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THE MORPHOMETRIC ASPECTS OF THE UZ HYDROGRAPHIC BASIN

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Abstract. The hydrographic basin of the river Uz is situated in the eastern part of Romania, with a total surface of 475 km^2. It is asymmetric, elongated and with a total perimeter of 134.26 km. The river Uz is a right tributary of the river Trotuș and has a length of 46 km. It has a SW-EN orientation. On the river Uz can be found the Poiana Uzului pond built between 1965 and 1972, which has entered production in 1974. On the Izvorul Negru brook, tributary of the river Uz, following a landslide that blocked the riverbed, arose the Bălătău natural lake. The river Uz and its tributaries brought a big contribution to the landscape fragmentation and to the creation of its current energy. The hydrographic Uz basin has numerous relief forms (mountains with medium and small height, hills and depressions) with an average altitude of 982.345 m. The declivity of the slopes varies between 5˚ and 50˚, the meadows sectors between 1˚ and 3˚, while the interfluves and the bridge terraces between 0˚ and 6˚. From a geological standpoint, in the Uz hydrographic basin can be distinguished the Cretaceous and Paleogene flysch in the mountainous sector, while in the depression sector can be distinguished the Neogene zone. For the realization of this study was used as a spatial database the DTM with a scale of 1:5000 and with a zoom of 3 m and the SRTM with a scale of 1:25000, corresponding to the Uz basin. The methods being used were GIS, the graphic method, the analytical method, etc. The study was performed taking into consideration the necessity of an analysis which highlights the morphometric aspects of the Uz hydrographic basin.

Keywords: Altitude, asymmetry coefficient, morphography, slope, relief units

1. Introduction

The first extensive Romanian paper from the field of morphometry was elaborated by Ion Zăvoianu (*Morfometria bazinelor hidrografice*) (1978), published in two versions (*Morphometry of drainage basins, 1985*). Relevant are also the papers written by: *Enea et al., 2011; Enea et al., 2015; Ichim and Rădoane, 1986; Ichim et al., 1989; Gâştescu and Driga, 2008; Gheorghe and Dăscăliţa, 2010; Grecu and Zăvoianu, 1997; Howard and Macklin, 1999; Loghin, 2009; Mihu-Pintilie and Romanescu, 2012; Minea, 2012; Rădoane et al., 2001; Romanescu, 1996, 2004, 2005a,b,c, 2009; Romanescu and Jigău, 1998; Romanescu and Stoleriu, 2010; Verger, 1976.*

The terrain configuration, its structured and its geological make-up, as well as the climatic conditions which influenced the evolution in time of the hydrographic basins has led to a great variability of the basins' forms with impact over the birth and transmission of the flood waves (*Romanescu, 2004*). In order to highlight the occurrence and evolution peculiarities for the hydrological phenomena, it is necessary, besides knowing the physical

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and geographical conditions, to know also the morphometric characteristics specific to each basin (*Romanescu, 2004*). After the establishment of Hydro-meteorological General Directorate (1951), which afterwards had other names, were laid the foundations for the modern development of hydrology whose impact were seen in the area of the Uz hydrographic basin. In 1967 began the first systematic observation of the Uz Valley, followed afterwards by Cremenea and Dărmănești stations (1976) (Table 1). The current study aims at highlighting the morphometric peculiarities of the Uz hydrographic basin and of its hydrographic network, thus establishing the physical and geographical features of the basin that contribute to its supply.

Table 1 : Morphometric features of the hydrometric station from Uz hydrographic basin

River	Station	Distance from the confluence (km)	Catchment basin		Establishment date	Distance from spring (km)
			Surface (km^2)	Altitude (m)		
UZ	VALEA UZULUI	22	150	1070	1967	28
UZ	CREMENEA	16	337	1070	1976	34
UZ	DĂRMĂNEȘTI	7	404	975	1976	43

2. Regional setting

The Uz hydrographic basin is part of the Trotuș hydrographic basin. The river Uz, being one of its important right tributaries, has its springs in the Ciucului Mountains and has its confluence point with the river Trotuș in Dărmănești depression zone. From a mathematical standpoint the surface of the basin is situated between 26˚00'16", 26˚30'56" eastern longitude and 46˚08'44", 46˚23'27" northern latitude (Figure 1).

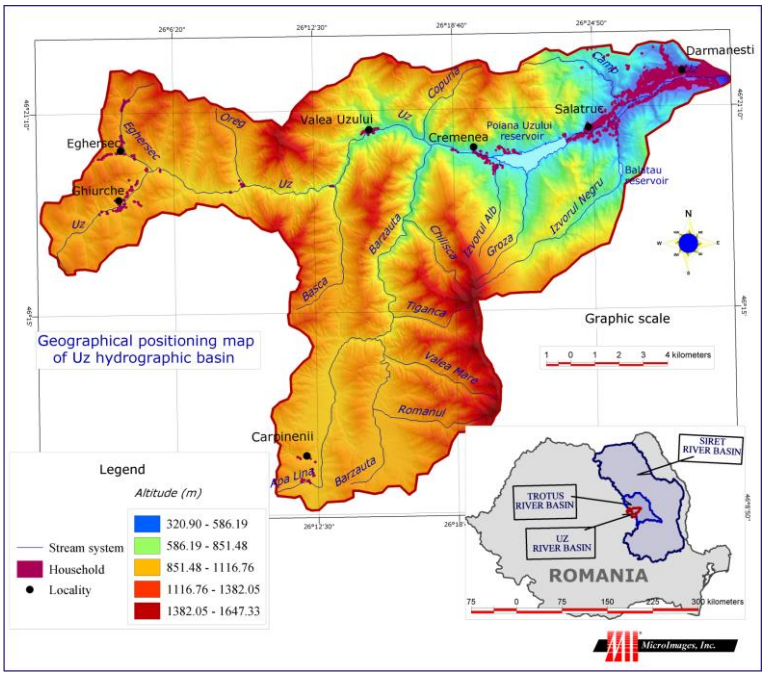

Figure 1: The geographical positioning of the Uz hydrographic basin

The positioning in the central-eastern part of the Oriental Carpathians situates the hydrographic basin in the middle of a continental temperate zone where the climatic conditions favors a seasonal cycle with big timely variations and with significant torrential character of the rainfall. The variation of the air temperature in the Uz hydrographic basin places these conditions in those related to subalpine climate visible on the highest peaks, to slope foehnisation, to sheltering or thermal inversion in valleys and depressions. The hydrographic network of the basin has a high density. The river Uz and its tributaries had a great contribution to the landscape fragmentation and to the creation of its current energy. In reference to the characterization of the Uz river valley, one can affirm that from the spring onwards, the river collects a series of brooks on both sides of the Uz pitch, continuing its course towards East. After traversing a succession of anticlines and synclines of the external flysch until the „Ocoliș" point, the valley of the river is large, the relief has a depressionary aspect with tiered levels mountains. Downstream of Ocoliș basinet up close to Valea Uzului locality, the river enters the defile where tough sandstones of the Tarcău type flysch can be found. In the following, the river valley present gorge-like aspect, thus narrowing itself. There are highlighted numerous rapids which are succeeding at little intervals. Near Valea Uzului locality the riverbed gets in contact with the northern part of the Nemira Mountains and it widens. Then the river changes its direction towards the East and traverses a defile flanked on both sides by steep slopes. The zone is well afforested and depending on the alternating rock hardness, the river changes its direction from place to place. In the Valea Uzului basinet can be found the Valea Uzului pond which entered production in 1974 with the main aim of supplying water to downstream localities. In the Pivniceri area the river traverses a short defile in which is built the impoundment. Downstream of the dam, the river valley exits the mountainous region close to Sălătruc locality. It continues its course for a 13 km length until it flows into Trotuș (Dărmănești depression).

The hydrographic Uz basin has in its component a natural pond. The Bălătău lake in the Nemira Mountains at an altitude of 532 m at 4 km from Sălătruc locality. The lake belongs to the natural reservation from the Nemira Mountains. It has formed in 1883 following a landslide after a torrential rainfall. The displaced material blocked the Izvorul Negru riverbed resulting a natural lake with a total surface of 4.5 ha and a depth of 3 m. Currently, the lake is in a continuous process of clogging.

3. Materials and methods

For the morphometric analysis of the hydrographic basin spatial data was utilized: the topographic map at a scale of 1:25000, SRTM with a scale of 1:25000, DTM with a scale of 1:5000 with a zoom of 3 m, vectorial strata with the relief units limits, as well as morphometric data of the hydrometric stations situated on the river Uz, data which were taken from the Water Basin Administration of Siret Bacău. For the preparation of thematic maps, the TNT Mips and Arc GIS programs were used. The TNT Mips program permitted the use of "Watershed" function in order to obtain the ranking river map in Horton and Strahler systems. For data processing with the aim of obtaining morphometric parameters and chart construction, was used the Ms Excel program. The study of the morphometric aspect involve the quantitative description of the landscape, but also a methodological approach through the particularization of significant correlations between selected parameters and the geomorphological, geological indices.

4. Results and Discussions

The hydrographic Uz basin has a surface of 466.13 km^2 and has an average length of 11.95 km. The perimeter of the basin is set by the watershed which permits the delineation from the neighboring basins (134.26 km). The river Uz, is like the main collector, traverses the basin on a length of 46 km. It springs from an altitude of 1175.33 m and flows into Trotuș at an altitude of 320.43, with a hydraulic slope of 854.91 m. The moderate meandering coefficient is illustrated by the sinuosity coefficient with a value 1.18. The major riverbed for the longest part of the Uz river presents typical mountain features from a geological standpoint.

The asymmetry of the Uz basin is pronounced upstream of the Poiana Uzului pond. The most tributaries of the main collector are on the right side, there where the asymmetry is the most pronounced. The asymmetry coefficient highlights the distribution of the basin surface in relation to the drainage axis. The hydrographic Uz basin presents an asymmetry coefficient of 0.58. The quantitative evaluation of the basin form is important, because it makes a connection with a series of hydrologic processes. In an elongated basin, the tributaries have a dendritic position, and the floods have a lower amplitude, because they have lower erosion and transport power. By comparing the surface of the Uz basin (466.13 km^2) to the square of the real length of the river (46 km^2), one obtains the basin shape factor, i.e. 0.22. The shape of the main basin and sub-basin is elongated (Table 2).

From a hypsometric point of view the studied area falls under the category of the altitudinal gap between the values 319.21 m in the conjunction sector with Trotuș and 1647.18 m in the upper sector of the basin. The average altitude of the Uz basin is 69.54 m. The biggest part of the Uz basin has an altitudinal range in the hypsometric interval of 1050-1200 m and it is represented by the Gura Muntelui mountaintop, Gruiul Mare mountaintop, Bobișca plateau and Nemira Mountaintop, including the southern part of the Slănicului fields. The smallest part of the basin has an altitudinal range in the hypsometric interval of 300-500 m, nearby Dărmănești depression (Figure 2).

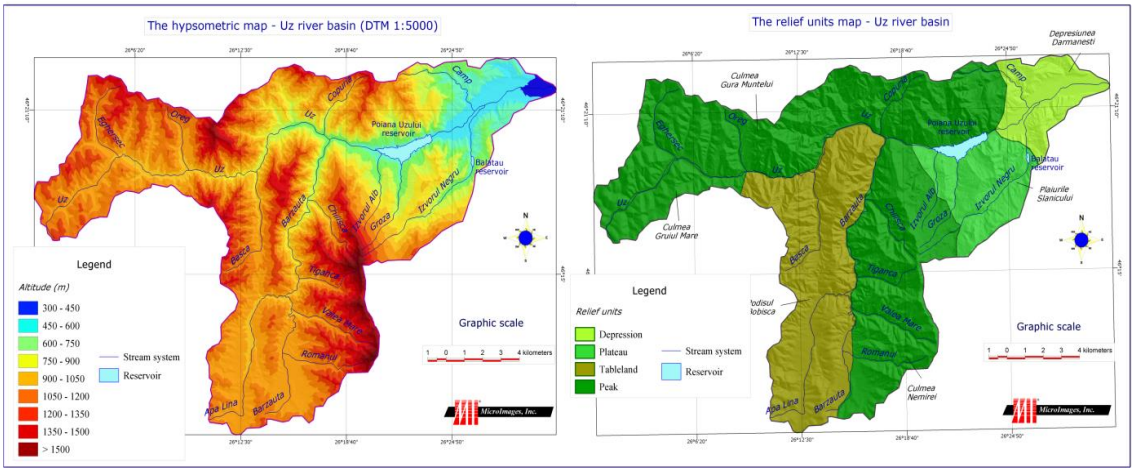

Figure 2: Hypsometry and relief units from Uz hydrographic basin

The declivity of the slopes reflects the geological make-up, the evolution steps and the nature of the past and present molding. In order to highlight the declivity variation of the surfaces from the Uz hydrographic basin, it was made a map with 10 value classes found between zero and above forty degrees (Figure 3).

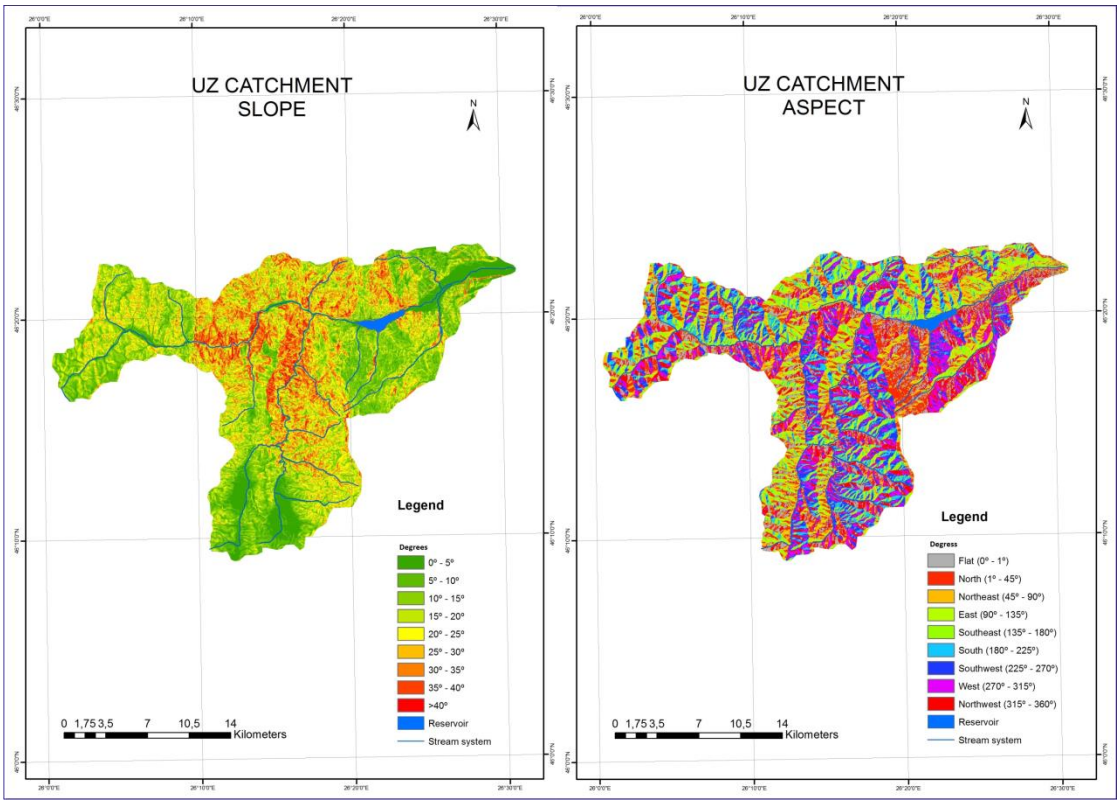

Figure 3: The slopes and their orientation in the Uz hydrographic basin

The slope declivity presents an external influence over the direction of the water drain. The main orientation direction of the slopes in relation with the cardinal points, determine the differentiation of the current molding processes. The slopes orientation in relation to the solar rays determine significant contrasts: the sharpest differences are between the sunny and the shady slopes. The duration of the sunstroke which conditions the sunlight incidence, besides the slope, imposes a heat balance regime of the surface and imposes the moisture content of the soil, the duration of the snow layer (Figure 3).

The distribution of the altitudinal layers derives from the relief morphometric features as an effect of evolution and fragmentation. The depth of the relief fragmentation (relief energy) is an important geomorphological indicator calculated based on the difference between the maximum and the minimum altitude inside a specific area. The energy of the relief can be considered a good indicator in the reflection of the torrential process intensity, but also for the evolution of the hydrographic network. The depth of the relief fragmentation was classified in five value intervals. The perimeters of the Dărmănești and Cremenea localities can be found in the relief energy class with the lowest values (0-200 m), followed by Sălătruc (200-300 m) and Valea Uzului (300-400 m) (Figure 4). The density of relief fragmentation contributes to the understanding of a basin's morphometry by evaluation the ratio between the length of hydrographic network and the surface of the basin. The highest percentage is represented by the Groza sub-basin (17%), Izvorul Alb (16%). The lowest percentage is represented by the Bâșca sub-basin (8%) (Figure 5).

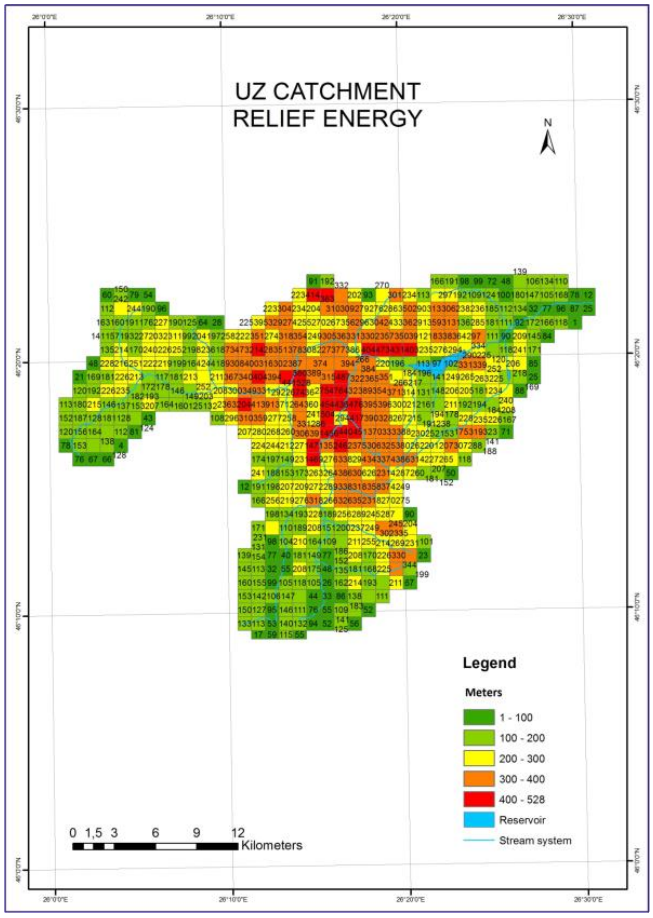

Figure 4: The energy of the relief from the Uz hydrographic basin

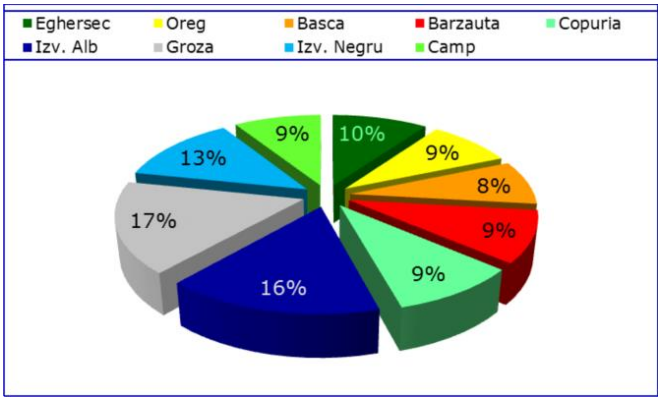

Figure 5: The relief fragmentation density from the main hydrographic sub-basins

The Uz hydrographic basin present nine sub-basins of the main tributaries: Eghersec, Oreg, Copuria, Câmp on the right side, Bâșca, Barzăuța, Izvorul Alb, Groza, Izvorul Negru on the left side. The surfaces are found in the intervals 11.55 km^2 (Oreg) and 152.3 km^2 (Bărzăuța) (Tabel 2). All the Uz river's tributaries present an important level difference (hydraulic slope) between the springs and the denudation point. The average slope of the

watershed is given by the ratio between the double of the height difference from the highest peak down to the river mouth, and the watershed perimeter. In the case of the Uz basin it results an average slope of 12.7 m/km (32˚). One can observe significant differences between the lowest zones with slopes under 20˚ and the highest slopes above 30˚. The highest hydraulic slope can be found on the Izvorul Negru river (1125.00 m), and the lowest on the Eghersec river (86.89 m). At the majority of the tributaries the hydraulic slopes are very high, between 518.73 and 1125.00 m which determine a very significant drain coefficient. As a result of this fact the hydrographic arteries contain important volumes of water which flow at important speeds, the core specifics being torrentiality.

Table 2: Morphometric and morphographic characteristics of the main sub-basins

Nr.crt.	River	L_r (km)	L_c (km)	H (m)		Hydraulic slope (m)	$H_{med\ Bh.}$ (m)	A (km^2)	F_f	K_s
				Am.	Av.					
0	1	2	3	4	5	6	7	8	9	10
1	**Eghersec**	6.93	4.98	1305.9	949.02	86.89	1155.1	17.66	0.37	1.39
2	**Oreg**	5.12	4.70	1183.3	881.17	302.17	1146.4	11.55	0.44	1.09
3	**Bâsca**	9.08	7.31	1130.1	814.01	316.06	1117.3	25.14	0.30	1.24
4	**Copuria**	5.86	5.34	1301.3	584.94	716.37	1019.5	10.06	0.29	1.10
5	**Bârzăuța**	25.77	19.73	1089.7	571.01	518.73	1091.8	152.3	0.23	1.31
6	**Izvorul Alb**	6.11	5.54	1184.0	503.87	680.09	868.39	12.74	0.34	1.10
7	**Groza**	8.39	6.67	1478.3	513.58	964.72	808.98	11.87	0.17	1.26
8	**Câmp**	7.96	6.18	974.0	392.33	581.68	654.72	16.25	0.26	1.29
9	**Izvorul Negru**	16.09	14.06	1506.2	381.16	1125.00	782.90	30.54	0.30	1.14

Lr – real river length; Lc – the projection of the real river length; H – altitude; Am. – upstream; Av. – downstream; Hmed Bh. – average altitude of the hydrographic basin; A – the surface of the hydrographic basin; Ff – shape factor; Ks – sinuosity coefficient

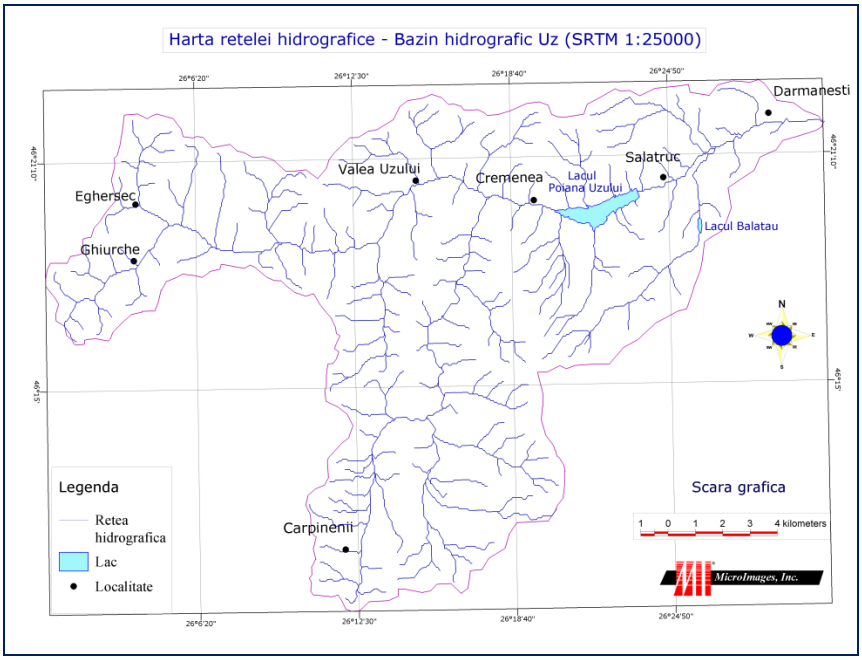

Figure 6: The drainage network of Uz hydrographic basin

A big part of the tributaries form at the confluence right angles which confer to the network a rectangular feature (Figure 6). The capacity of the river to collect water from rainfall and from the subterranean is conditioned by the density of the *drainage network*. The density of the *drainage network* is calculated on the map at a scale of 1:25000 and is about 1.07 km/km^2. The sinuosity coefficient of the river Uz tributaries does not exceed 1.5. Therefore one can talk about tributaries with a strong meandered riverbed (*Grecu, Comănescu, 1998*).In the Horton and Strahler classification systems were identified eight orders of magnitude depending on the value established by the river segment at the confluence point (Figure 7). The highest percentages are found among the rivers ranking VI and VIII (Figure 8).

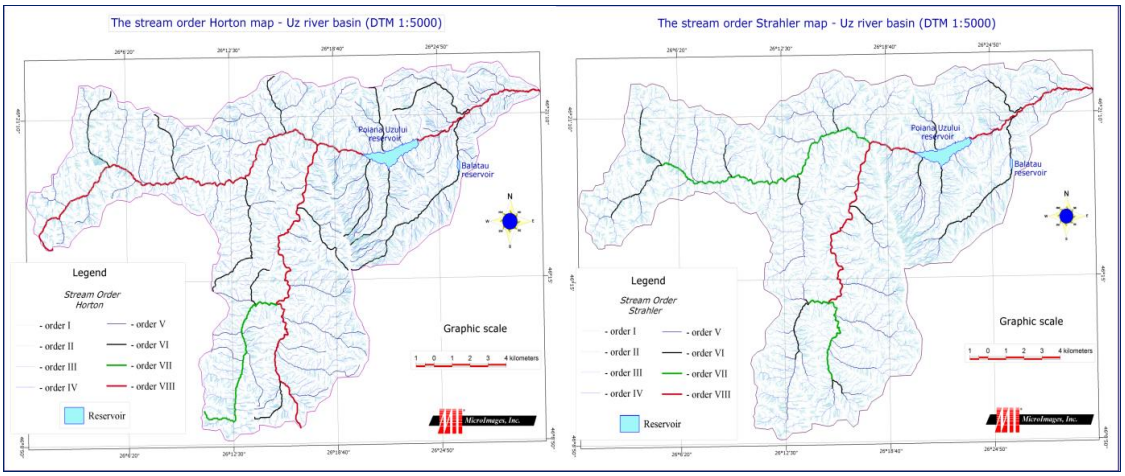

Figure 7: The ranking map of the hydrographic network in Horton-Strahler system

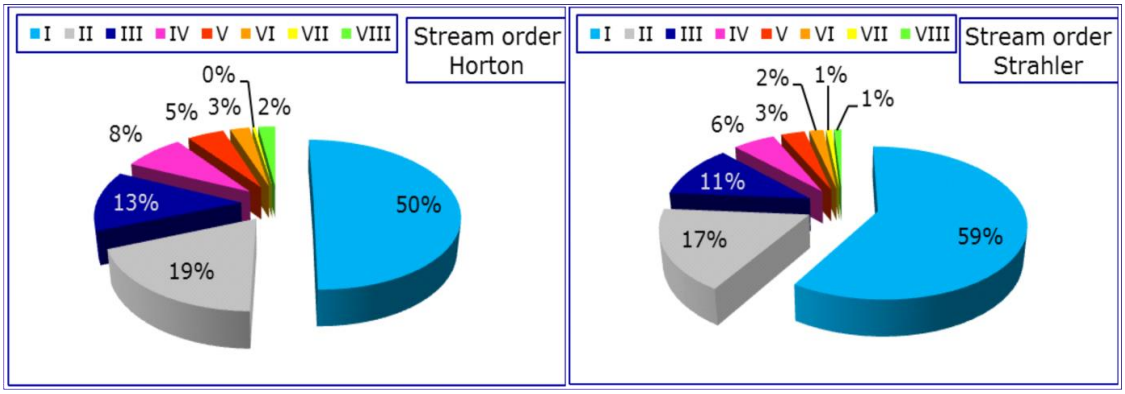

Figure 8: Horton-Strahler Stream Order Charts

5. Conclusions

The hydrographic Uz basin has SW-EN structural orientation. The perimeter of the basin given by the watershed perimeter is about 134.25 km. The basin sums up a surface of about 466.13 km^2 and a value for the shape factor of about 0.22, which highlights an elongated form. The real shape of the river Uz is about 46 km, and the sinuosity coefficient is over the unity (1.18). It present numerous and different forms of relief: mountains with medium height, hills and depressions, having an average height of 696, 54 m. The declivity of

the slopes varies between 5˚ and 50˚, the meadow sector between 1˚ and 3˚, the interfluves and the bridge terraces between 0˚ and 6˚.

The basin presents an asymmetry on the right side (0.58), these being one of the definitive features. This feature is a result of the evolution in time of the Uz valley, of the permanent adaptation of the valley at local tectonic structure. The tributary water intake is delayed in time. The floods have a bigger duration, while the amplitudes are reduced. The average basin slope is about 12.7 m/km (32˚).

The basin includes nine main sub-basins: Egersec, Oreg, Copuria şi Câmp on the right side, Bâsca, Bărzăuţa, Izvorul Alb, Groza, Izvorul Negru on the left side. All the basins present a hydraulic slope, elongated shapes and over the unity sinuosity coefficients. The density of the hydrographic network is about 20.12 km/km^2 at a scale of 1:5000. The main tributaries form right angles of confluence, the nature of the hydrographic basin being a rectangular one. In the Horton Strahler classification system, the river Uz ranks VIII. Based on these classification systems the lowest percentages are represented by the rivers ranking VI and VIII, and the highest percentages are represented by the rivers ranking I. The study of the Uz hydrographic basin's morphometric aspects presents an importance for the elaboration of the hydrological parameters and putting them into practice.

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