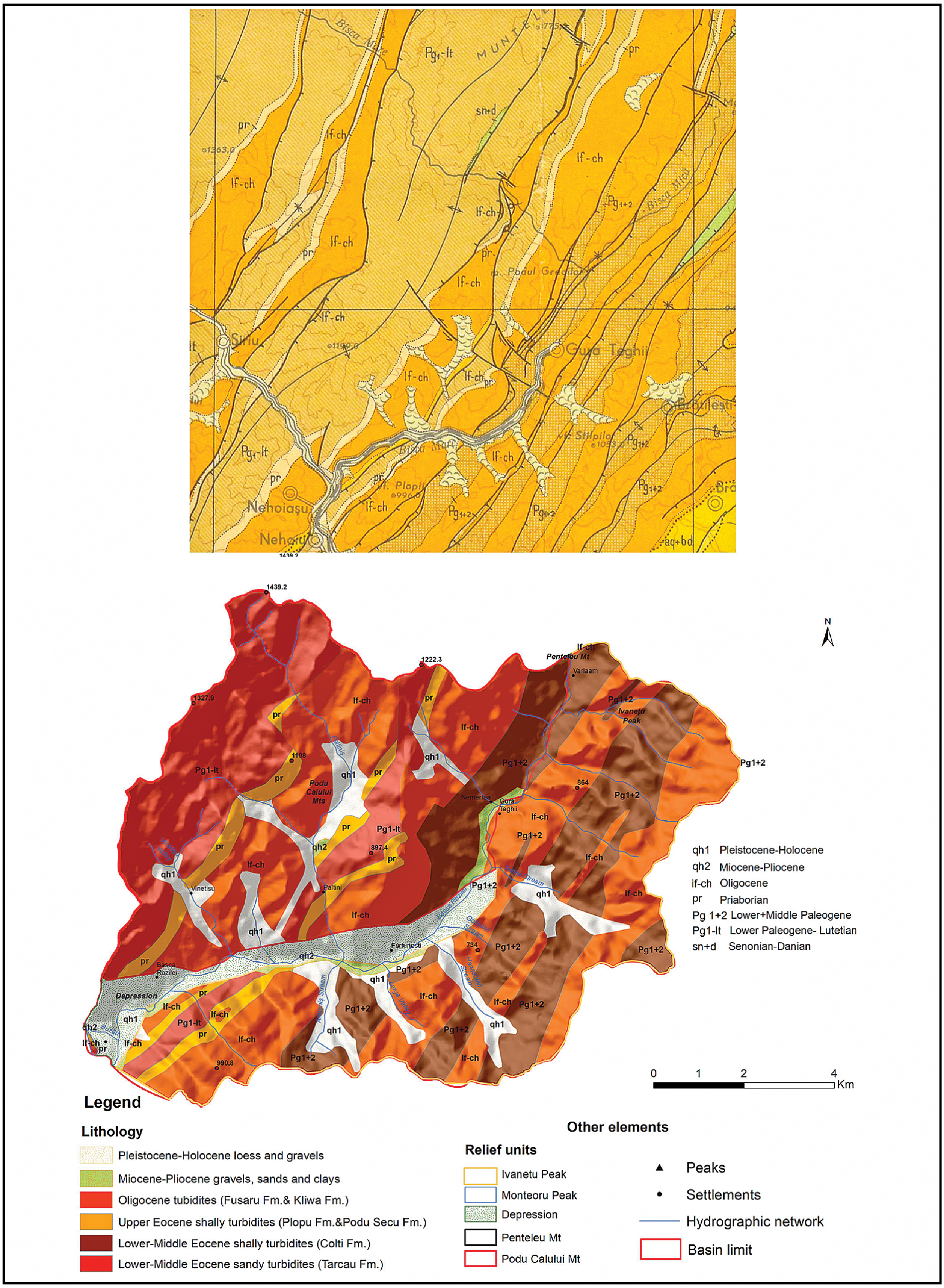

Fig. 6. *Up*: Geology of the area from Geological Map 1:200.000; *Down*: Lithology of the area comprising the Bâsca Rozilei basin (compiled after Dumitrescu *et al.*, 1968; Ştefănescu *et al.*,1993; Melinte-Dobrinescu *et al.*, 2017).

but a high predisposition to subaerial modeling, due to inconsistent vegetation (degraded meadows) where surface erosion, runoff, ravaging and torrentiality are accelerated. Superficial landslides occur on the slopes covered with grassy vegetation, where the lithological substrate is made of impermeable rocks (clays, marls). Along the deforested slopes, at the river banks, collapsing and rolling phenomena also occur (Table 2 and Fig. 7).

In conclusion, the less steep slopes are predominantly found on the bed of the Bâsca Rozilei river and its tributaries. Characterized by stability, the current geomorphological processes are few and low in intensity. Slopes with inclinations between 7-25^0, which ensure and accelerate the waterflow on slopes and torrential channels as well as on gravitational displacements, hold about 79% of the basin surface, thus being the main geomorphological factor that controls morphodynamic processes. The highest slopes (over 25^0) define areas mainly covered, by lithological point of view, by massive Paleogene sandstones; hence, the structural steep slopes, the peak slopes, and also the torrent slopes and the detachment ravines of the deep landslides dominate.

Tabel 2. Areas occupied by slope intervals (km^2).

Relief units	0 -3%	3 -7%	7-15%	15-25%	> 25%
Depression	0.68	0.88	2.81	1.58	0.75
Ivănețu Peak	0.47	2.99	18.42	20.34	6.71
Mt. Penteleu	0.00	0.00	0.00	0.00	0.00
Mts. Podu Calului	0.59	2.44	18.83	22.92	7.37
Monteoru Peak	0.00	0.01	0.02	0.02	0.00

4.4. Energy relief

In the Bâsca Rozilei hydrographic basin, this parameter varies between 13-451 m/km^2 (Fig. 8), with the average value of 245.62 m/km^2. Compared to this value, the standard deviation is 84.06 m/km^2. The absolute maximum value (451 m/km^2 is registered in the Podu Calului Mts., on Corbului Peak, where the slope inclination over 25^0 is also indicated.

4.5. Fragmentation density

The analysis of the relief fragmentation density (indicating the surface fragmentation of the relief) is performed by calculating the length of all negative landforms created by the geomorphological processes such as erosion on a certain surface and their relation to it. The mathematical expression of the ratio between the landform length created by erosion and the studied surface, becomes one of the basic indicators in defining the morphodynamical potential of the relief (Posea & Cioacă, 2003).

The density parameter of the relief fragmentation was calculated on the surface of the Bâsca Rozilei morpho-hydrographic basin by using the standard surface of 1 km^2. It is ascertained that the lowest values of fragmentation density, i.e., <1, are found in the outer and higher part of the basin, occupying 7.46% and 9.8 km^2 of the total surface, and the maximum values are concentrated on the slopes that accompany the creek valleys. The 4-5 km/km^2 interval that sums up the largest area (22.5 km^2), occupies 17.17% of the total area of the basin. The values included in this interval belong mainly to the river slopes characterized by the presence of torrential valleys. The fragmentation density in the Bâsca Rozilei basin is variable, with a highest surface fragmentation correspond to 3-4, while the smallest surface is linked to high density values (Table 3 and Fig. 9).

Extensive surfaces with horizontal fragmentation over 3 km/km^2 characterize the entire Bâsca Rozilei basin, covering 68% of the basin surface (Table 3). For the whole basin, the average density is 3.60 km/km^2 with a standard deviation of 2.61. More than half of the surface of the basin has a density exceeding 3 km/km^2, an indicator of the hydrographic system progress that is mainly characterized by rivers with temporary runoffs and pronounced slopes.

5. DISCUSSION

The morpho-hydrographic basin is considered by Chorley (1962) a basic geomorphological unit, while Posea *et al.* (1976) considered it to be the most general geomorphological evolutionary system, the basic cell of a network that covers and dominates most of the land areas. In the geographical literature, it is described as one of the typical systems that exist in the nature, as a result of the spatial-temporal interaction between the matter and energy flows, which are in a permanent dynamic relation and have great variability (active factors) and topographic surface (relief, geology, vegetation and soil) as passive factors (Comănescu, 2004). The morphometric model of the drainage is generated using a mathematical procedure which analyzes the hydrographic basins, quantifies the drainage network, highlights its degree of development and outlines the future directions in terms of evolution, being applied to many morpho-hydrometric basins in the Romanian Carpathian area (Grecu & Zăvoianu, 1997).

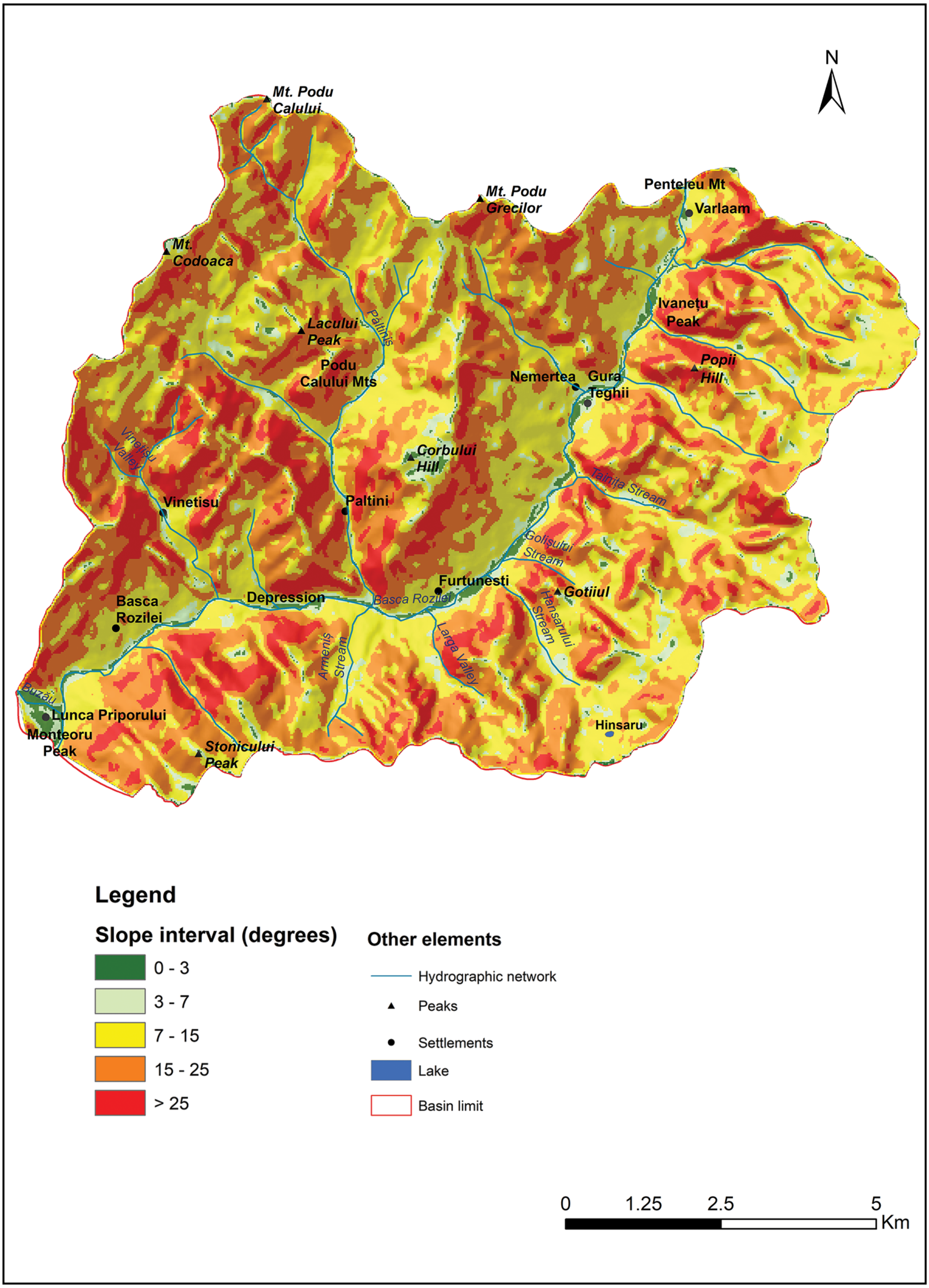

Fig. 7. Slope map of the area enclosing Bâsca Rozilei basin.

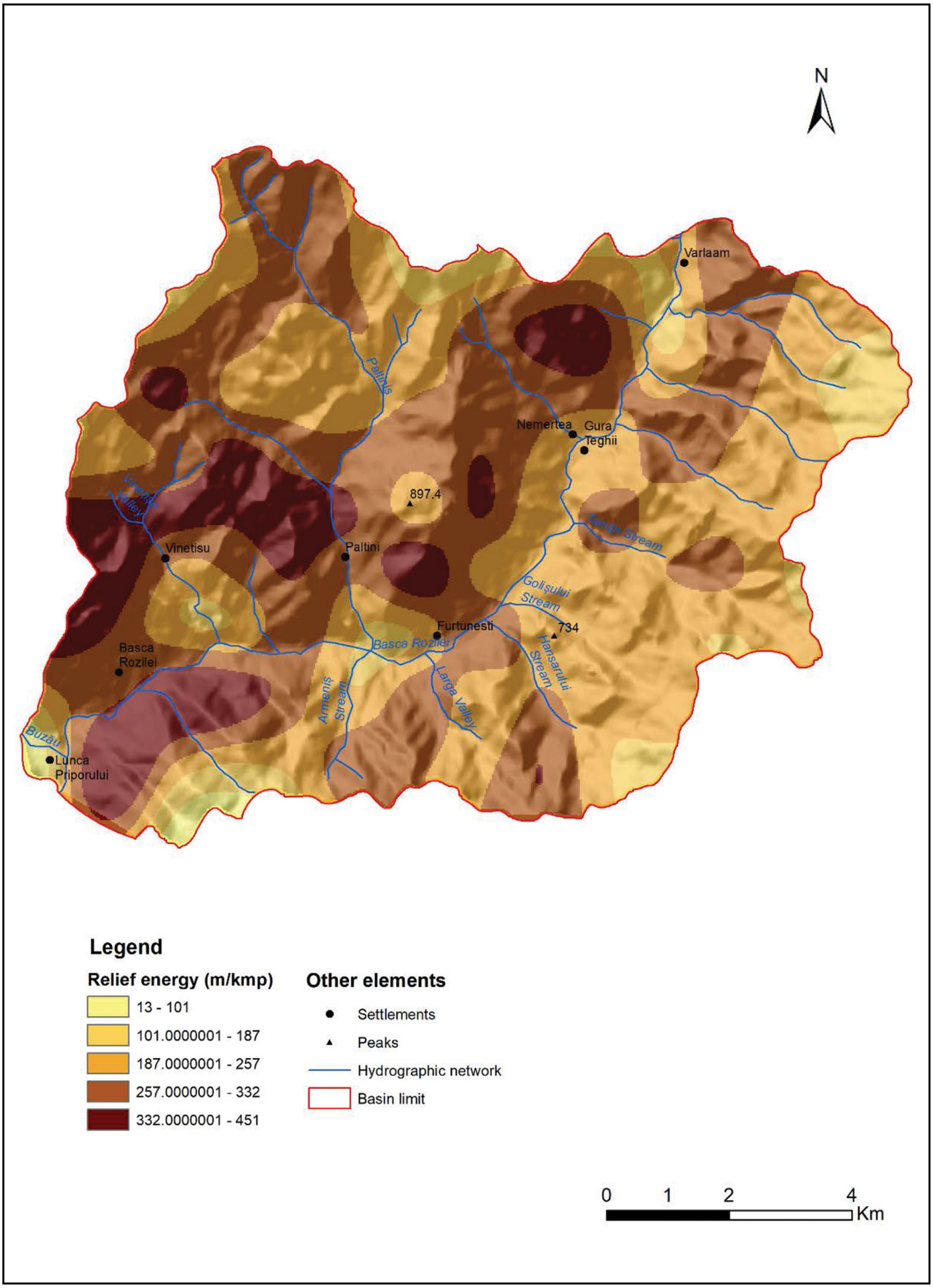

Fig. 8. Energy relief map of the area covered by Bâsca Rozilei basin.

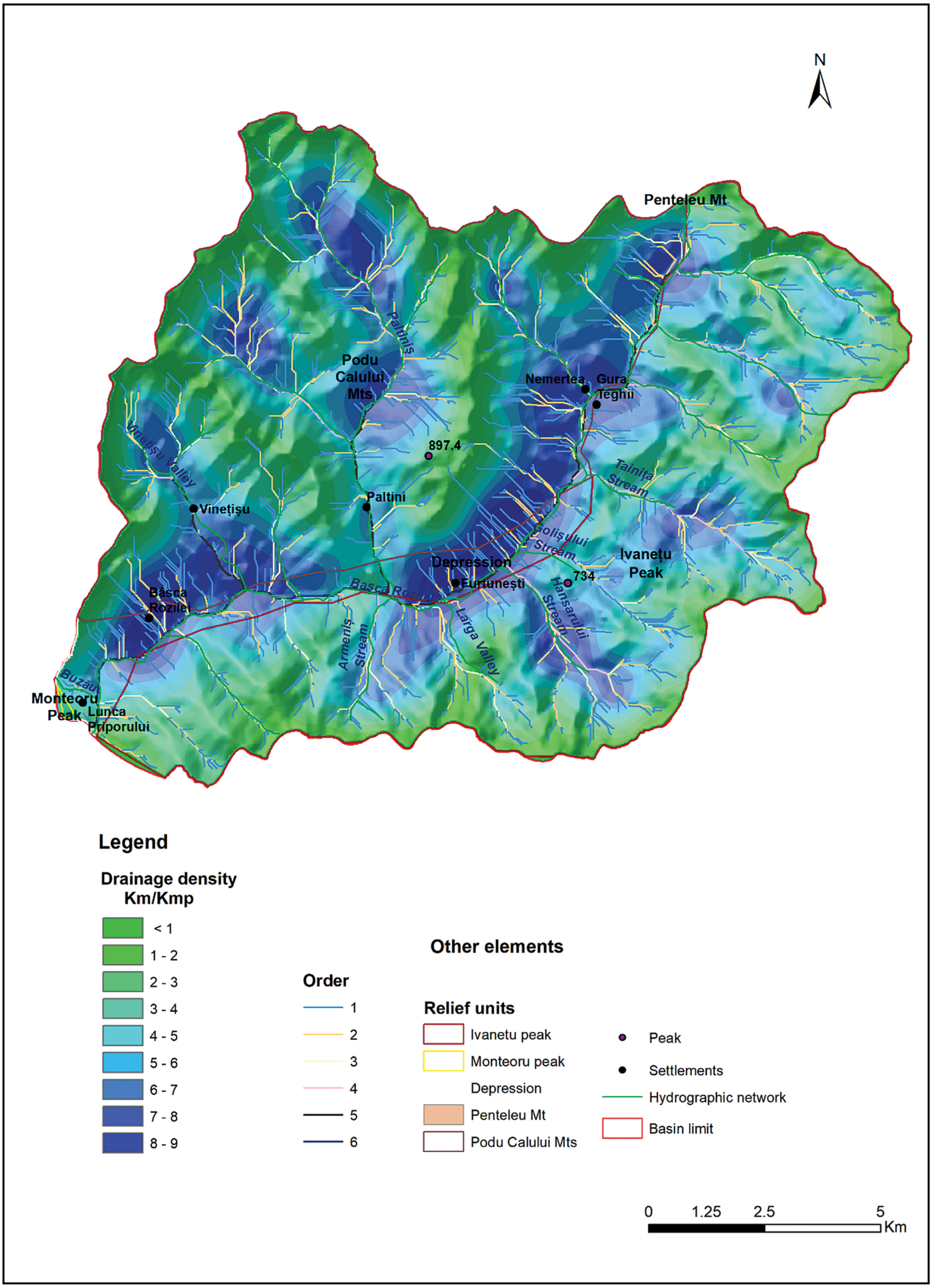

Fig. 9. Drainage density map in the Bâsca Rozilei Basin.

Table 3. Fragmentation density on the surface of the Bâsca Rozilei morpho-hydrographic basin at the standard surface of 1 km^2.

Minimum	Maximum	Average	Standard deviation
-0.99	9.98	3.60	2.61
Density	**Count**	**%**	**Surface (km^2)**
< 1	322941	7.46	9.8
1-2	444167	10.27	13.4
2-3	598522	13.83	18.1
3-4	638858	14.77	19.3
4-5	742896	17.17	22.5
5-6	653716	15.11	19.8
6-7	519545	12.01	15.7
7-8	286810	6.63	8.7
8-9.88	118751	2.74	3.6
Total	4326206	100.00	130.9

In the studied area, according to these calculations, the length of the river is 16.67 km. Elevation A (538 m) is the highest altitude in the Bâsca riverbed of our studied area, and Elevation B (384 m) is the lowest altitude in the Bâsca riverbed located at the confluence with the Buzău River. Therefore, the difference between the levels is 154 m and the sinuosity coefficient is 1.27 (Table 4).

The calculated circularity ratio $R_c = 4\pi \times F/P^2$, whose value is close to 1, indicates a circular shape of the hydrographic basin. According to these calculations, the Bâsca Rozilei basin has a slightly elongated shape that allows floods to form, generating a high level of erosion and transportation rates due to fast transferring speeds.

The number of segments for the Bâsca Rozilei basin was also calculated, according to the Horton-Strahler hierarchy (Tables 5 and 6). As a general feature, the number of river segments decreases simultaneously with the increasing level of magnitude, and the average length of segments increases together with the increasing order size. The largest share of lengths encompasses the first order of segments that hold 78.29% of the total number of river segments and 61.89% of the basin area.

The number of low order segments is much higher compared to the number of high order segments; 1st and 2nd order segments correspond to torrential flows, ravines and gullies in different stages of evolution. Segments of order 3, 4 and 5 correspond to a permanent hydrographic system. The total number of river segments from the basin is 1,829 (Tables 5-7). The length of successively increasing river segments indicates a decrease in geometric progression from 316.56 km, for the first order, to 6.61 km for the 6th order segment with a ratio of 2.22. By relating this number to the basin surface area (108.21 km^2), the segment frequency is 16.90/km^2.

Table 4. Hydrographic characteristics of the Bâsca Rozilei basin.

Characteristic	Symbol	Formula	Value	Unit
Lenght of the river	L_s		16670	m
Lenght in the straight line	L_d		13139	m
Sinuosity	K_s	$K_s=L_s/L_d$	1.27	
Elevation A	C_A		538	m
Elevation B	C_B		384	m
Altitude difference	D_h	$D_h=C_A-C_B$	154	m
Slope of the riverbed	P_a	$P_a = D_h \times 100/L_s$	0.92	%

The incipient torrentiality, which represents the ratio between the length of the 1st order segments and the surface of the basin, is $\Sigma L_1/S_b$ = 2.92 km/km². The total torrentiality, which is calculated as the ratio between the sum of the lengths of the 1st and 2nd order segments and the basin surface, is $\Sigma(L_1 + L_2)/S_b$ = 3.89 km/km². The average density of the riverbed length, which represents the ratio between the sum of the lengths of all segments and the surface of the basin, is $\Sigma(L_1 + \ldots + L_5)/S_b$ = 4.73 km/ km².

The calculated values for these indicators in the Bâsca Rozilei basin prove the high frequency of active torrential events. They also prove the intense fragmentation of the relief and the torrential character of the hydrographic system:

Table 5. The share of river number segments for the Bâsca Rozilei basin, in the size order corresponding to the Horton-Strahler hierarchy.

Order	Number of segments	%
1	1432	78.29
2	311	17
3	66	3.61
4	16	0.88
5	3	0.16
6	1	0.06
Total	**1829**	**100**

Table 6. The share of the river segments lengths for the Bâsca Rozilei basin, in the size order corresponding to the Horton-Strahler hierarchy.

Order	Length (km)	%
1	316.56	61.89
2	104.32	20.40
3	44.03	8.61
4	24.86	4.86
5	15.1	2.95
6	6.61	1.29
Total	**511.48**	**100**

Table 7. Length of river segments for the Bâsca Rozilei basin, in the size order (from 1 to 6) corresponding to the Horton-Strahler hierarchy.

Summed lengths/ Medium lengths		1	2	3	4	5	6	%	Ratio R_L/r_l	Total
L	m	316.56	104.32	44.03	24.86	15.1	6.61	102.85	2.22	511.48
	c	367.52	165.46	74.5	33.54	15.1	6.8			
l	m	0.22	0.34	0.67	1.55	5.03	6.61	158.11	2.08	14.42
	c	0.27	0.56	1.17	2.42	5.03	10.45			

According to the analyzed data plotted on the Horton-Strahler hierarchy, the size order of the hydrographic basin is given by the highest value, which in the Bâsca Rozilei basin is 6 (Fig. 10).

The drainage model for Bâsca Rozilei was represented graphically (Fig. 11), by considering the number of segments of the basin, their lengths and their hierarchy. The graphical representation of the functions $N(i)$, $L_{(i)}$ and $l_{(i)}$, where i = 1,2 ..., was made through semilogarithmic coordinates: X axis – indicates the size orders of the river segments, and the Y axis – indicates the number of river segments (N), the length (L), as well as the average river segments length (l). The points on the graph are the measured values, and the lines that define each progression have been drawn in order to pass through as many measured points (values) as possible. The top of the triangle located at the intersection of the graphs $L_{(i)}$ and $l_{(i)}$ represents the size order of the basin (Fig. 11).

6. CONCLUSIONS

The drainage model analyzed for the Bâsca Rozilei basin is the result of a long evolution process, not yet finalized, where the morphodynamical events were influenced by several active and passive factors, which can be potential factors for triggering imbalances (Table 8). According to the principle of interdependence between system components and mutual conditioning, the current modeling of the Bâsca Rozilei hydrographic basin is directly influenced by the connection between the energy flow and the matter exchange with the environment. This finding is in agreement with previous works in the area (Minea, 2013).

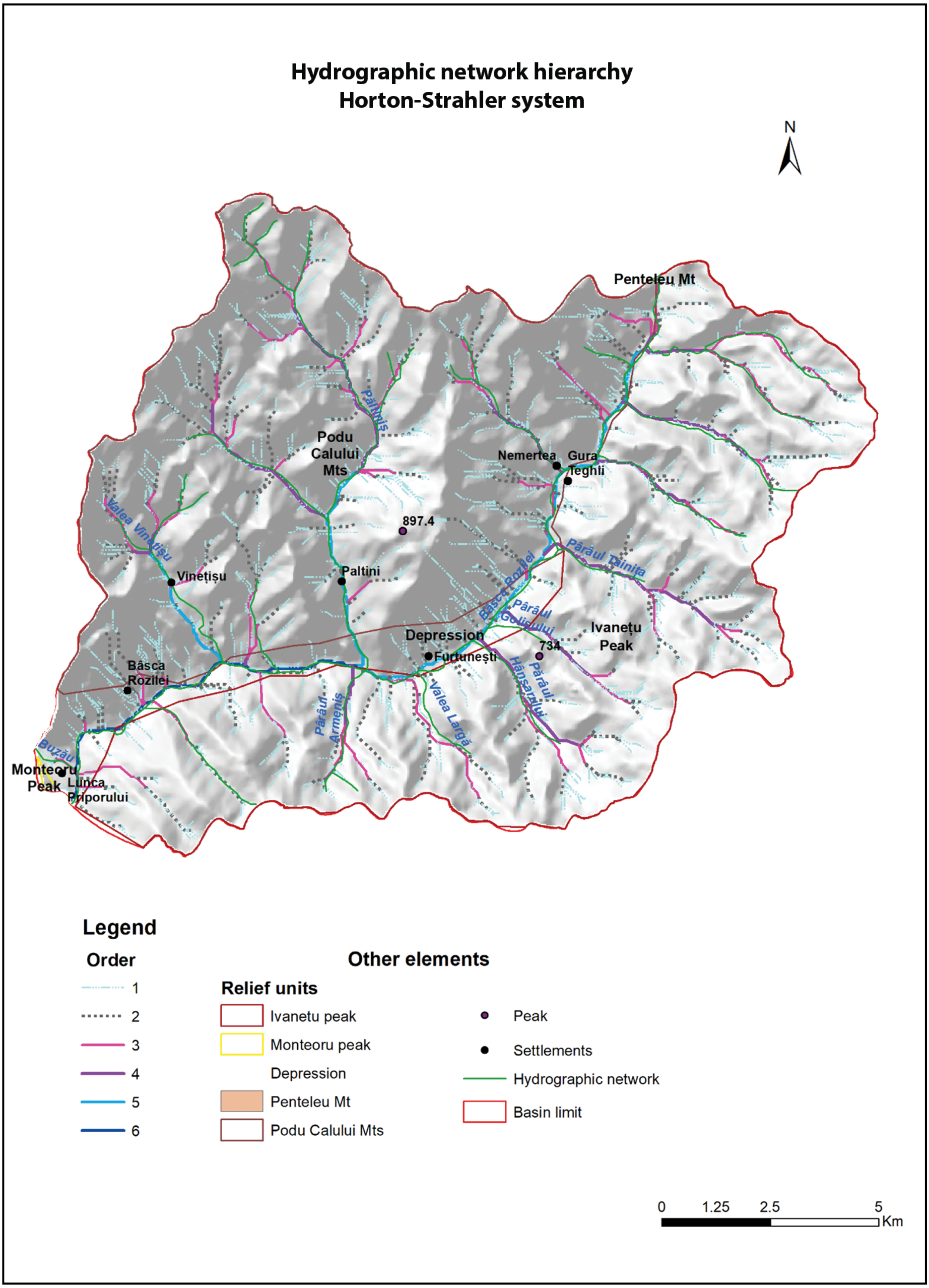

Fig. 10. Bâsca Rozilei hydrographic basin hierarchy.

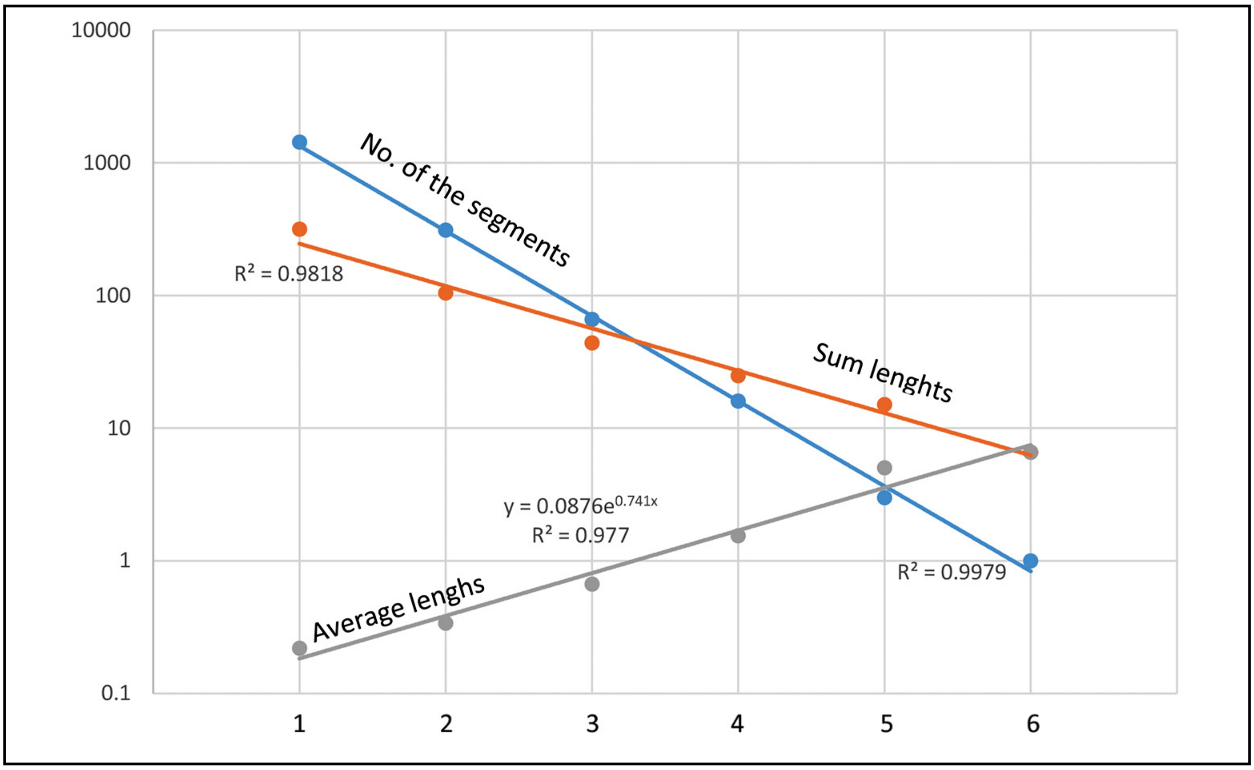

Fig. 11. Morphometric drainage model for the Bâsca Rozilei basin.

Table 8. Number of river segments for the Bâsca Rozilei basin in size order.

Measured/ Studied	N_1	N_2	N_3	N_4	N_5	N_6	Total N	R_c	Degree of achievement (%)
M	1432	311	66	16	3	1	1829	4.35	68.97
S	1352.85	287.1	69.6	13.05	3	0.69			

Bâsca Rozilei is a 6th order-type basin, with a slightly elongated shape, developed asymmetrically to the west, covering an area of 108.21 km². The degree of development of the basin in terms of the total length of river segments is 102.85%. The morphometric analysis of the Bâsca Rozilei basin shows that the degree of development regarding the total number of river segments is 68.97%. This indicates a torrential basin which has not yet reached the stage of maturity, still active in its evolution.

According to the hierarchy of the hydrographic system, the resulted 6 size order for the Bâsca Rozilei basin reflects the high degree of branching of the hydrographic system and its torrential character. The actual relief modeling processes depend on surface and deep erosions, which are associated with landslides and muddy flows in the areas with clays and marls cropping out.

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