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THE ANALYSIS OF THE RELIEF FRAGMENTATION FEATURES WITHIN THE BĂLĂCIŢA PIEDMONT

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Abstract
Within the Bălăciţa Piedmont there are to be distinguished two areas with specific features, which correspond to the Danube catchment and to the Jiu drainage area. Both in the case of the drainage density, as well as in that of the relief energy, the distribution of the value classes correlated with the two catchments underlines major differences, but also certain resemblances, situation which is explained by the evolution time, the base level, the flow direction in relation with the structure and the lithological and climatic homogeneity.
The analysis of the data enabled the quantification of the relief energy and of the drainage density within the Bălăciţa Piedmont, as well as the correlation of the two parameters in report to the main catchments. The computation and representation methods for the two indicators of the relief fragmentation (i.e. the depth and the density) allowed for a quantitative interpretation (the identification of five value classes), as well as for a spatial interpretation (the grouping of the values depending on the two collecting rivers: the Danube and the Jiu). The aggregation of the influence factors on the two main drainage areas is mostly due to the fact that the Danube catchment extended its area in the detriment of the Jiu catchment, the three more important tributaries (the Blahniţa, the Drincea and the Desnăţui) catching sectors within the upper course of the tributaries of the Jiu.
The analysis of the relief fragmentation within the Bălăciţa Piedmont shows that this unit is on different evolution stages. The complexity of the fragmentation is closely connected to the maturity degree of the valleys and to the morphogenetic complexes imposed by the paleogeographical evolution.

Keywords: *catchment, relief energy, drainage density, correlation coefficient, the Bălăciţa Piedmont*

Rezumat
Analiza particularităţilor fragmentării reliefului în PiemontulBălăciţei. În Piemontul Bălăciţei se disting două areale cu particularităţi diferite, aferente bazinului hidrografic al Dunării şi bazinului Jiului. Distribuţia claselor de valori corespunzătoare celor două arii de drenaj, atât în cazul densităţii, cât şi în cel al adâncimii fragmentării, reliefează diferenţe majore, dar şi unele similitudini, fapt datorat timpului de evoluţie, nivelului de bază, direcţiei de scurgere faţă de structură şi omogenităţii litologice şi climatice.
Analiza datelor a permis cuantificarea energiei reliefului şi a densităţii fragmentării reliefului din Piemontului Bălăciţei şi corelarea celor doi parametrii în funcţie de bazinele hidrografice principale. Metodele de calcul şi reprezentare a celor doi indicatori ai fragmentării reliefului au permis atât o interpretare cantitativă (identificarea a cinci clase de valori), cât şi una spaţială (gruparea valorilor în funcţie de cele două râuri colectoare: Jiu şi Dunăre). Gruparea factorilor de influenţă, pe cele două bazine hidrografice principale se datorează în principal faptului că bazinul Dunării s-a extins în detrimentul bazinului Jiului, cei trei afluenti mai importanti - Blahniţa, Drincea şi Desnăţuiul captând sectoare din cursul superior al afluenţilor Jiului.
Din analiza fragmentării reliefului Piemontului Bălăciţei rezultă că acesta se află în diferite stadii de evoluţie, complexitatea fragmentării fiind strâns legată de gradul de maturitate a văilor şi de complexele morfogenetice impuse de evoluţia paleogeografică.

Cuvinte-cheie: *bazin hidrografic, adâncimea fragmentării, densitatea fragmentării, coeficient de corelaţie, Piemontul Bălăciţei*

INTRODUCTION

The Bălăciţa Piedmont represented the study object for both geographers and geologists and, thus, a series of information was recorded in papers that were particularly dedicated to this sub-unit of the Getic Piedmont, or in works that referred to more extended regions. Among these authors, we mention Roşu Al. (1959), Ghenea C. et al. (1963), Badea L. (1970) Badea L. et al. (1974, 1976), Posea Gr. et al. (1974), Cucu V. et al. (1980), Stroe R. et al. (1980, 1983).

The study of this region is minutely resumed in 1992, in the work entitled *Geografia României*, volume IV, where the natural background, the human geography elements concerning the population and the settlements, as well as the economic potential of the Bălăciţa Piedmont are analysed. Within this study, the denomination used for the researched area is "Bălăciţa Piedmont" (Rom. "Piemontul Bălăciţei"), as a component of the Getic Piedmont. The most recent studies that deal with this geographical unit belong to Stroe R. (2003), Enciu P. (2007), Enache C. (2008) and Boengiu S. (2008).

The river network in the Bălăciţa Piedmont is distributed on two drainage basins: of the Danube and of the Jiu. The interfluve between the two catchments divides the piedmont into two parts that are approximately equal and symmetrical in form. The geological conditions, although apparently simple, the generally divergent character, the dominance of the autochthonous rivers, except for the Motru and the Jiu, give the original note in the organization and the evolution of the hydrographical network within the Bălăcița Piedmont (Boengiu S. 2002).

The hydrographical network that is tributary to the Jiu has west – east orientation, the main tributaries being on the right; towards the springs, the slope of the thalweg ascends rapidly – in the area of origin being 3 – 6 gullies that come together to form the main watercourse. The valleys are asymmetrical, the slopes on the left (the north) being much steeper and more linear, while those in the right (the south) are generally convex and show gentler slopes. At the same time, the rivers are quite long, 20 – 70 kilometres, showing narrow valleys in the upper sector, but also wide floodplains at least on half of the distance covered.

All these characteristics show the fact that the watercourses situated north of the watershed between the catchments of the Jiu and of the Danube appeared on the initial surface that was cut by the rivers that regressively advanced from the Jiu towards the west, as the Jiu deepened its riverbed, but they were also influenced by the structure of the fundament in which the strata incline towards north-east, making easier the appearance of the right side tributaries. The main factor that led to the configuration described above and to the slopes of the valleys, which are steeper towards north, is represented by the general inclination of the piedmont that, as shown by the maximum heights on the interfluves, descends from the north-west (330 – 350 meters) towards the south-east (150 – 200 meters).

The watercourses that head from the Piedmont towards the Danube show a west – east or north-west – south-east orientation in the upper sector, they gradually gravitate towards south and, before leaving the piedmont or at its limit, they bend towards west. There can be noticed a resemblance between the course of the Danube, which firstly bends towards west at Ostrovul Corbului, and its tributaries, fact which underlines the dependency of these watercourses on the route followed by the Danube (Boengiu S. 2002).

The analysis of the cross-sections and the hypsometrical map shows the permanent movement of the Blahnița and of the Drincea towards east, the western slope being less inclined than the eastern one, which is steep, forming the scarp of a cuesta. All the tributaries are consequent to the geological structure and come from the west, on the eastern slope in the upper and middle sector being only much younger gullies.

MATERIALS AND METHODS

The map of the relief drainage density and that of the relief energy were achieved on the basis of the topographical maps, scale 1:25,000, through the method of the cartograms; a geographical database was realised by using the ArcGIS 9.2 software and the entire hydrographical network was vectorised, starting with the 1st order in the Horton-Strahler system. Taking into account the significant leaps within the series of values and the morphometrical aspects of the study area, there were chosen five classes. The repartition of the surfaces and the share of the value classes were graphically represented and, in order to realise a unitary, comparative analysis, the classes of the drainage density and relief energy were also computed and represented in intervals with entire values.

Methods specific to the statistical analysis allowed for the observance of the parameters of the drainage density, relief energy, as well as the correlation between the two parameters.

The field observations were conducted in order to clarify or to add certain elements that did not appear on the maps.

DISCUSSIONS AND RESULTS

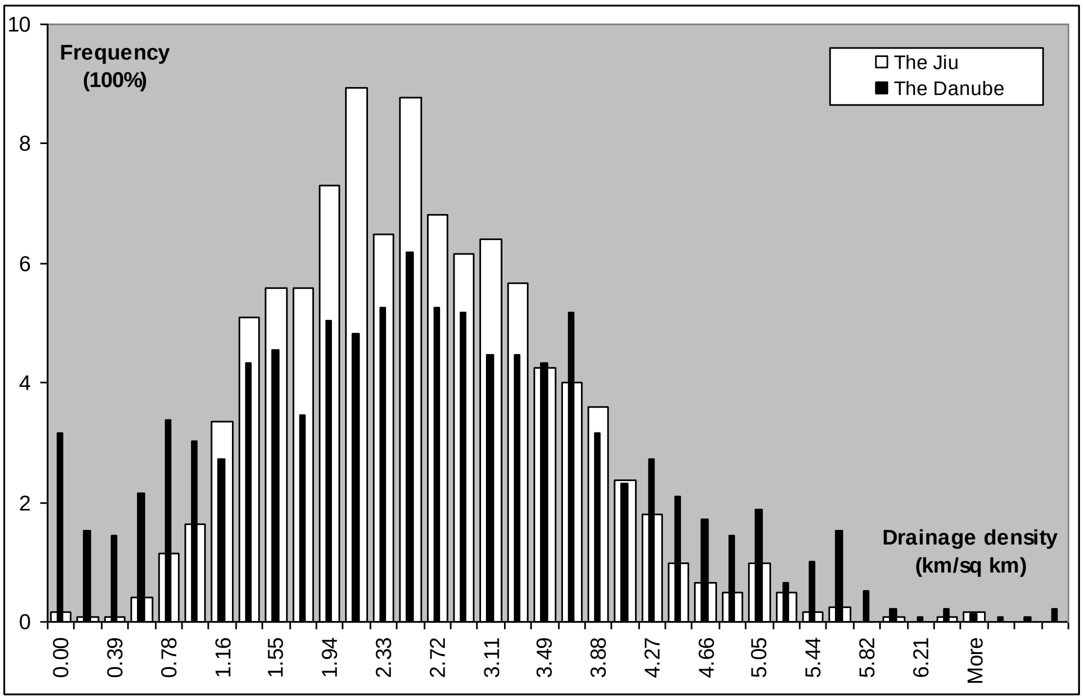
The relief of the Bălăcița Piedmont is characterised by the existence of three areas that display specific features (Boengiu S., 2008), i.e. the catchments of the Blahnița and of the Drincea, that of the Desnățui and the Jiu catchment area.

The drainage areas of the Blahnița and of the Drincea (Boengiu S. et. al, 2003) are characterised by rivers with subsequent valleys, which deeply cut a monocline structure with north-west – south-east orientation, made up of deposits of soft, predominantly sandy rocks; thus, they reduced much of the initial piedmont surface, which was maintained only on the narrow interfluves. The catchment of the Desnățui is completely different, the interfluves are broad, tabular, the deepening of the hydrographical network being much diminished. The drainage area of the Jiu river is characterised by the parallelism of the main valleys and the consequent watercourse of the Jiu tributaries, while the interfluves are narrow, sometimes made up of intersection hills and the valleys keep a relatively important width.

The previous analyses (Stroe R., 2003; Boengiu S., 2005, 2008; Boengiu S. & Avram S., 2009) were conducted for the entire piedmont or for each catchment area within the piedmont, while the present study follows a comparative analysis between the area corresponding to the Danube catchment and that connected to the Jiu river catchment.

The drainage density

The map of the drainage density (Fig. 1) displays values comprised between 0 km/sq km and 6.6 km/sq km. The density that accounts for the highest share (Table 1), representing more than half of the territory (54.11 percent) is given by the values of up to 3 km/sq km; this class of values is mostly distributed in the catchment of the Desnățui, where the interfluves present the aspect of genuine high plains.There follows the class with density values comprised between 3 and 4 km/sq km, with a share of 19.35 percent, which underlines the fact that higher densities (4 – 6.6 km/sq km) represent exceptions from the general rule (6.47 percent). The distribution of the value classes corresponding to the two basins (Graph 1) points out to major differences, but also to certain similarities. Thus, the repartition of the surfaces and the share of the drainage density classes display lower values within the area related to the Danube (2 - 3 km/sq km – 15.37 percent, 3 - 4 km/sq km – 8.16 percent and 4 – 6.6 km/sq km – 2.49 percent) than within the one corresponding to the Jiu river (2 - 3 km/sq km – 17.36 percent, 3 - 4 km/sq km – 11.19 percent and 4 – 6.6 km/sq km – 2.98 percent) for the classes comprising values above 2 km/sq km.



Graph 1. The frequency of the value classes of drainage density on the sectors corresponding to the Danube and to the Jiu

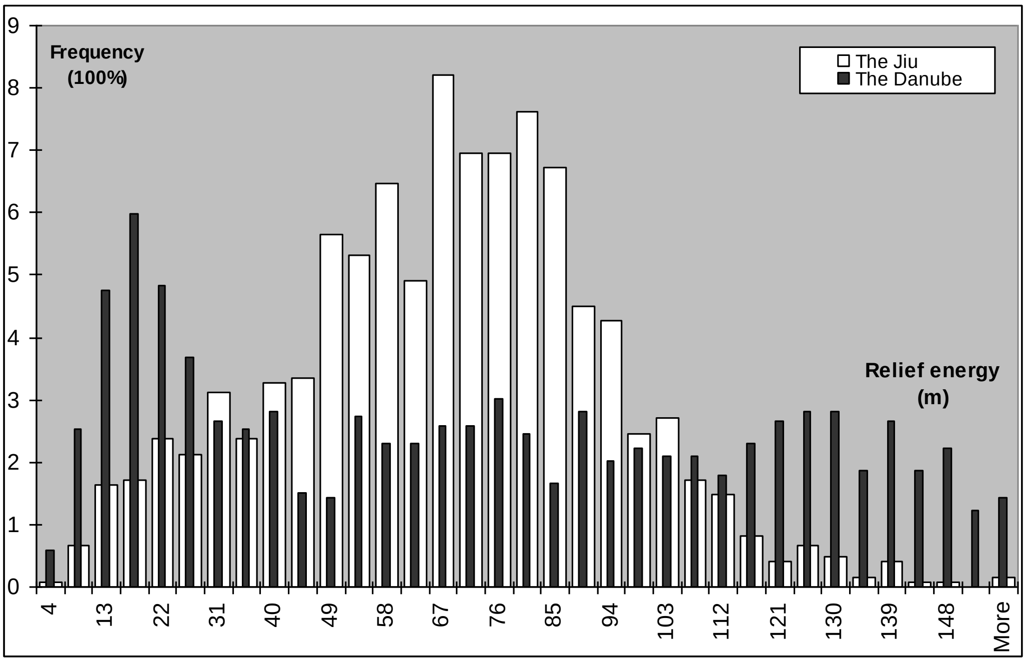
When the values between 0 and 2 km/sq km are taken into account, the share is favourable to the area that corresponds to the Danube (0 - 1 km/sq km – 9.27 percent, 1 - 2 km/sq km – 17.90 percent), as compared to the area that corresponds to the Jiu (0 - 1 km/sq km – 1.64 percent, 1 - 2 km/sq km – 12.57 percent). The most important difference of the drainage density between the two areas is to be noticed in connection with the 0 - 1 km/sq km class – with 7.63 percent, followed by the 1 - 2 km/sq km class – with 5.33 percent, while at the upper classes the difference is attenuated, being under 3 percent.

The relief energy

The map of the relief energy (Fig. 2) displays values comprised between 0 and 157 meters. The highest share in the relief energy (Table 2), representing almost half of the territory (45.52 percent) is given by the values of up to 30 meters, which are mainly distributed in the north and the west of the piedmont.

They are followed by the 30 - 60 meters and 60 - 90 meters value classes, which account for 31.93 percent, respectively 32.01 percent of the surface; the less extended surfaces are occupied by the values comprised between 90 and 120 meters (8.50 percent) and above 120 meters (only 1.45 percent).

The distribution of the values corresponding to the two catchment areas (Graph 2) underlines a total lack of synchronization related to the repartition of the surfaces and of the share of the relief energy classes. Thus, the most numerous population of values within the catchment corresponding to the Danube is registered at the level of the 0 – 30 meters class (21.5 percent), while in the drainage area corresponding to the Jiu, it registers only 4.02 percent and the highest share for the surface corresponding to the Jiu is given by the 60 – 90 meters class (21.47 percent), while within the area corresponding to the Danube, it owns only 10.54 percent of the values.



Graph 2. The frequency of the value classes of relief energy on the sectors corresponding to the Danube and to the Jiu

Table 1

Quantitative data on the drainage density

Values (km/sq km)		Number of values		Relative frequency (percent)	
The Jiu	The Danube	The Jiu	The Danube	The Jiu	The Danube
0.00	0.00	2	44	0.16	3.17
0.19	0.15	1	21	0.08	1.51
0.39	0.30	1	20	0.08	1.44
0.58	0.45	5	30	0.41	2.16
0.78	0.61	14	47	1.15	3.39
0.97	0.76	20	42	1.64	3.03
1.16	0.91	41	38	3.36	2.74
1.36	1.06	62	60	5.08	4.32
1.55	1.21	68	63	5.57	4.54
1.75	1.36	68	48	5.57	3.46
1.94	1.52	89	70	7.30	5.04
2.14	1.67	109	67	8.93	4.83
2.33	1.82	79	73	6.48	5.26
2.52	1.97	107	86	8.77	6.20
2.72	2.12	83	73	6.80	5.26
2.91	2.27	75	72	6.15	5.19
3.11	2.43	78	62	6.39	4.47
3.30	2.58	69	62	5.66	4.47
3.49	2.73	52	60	4.26	4.32
3.69	2.88	49	72	4.02	5.19
3.88	3.03	44	44	3.61	3.17
4.08	3.18	29	32	2.38	2.31
4.27	3.34	22	38	1.80	2.74
4.46	3.49	12	29	0.98	2.09
4.66	3.64	8	24	0.66	1.73
4.85	3.79	6	20	0.49	1.44
5.05	3.94	12	26	0.98	1.87
5.24	4.09	6	9	0.49	0.65
5.44	4.25	2	14	0.16	1.01
5.63	4.40	3	21	0.25	1.51
5.82	4.55	0	7	0.00	0.50
6.02	4.70	1	3	0.08	0.22
6.21	4.85	0	1	0.00	0.07
6.41	5.00	1	3	0.08	0.22
More	5.16	2	2	0.16	0.14
-	5.31	-	1	-	0.07
-	5.46	-	1	-	0.07
-	More	-	3	-	0.22

Table 2

Quantitative data on the relief energy

Values (meters)		Number of values		Relative frequency (percent)	
The Jiu	The Danube	The Jiu	The Danube	The Jiu	The Danube
4	4.00	1	8	0.08	0.58
8.5	7.70	8	67	0.66	4.83
13	11.41	20	155	1.64	11.17
17.5	15.11	21	98	1.72	7.06
22	18.81	29	54	2.38	3.89
26.5	22.51	26	60	2.13	4.32
31	26.22	38	58	3.11	4.18
35.5	29.92	29	49	2.38	3.53
40	33.62	40	67	3.28	4.83
44.5	37.32	41	82	3.36	5.91
49	41.03	69	53	5.66	3.82
53.5	44.73	65	51	5.33	3.67
58	48.43	79	60	6.48	4.32
62.5	52.14	60	54	4.92	3.89
67	55.84	100	52	8.20	3.75
71.5	59.54	85	79	6.97	5.69
76	63.24	85	65	6.97	4.68
80.5	66.95	93	40	7.62	2.88
85	70.65	82	48	6.72	3.46
89.5	74.35	55	36	4.51	2.59
94	78.05	52	31	4.26	2.23
98.5	81.76	30	21	2.46	1.51
103	85.46	33	18	2.70	1.30
107.5	89.16	21	16	1.72	1.15
112	92.86	18	17	1.48	1.22
116.5	96.57	10	15	0.82	1.08
121	100.27	5	9	0.41	0.65
125.5	103.97	8	5	0.66	0.36
130	107.68	6	4	0.49	0.29
134.5	111.38	2	5	0.16	0.36
139	115.08	5	1	0.41	0.07
143.5	118.78	1	2	0.08	0.14
148	122.49	1	0	0.08	0.00
152.5	126.19	0	1	0.00	0.07
More	129.89	2	2	0.16	0.14
-	133.59	-	1	-	0.07
-	137.30	-	3	-	0.22
-	More	-	1	-	0.07

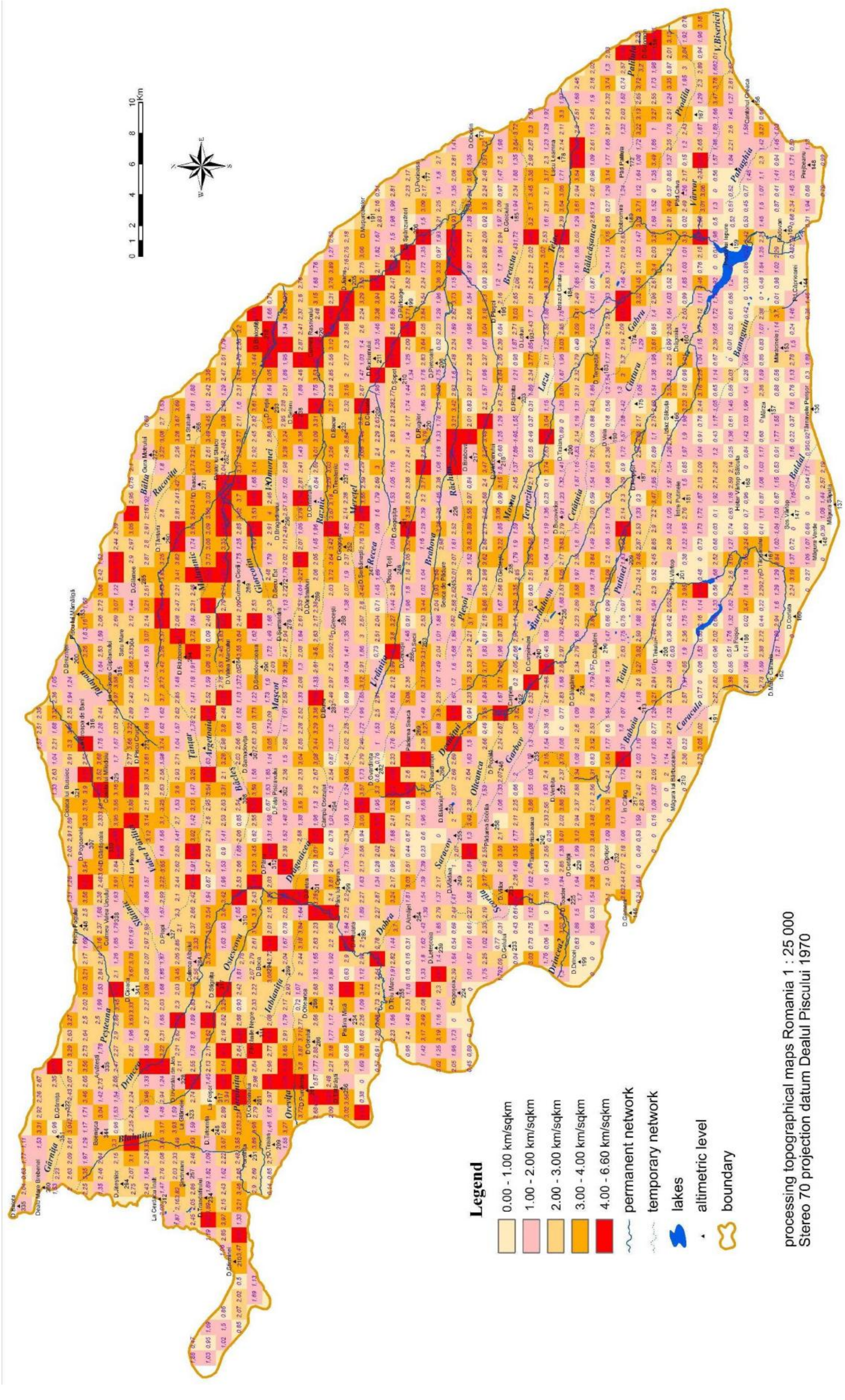


Fig. 1. The map of the drainage density in the Bălăcița Piedmont

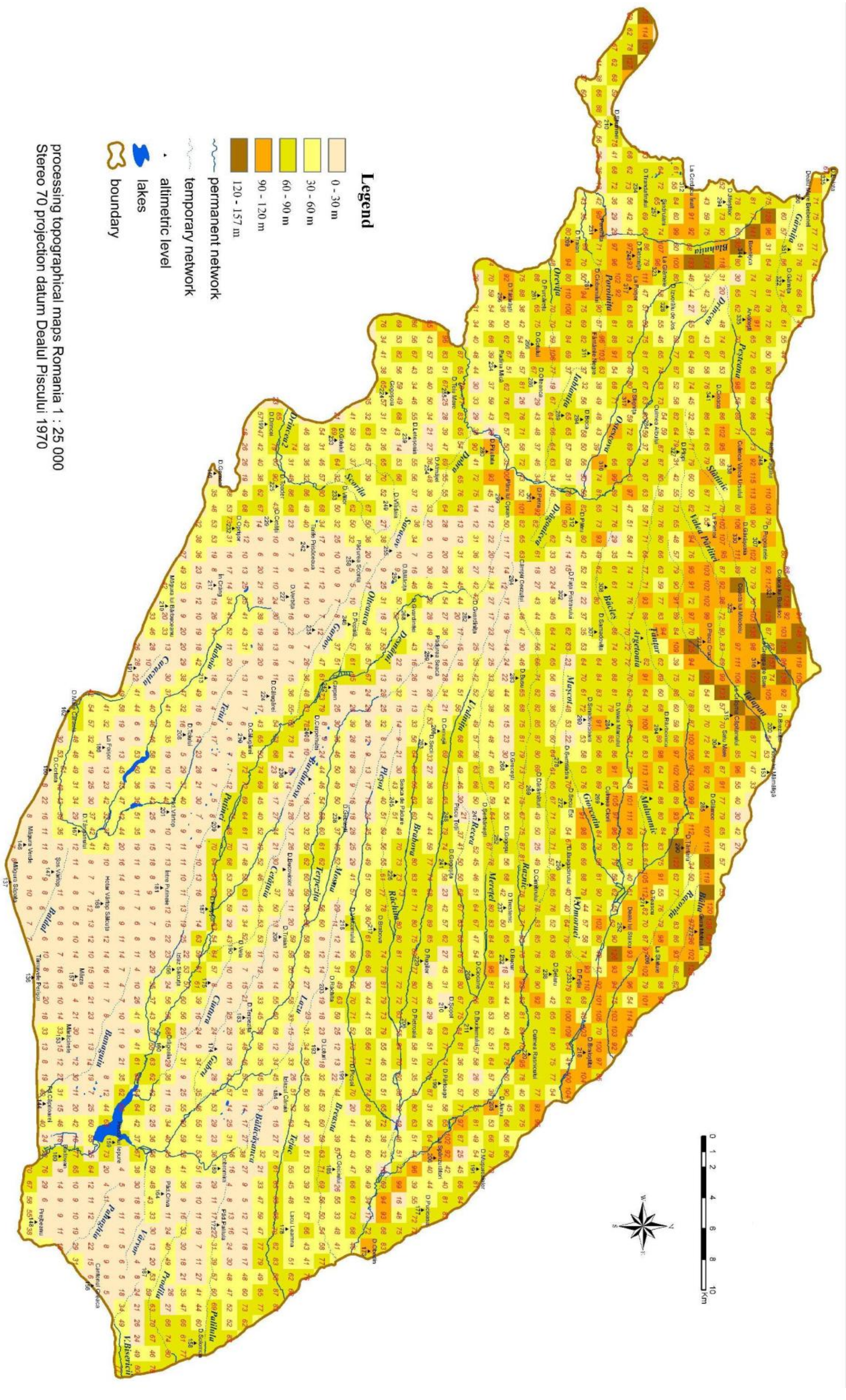


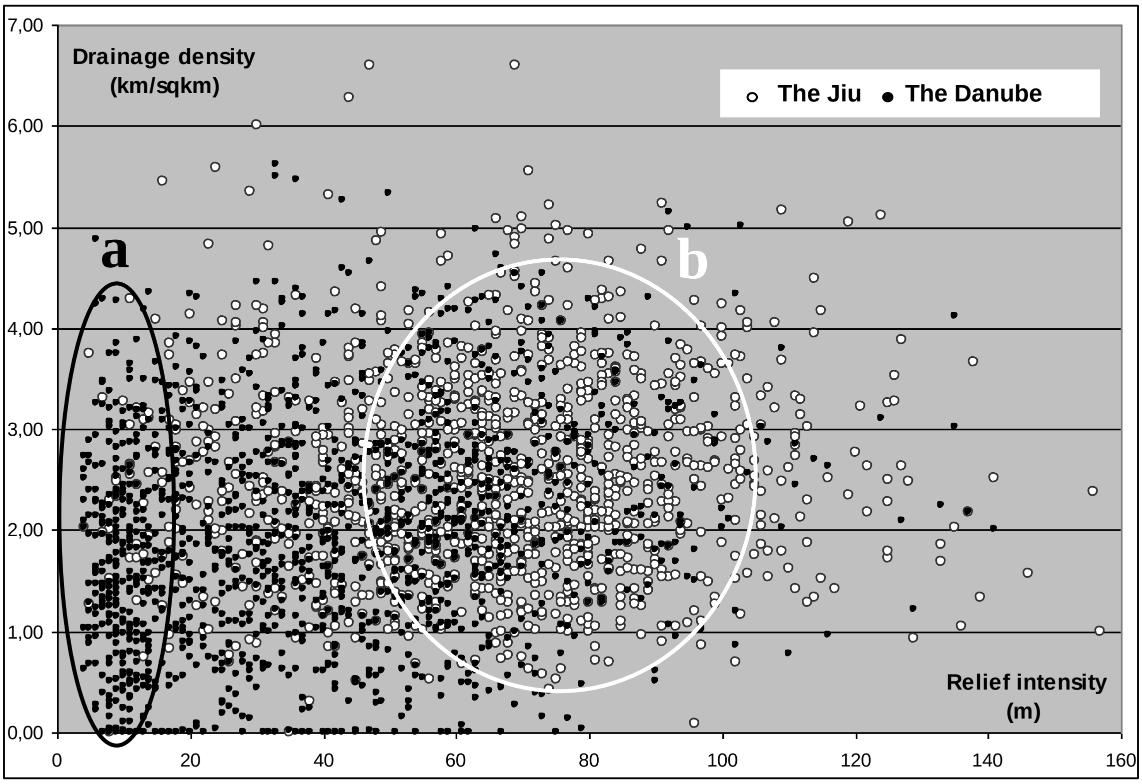
Fig. 2. The map of the relief energy in the Bălăcița Piedmont

The correlation between the drainage density and relief energy

The representation in rectangular system (Graph 3) of the 2,608 values (1,388 for the area corresponding to the Jiu catchment and 1,220 for that within the Danube catchment) led to a correlation coefficient (r) of 0.202. The signification of this value was achieved through the application of the Student t=10.528 and Fischer z=0.327 control tests, as well as through the computation of the standard deviation or of the square average error of the size Sz, Sz=0.019.

For the drainage density – relief energy correlation there was computed the determination coefficient CD=4.07, which means that 4.07 percent of the values of the relief energy are determined by the drainage density (the unexplained variation showing the value of 95.93 percent).

The analysis conducted on the basis of the applied tests and of the graphical representation led to the conclusion that the repartition of the fragmentation density and depth determinations that were obtained do not enter a Gauss curve, being dependent on certain other factors. The significant spreading of the data into the intervals of values of relief energy of 0 - 20 meters and 60 - 70 meters demonstrates the grouping of the influence factors on the two main catchments (of the Danube and of the Jiu).



Graph 3. The correlation between drainage density and relief energy
a – the interval of points concentration within the area corresponding to the Danube catchment;
b – the interval of points concentration within the area corresponding to the Jiu catchment

CONCLUSION

The highest values of the fragmentation are registered in the western and the northern parts, while the south and the east display the lowest values.

The analysis of the relief fragmentation within the Bălăcița Piedmont shows that this unit is on different evolution stages, the complexity of the fragmentation being closely connected to the maturity degree of the valleys and to the morphogenetic complexes imposed by the paleogeographical evolution (Boengiu, 2005). The sector corresponding to the Danube, which comprises the catchments of the Blahnița and of the Drincea, as well as the Danube slope between Șimian and Batoți settlements, is characterized by erosion in the most advanced stage, the initial piedmont surface being almost totally destroyed. The sector that comprises the Desnățui drainage area is characterised by much more reduced fragmentation densities and depths than the rest of the unit, the piedmont surface forming interfluves.

The sector corresponding to the catchments of the Jiu and of the Motru rivers is characterized by a less advanced evolution stage, the piedmont surface forming relatively rounded and very narrow surfaces on the interfluves.

The resemblances concerning the fragmentation parameters between the two areas are due to the lithological and climatic homogeneity, while the differences are a consequence of the evolution time depending on a certain base level and of the flow direction in report to the structure.

The grouping of the influence factors on the two main catchments (of the Danube and of the Jiu) is mainly due to the fact that the Danube catchment extended its surface in the detriment of the Jiu drainage area, the three more important tributaries, i.e. the Blahnița, the Drincea and the Desnățui capturing sectors from the upper course of the tributaries of the Jiu river.

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REFERENCES

Badea, L., (1970), *Terasele fluviatile din Oltenia*, SC GGG, Seria Geografie, t. XVII, nr. 1, Bucureşti.

Badea, L., Ghenovici, Alexandra, (1974), *Județul Dolj,* Edit. Academiei. Bucureşti.

Badea, L., Niculescu, Gh., Sencu, V., (1976), *Harta geomorfologică a României, sc. 1:1000000*, Atlasul Național al R.S.R., pl. III-1, Edit. Academiei, Bucureşti.

Boengiu, S., (2002), *Observații hidrogeografice în Piemontul Bălăciței*. Revista Geografică T. VIII –2000, Institutul de Geografie, Academia Română, Bucureşti.

Boengiu, S., Curcan, Gh., Marinescu, E., (2003), *Relief aspects within the hydrological basin of the Drincea river*, Analele Universității de Vest din Timişoara, Seria Geografie, vol. XIII.

Boengiu, S., (2005), *Caracteristici morfometrice ale versanților din Piemontul Bălăciței,* Edit. Universității din Bucureşti, Revista de Geomorfologie, vol. 4-5 / 2002-2003, Bucureşti.

Boengiu, S., Torok-Oance, M., (2005), *Features of the fragmentation, within the Blahnița basins. The piedmont sector*, Forum Geografic – SCGPM, nr. 4, Edit. Universitaria, Craiova.

Boengiu, S., (2008), *Piemontul Bălăciței. Studiu de geografie*, Edit. Universitaria, Craiova.

Boengiu, S., Avram, S., (2009), *Bălăcița piedmont. A model of formation and evolution*, Zeitschrift fur Geomorphologie, suppl. 2, nr. 53, Stuttgart–Berlin.

Coteț , P., (1957), *Câmpia Olteniei*, Edit. Ştiințifică, Bucureşti.

Cucu, V., Popova-Cucu, Ana, (1980), *Județul Mehedinți,* Edit. Academiei, Bucureşti.

Enache, C., (2008), *Geologia Olteniei,* Edit. Universitaria, Craiova.

Enciu, P., (2007), *Pliocenului şi Cuaternarului din vestul Bazinului Dacic,* Edit. Academiei Române, Bucureşti.

Ghenea, C, Mihăilă, N, Ghenea, Ana, (1963), *Cercetări geologice între valea Topolnița şi valea Desnățui,* Inst. Geol. Geof. St. Tehn. Econ. Seria E, nr. 6, Bucureşti.

Posea, Gr., Popescu, N., Ielenicz, M., (1974) *Relieful României,* Edit. Didactică şi Pedagocică, Bucureşti.

Roşu, Al., (1959), *Câteva observații fizico-geografice în Câmpia înaltă a Bălăciței,* Probleme de geografie, vol. VI, Bucureşti.

Stroe, R., (1983), *Harta geomorfologică a Piemontului Bălăciței,* Lucr. Seminar. Geogr. „Dimitrie Cantemir”, Iaşi.

Stroe, R., (2003), *Piemontul Bălăciței. Studiu geomorfologic*, Edit. MondoRo, Bucureşti.

*** (1992), *Geografia României, vol. IV,* Edit. Academiei Române, Bucureşti.