MUREŞ RIVER HYDRO-MORPHOLOGICAL CLUSTERING

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ABSTRACT. Mureş River hydro-morphological clustering. The Mureş River, contrary to the simple theoretical river profile, presents the best example regarding the alternation of characteristic (upper, middle and lower) river courses along one river. The alternation of the river course characteristics can be explained by several different factors which help or obstruct the rivers evolution. In this study these dynamics of the river are followed by analyzing different morphological and hydrological characteristics. The analysis was completed using GIS software and topographic maps for the current situation and the third topographic survey maps of Austria-Hungary (1869-1873) for the historical analysis. The river course evolution was followed on the entire river reaching over Romania and Hungary.

Keywords: river course characteristics, meandering coefficient, longitudinal profile, Mureş River.

1. INTRODUCTION

Water is the most dynamic Earth modeling agent. In this context the fluvial systems circulate energy and materials and through them they model the lithological substrate. Of course along with the main action factor – the water in nature as polyphasic fluid – there are other factors that accelerate or slow down the rhythm and rate of the modeling processes. Such factors are the tectonic, the geological structure, lithology, subsidence or local lifting, orography type and morphometry, vegetation cover, anthropic processes etc. These factors are in a continuous connection, creating synergistic processes that shape catchments and riverbeds.

Correlation of the catchments morphological components with the hydrological components (mainly the flow regime) led to the river course classification. Theoretically, over the course of a river, one can differentiated according to the geomorphological units, three sectors: upper (mountains), middle (hills or/and plateaus) and lower (plains). They differ not only by valley characteristics, but also in the hydrologic-hydraulic characteristics: runoff growth rate, propagation velocity, flow turbulence, silt genesis and deposits, river competence and capacity, water energy. In case of rivers that cross various

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landscapes the course characteristics repeat, including the hydromorphological properties of water, riverbed and valley.

The clustering riverbeds and sectoring them by hydraulic parameters and morphotectonic regions first appeared in the Russian geographical school at the end of the 8th decade of the 20th century. Başenina, A., and Kamenskaia, OV (cf. Ufimţev, I., 1989) developed the first clustering of the Russian rivers by identifying homogeneous segments as meandering coefficients, riverbed morphology, hydraulics, bank slope stability and cross sections.

2. MUREŞ RIVER EVOLUTION AND SECTORING

In the interior of the Carpathian arch there is a great diversity of genetic and runoff influencing factors, due to these the catchment systems have complex features. The Mureş River is one that runs through the most various physico-geographical units, crossing from east to west the depression.

The Mureş drainage systems genesis starts in the Dacian period together with the lake water withdrawal. Under the influence of the lower Pannon Lake base-level and the lifting movements due to the Carpathian orogen, the waters were drained in the north and south of the island which was at the current area of the Apuseni Mountains.

In the old depression surrounded by the Carpathians the discontinuities favored the appearance of corridors along which subsequently concentrated the main course of the Mureş River. So, in the Topliţa-Deda Gorge there was a paleo-riverbed prior to the volcanic eruptions, situated along some lithological discontinuity lines. The lake formed behind the volcanic eruptions dam in the Giurgeu Depression which gradually was clogged by volcanic sediments and was drained in successive phases by the river which continued its way through the gorge (Orghidan, 1969).

In the Transylvanian Depression the rivers traced tectonic lines and adapted to structural features which were revealed by the epigenesis, following the limits of morphostructural blocks (Mac, Sorocovschi, 1979). So have been modeled the wide corridors, with meandering riverbeds which cross Transylvania to Deva.

The Mureş River Mio-Pliocene evolution was influenced by the Gurghiu and Călimani Mountains volcanic eruptions and the Post-Pontian phase is defined by the salt diapir and the tectonics isostatic compensation, aspects reflected in the floodplain and terrace steps duplication (Brâncoveneşti), the meandering coefficient (high values in inter-domal basins or before crossing diapir anticlinals), confluence angle, riverbed morphology, water chemistry etc. (Irimus, 1998).

Between Deva and Lipova, the second breakthrough has a complicated epigenetic and antecedence genesis, (Orghidan, 1969), where there are several areas of narrowing in volcanic and stronger sedimentary rocks and enlargements in more friable deposits. The gorge name is not very appropriate, because in the micro-depressions we find even strong meanders.

In the Pleistocene, along the current course of the Mureş River, there were several small lake units, marshes and streams. Rivers were very divagating, carrying huge amounts of material and formed large dejection cones. In this manner formed the thick sedimentary deposit, near the mouth of the Mureş River, which consists of overlapping cones, whose development was influenced by the vertical movements of the plains base-level.

Local lifting and lowering movements have also influenced the Mureş River evolution in the Holocene, when the territory was completely exondated (dried). The ancient riverbed was divagating with intense meandering processes and meander penetrations (Lászlóffi, 1982). Slowly the courses features have stabilized, but the natural evolution continues.

In the 19th and 20th centuries the riverbed dynamics were influenced by various human intervention plans, strips, meanders cuts etc. more frequently and more extensively before the Tisa confluence.

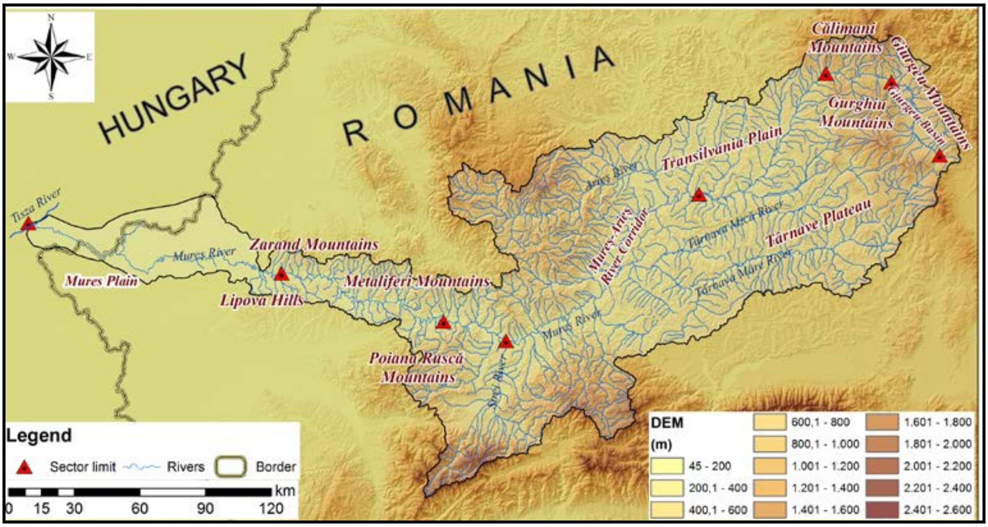

Fig. 1.*Crosed main geographic units and the Mureş River sectors*

Today's Mureş springs under the Black Mountain (Rez) peak, which belongs to the Giurgeu Mountains, at an altitude of 1325 m. There is also a "touristic spring", situated in Izvorul Mureşului settlement. The confluence point with the Tisza River is at 91 m altitude. The watercourse length is 766 m and the catchment area is 29.767 km^2. There have been determined eight characteristic sectors (Fig. 1.):

- Spring sector, in the Giurgeu Mountains, upper course character
- Giurgeu sector, in the Giurgeu Depression, middle course character
- Călimani sector, between the Călimani and Gurghiu Mountains, upper course character
- Plateau sector, between the Transylvanian Plain and the Târnave Plateau, middle course character

- River corridor sector, in the Mureş-Arieş River Corridor, lower course character
- Apuseni sector, between the Metaliferi and Poiana-Ruscă mountains, upper course character
- Zarand sector, between the Zarand Mountains and the Lipovei Hills, middle course character
- Confluence sector, in the Mureş Plain, lower course character (partially destroyed due to anthropic management works

We have to note that the sectors delimitation can never be made precisely. There is always a gradual transition from one course character to another. Also the considered parameters don't express exhaustively the character of a sector, but their ensemble differentiates one sector from the other.

3. METHODS AND DATA BASE

The Mureş River course analysis was performed using ESRI ArcGIS 10 program group and the 1:25.000 topographic maps. By extracting altitude values from the georeferenced topographic maps we plotted the longitudinal profile (Fig. 2.) of the river and its slope for different sectors, also by digitizing the watercourse enabled us to determine the meandering coefficient (Fig. 3.).

Calculations were made using two investigation intervals, the equal 10 km intervals and the above mentioned morphometrical sectors. Results of the analysis required to find explanations for some discrepancies observed in the last studied sector. For this we digitized the maps of the 3rd Military Mapping Survey of Austria-Hungary (1869-1873) when the riverbed was not yet fully rectified (especially at the Tisa confluence).

The hydrological database is formed of the average multiannual runoff data from the gauging stations located along the Mureş River. These values were translated into sections delineating the characteristic sectors, taking into account the ratio of the respective areas.

4. SECTOR CHARACTERISTICS

4.1. Morphometric characteristics

The morphometric elements of the sectors vary widely. The first, the Spring sector has the smallest area and shortest river length. The Mureş-Arieş River Corridor sector instead has the largest values at these elements. Of course these affect the sectors runoff volume. The three sectors with upper course character are also the shortest.

The slopes of the spring sector distinguish with the highest values (Table 1). The remaining slope values are small, but stand out the higher values (2.00 m/km) between Topliţa and Deda from than upstream in the Giurgeu Depression (1.81 m/km). In the Apuseni Mountain sector, with upper course character, the slope values are very small, which is one of the arguments for the existence of a breakthrough paleo-valley. The sectors with lower course character have very small slopes: 0.27 m/km and 0.39 m/km, the riverbed was modeled in the friable new deposits.

Table nr.1 Sectors characteristic elements

Sector nr.	Sector name	Course character	A	L	H_{med}	I	M_c	Q	q
			km^2	km	m	m/km	1997	m^3/s	$l/s.km^2$
1	Spring sector	upper	13	6	986	85.61	1.00	0.10	7.8
2	Giurgeu sector	middle	1307	74	984	1.81	2.10	6.78	5.2
3	Călimani sector	upper	780	41	1053	2.00	1.28	13.7	17.6
4	Plateau sector	middle	3704	131	530	1.25	1.51	19.8	5.3
5	River corridor sector	lower	15499	220	646	0.39	1.71	91.6	5.8
6	Apuseni sector	upper	3464	39	505	0.43	1.32	41.0	11.8
7	Zarand sector	middle	1993	129	344	0.37	1.57	7.00	3.5
8	Confluence sector	lower	3007	126	101	0.27	1.44	9.00	3.0

**A- area, L- length, H_d-average height, I- slope, M_c-meandering coefficient, Q-discharge, q-specific discharge*

The slope and meandering coefficient were also studied at constant distance of 10 km (Fig. 2). Slope variation highlights the role of Topliţa-Deda gorge threshold and the very low values over the last four sectors. These characteristics are reflected in the shape of the longitudinal profile. After a sharp fall in the Spring sector comes a gentle slope in the Giurgeu Depression followed by a steep Călimani sector. Further the rive profile is almost linear.

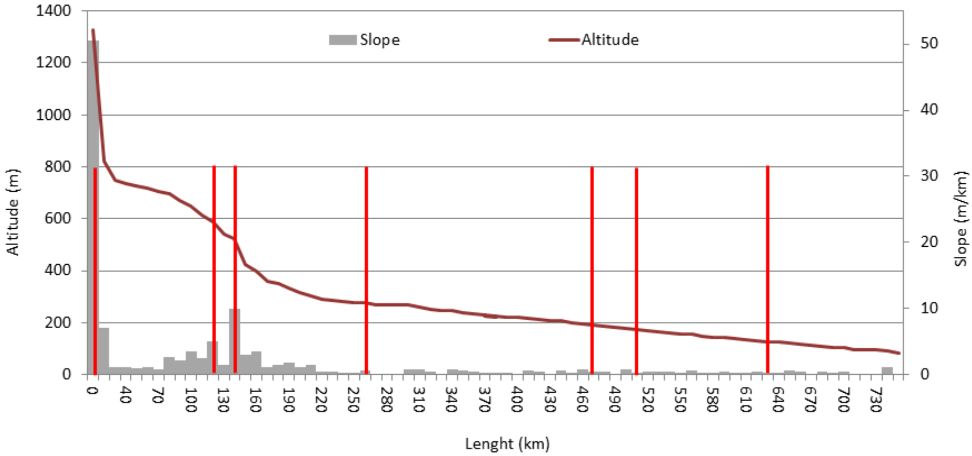

Fig. 2. ***Longitudinal river profile and the variation of the slope***

The meandering coefficients (Table 1.) present highly accurately the nature of the course. As it is logical, in sectors with upper character the meandering coefficient has minimum values (1.00, 1.28 and 1.32). In the lower Mureş-Arieş River Corridor the coefficient has large values 1.71. In the Mureş Plain these high value does not appear because the riverbed arrangements carried out in the 19th and 20th centuries (only 1.44). Interestingly measured on the Austro-Hungarian map from 1869-73 in this sector the meandering coefficient was 1.85. An exception from the course character is identifiable by the large meandering coefficient (2.10) of the Giurgeu Depression, where the Topliţa-Deda gorge threshold has a very strong role.

The meandering coefficient for constant 10 km intervals (Fig. 3) indicate the maximum values at the beginning of the Mureş-Arieş River Corridor, with lower course character, but values are kept high throughout the entire sector. Here one can observe the high meandering coefficient in the Cuci inter-dome basin (1.88), between the Ogra-Sânpaul and Bogata domes. We encounter similar situations on the Mureş sector downstream from the Arieş confluence, at Ocna Mureş, before sectioning a diapir fold, the Dealul Mare - Zăpodie anticline.

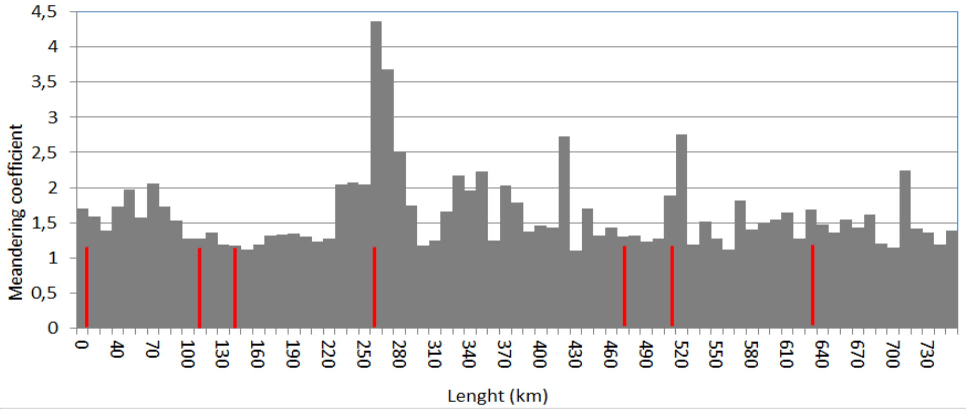

Fig. 3. ***Meandering coefficient variation***

We can also follow the high values of the meandering coefficient in the Giurgeu Depression. The two sectors of mountain crossing have constantly smaller meandering coefficients as the plateau, with middle course character. In the Zarand sector the highly differentiated meandering coefficient values are due to the succession of narrowings and micro-depressions of geological origin.

4.2. Hydrological characteristics

Besides the climatic factors, the landscape influences the river supply, so the water quantities flowing across sectors differ. The increase of runoff from the spring to the confluence is progressive, but the contribution is different by sectors (Fig. 4). So, in the Călimani and Gurghiu Mountain area, from a catchment area of 780 km^2 an additional discharge of 13.7 m^3/s is collected. This represents a specific discharge of 17.6 l/s.km^2, the largest of all sectors. In the Apuseni sector the discharge increases by 41.0 m^3/s, representing a still high specific value of 11.8 l/s.km^2.

The sub-basins belonging to the middle course have specific discharge rates between 3.5 and 5.3 l/s.km^2, higher in the Giurgeu Depression than between the Transylvanian Plain and the Târnave Plateau. In the Giurgeu Depression, although surrounded by mountains, the discharge contribution is only 6.78 m^3/s. Of course over the last two sectors, where the reliefs' altitude change is minimal and the catchment narrows strongly the discharge is minimal (7.0 m^3/s and 9.0 m^3/s), with very low specific discharges, 3.5 respectively 3.0 l/s.km^2.

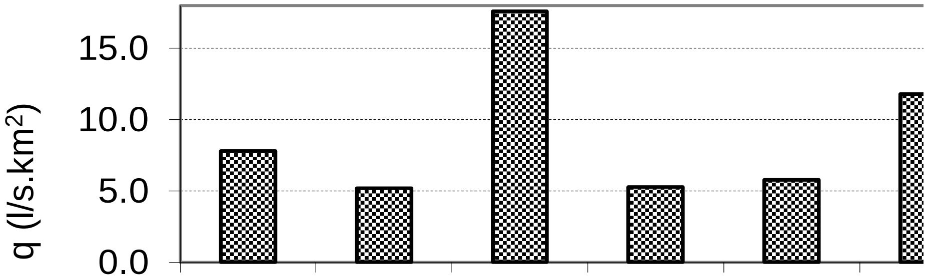

Fig. 4. Specific discharges in the selected sectors sub-basins

The specific discharge values belonging to different sectors sub-basin correlate well with the average altitude, although the Mureş River crosses a wide variety of physico-geographical units. Three correlations can be drawn (Fig. 5), which highlight the sectors distinguishing characteristics. It is remarkable the wealth of runoff in the Călimani-Gurghiu and Metaliferi-Poiana Rusca Mountains, two sectors with upper course character. It also stands out the smaller discharge in the Giurgeu Depression, which lies in a precipitation shadow. All the other specific discharge values are on one correlation.

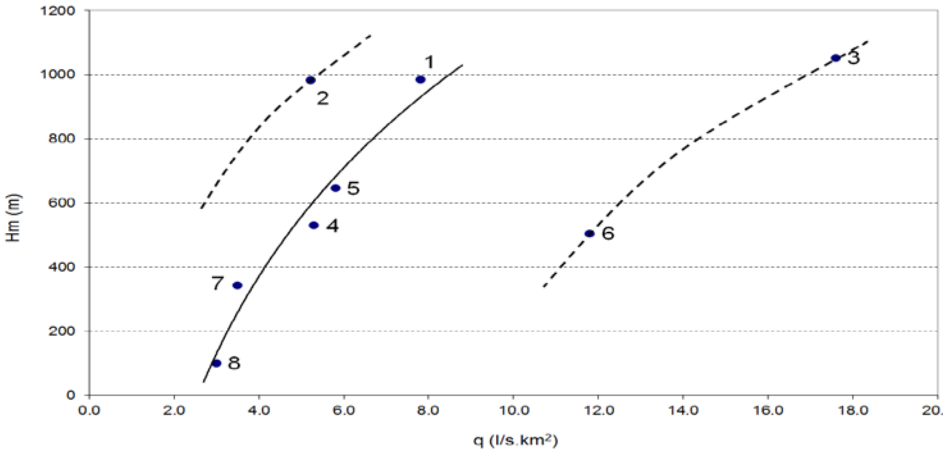

Fig. 5. Correlation of the specific discharge with the correspondent sub-basin mean altitude

5. CONCLUSION

The Mureş River is wonderfully suitable to demonstrate the different river courses hydrological and morphological characters. Most items differentiate simultaneously the eight sectors. Specific discharge, runoff growth rate, meandering coefficient and partly the longitudinal slope can be considered as defining.

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