THE GEOGRAPHY OF THE RIVER MAROS (MUREŞ) AND ITS RIVER SYSTEM

MIHÁLY ANDÓ

Introduction

The Maros drains the Transylvanian basin in a westerly direction and it meets the Tisza River at Szeged. The full length of the Maros is 749 km, the length of its valley is 651 km, the distance between its source and its mouth is 425 air km. Its length and 30,000 km^2 large drainage basin make the Maros one of the most significant rivers of the Carpathian basin. Most of its drainage area is covered with mountains and hills, and only a smaller proportion is plain surface. 25% of this territory is highland, 55% is plateau and hill-country, 15% is river valley and 5% is lowland. (Fig. 1.)

Geohistory of the Maros drainage area

The beginnings of the hydrogeological aspects of the Maros coincide with the formation of the Transylvanian basin and its spur mountain regions in the Tertiary period. The presence of the Poiana Ruscă and Bihor Mts.was especially important in the Miocene epoch, since these stood erect in the Mediterranean Sea as island mountains. Later the rise of the ranges of the Eastern Carpathians, (Carpaţii Orientali; Keleti Kárpátok) and the Transylvanian Mountains finalized the formation of the Transylvanian basin (Bazinul Transsilvaniei, Erdélyi medence).

The interior of the Transylvanian basin was further formed by the slow rotation of the volcanic and the inside blocks accompanying the movements in the mountain structure. Traces of the most intensive volcanic activity can be found in the Bihor Mountains and around the Maros river head, in the Călimani (Kelemen), the Gurghiu (Görgényi-) and the Harghitei (Hargita) Mts. The center of the basin subsided relatively quickly compared to the rise of the rings of the spur mountains. The forceful rise of the rings of the spur mountains and the relative backwardness of the basin resulted in the gradual and substantial recession of the shores of the Miocene (Pliocene) inner sea. [3., 4., 8.,12.,13]

The present territory of the Maros valley, between the Metaliferi and the Poiana Ruscă Mountains (Ruszka- havasi legelő), however, did not rise and thus the Pannonian sea of the Hungarian Plain (Alföld) and the Transylvanian inner sea were connected for a long time. This narrowing was the Zám-pass (Defileul Zam, Zámi szoros), the oldest element of the Maros valley and of the Transylvanian river system as well.

In the beginning of the Pliocene the lowland section of the Maros was still covered by the Miocene lake. In the central territory of the Transylvanian basin significant bay-like depressions formed. Even in the beginning of the Pliocene, shorter streams characteristically

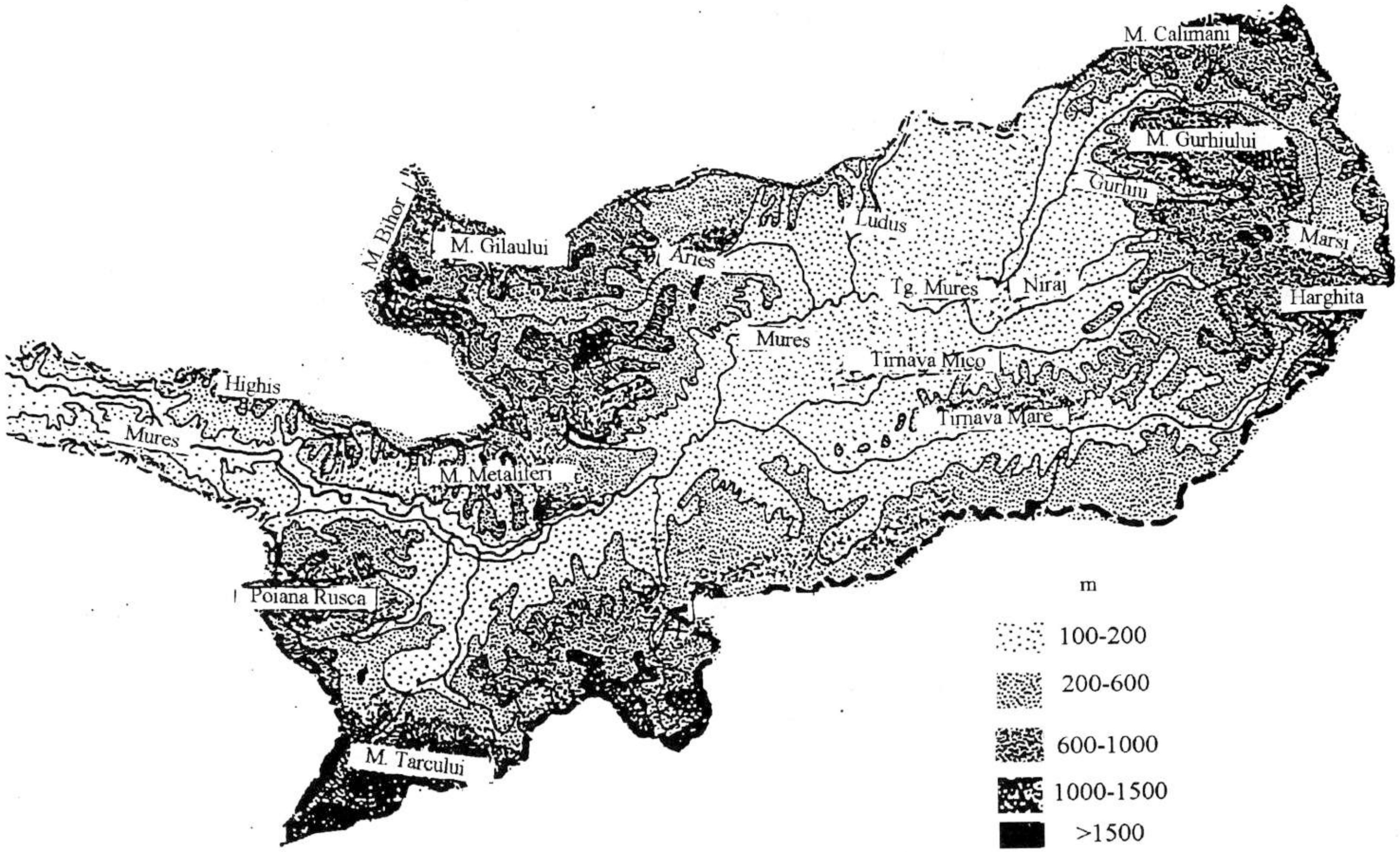

Fig.1. Surface of the Transylvanian drainage basin of the Maros (m above sea level)

started off from the surfaces of the surrounding higher mountains. Some of these streams were later taken up and further deepened by the Pleistocene Old Maros.

The Transylvanian bay formation developed into an independent closed lake and was filled up significantly only by the middle of the Pliocene. The talus, which determined the lowland section of the later Old Maros, accumulated from the coarse alluvium carried by the waters rushing down from the Highis-Drocea (Hegyes-Drócsa) and Măgura areas around this time as well. The torrential streams also deposited a significant quantity of alluvium at the meeting of the Hungarian Plain and the base of the surrounding mountains [5., 7].

An important rise in the drainage area of the Maros at the end of the Pliocene caused a recession in the inner lakes. By the end of the Tertiary period (and the beginning of the Pleistocene) the Maros had become a quick river, carrying the water of the Transylvanian inner lake to the significantly lower Hungarian Plain.

The Old Maros left the mountains and appeared in the Hungarian Plain in the Pliocene and left a large alluvial deposit in the tectonic valley. This deposit had been growing as a Levante talus, first only at the feet of the mountains and then slowly, with the further development of the talus system, it reached the talus systems of the Bega and the Criş (Körösök). [11].

The Hungarian Plain had been subsiding at the end of the Pliocene, and this process continued in the Pleistocene and even in the New Holocene. This significant subsidence can be traced back through the structure of the regional debris of the talus system beginning at Lipova (Lippa) and fanning out in the southeastern plain region. [1]. There was no permanent surface riverbed on the Maros Pliocene alluvium surface; the alluvium was spread in several branches. In the early Pleistocene the Maros took on a definite direction that coincides with the seismotectonic lines of the rim of the Hungarian Plain. One of these directions is the "Păuliş-Lipova" (Ópálos-Lippa) tectonic line, the other follows the foot of the Highis-Drocea (Hegyes-Drócsa) Mountains in northwest-southeast direction.

A very important change occurred in the "Günz" glacial, a large-scale deepening of the riverbed and a significant erosion. The destructive force of the river broke up and carried away the taluses and alluvial slopes it had built up, and formed a valley plain several kilometers wide.

A similar process took place in the "Mindel" glacial as well. During the "Günz" and "Mindel" periods the river formed a terrace system on its previous valley plain, influenced by the climatic change and the rise of the area, too. In the "Mindel" the Old Maros left the Lipova (Lippa) gorge and, supplying several meanders, turned northwest on the talus system of the Hungarian Plain. First the river ran on the southern rim of the talus, then, turning north, its main branch met the Old Tisza together with the Criş (Körösök). (Fig. 2.)

In the "Riss" period the talus developed mostly in the central area of the present talus. Significant surface changes occurred mostly in the glacial and interglacial periods of the "Würm," when predominantly coarse and medium sand deposits leveled the earlier deepenings of the riverbed. Simultaneously in the Transylvanian area the usually wide but not too high terrace systems of the Maros developed; these can be traced from Deda to Lipova (Lippa) [15].

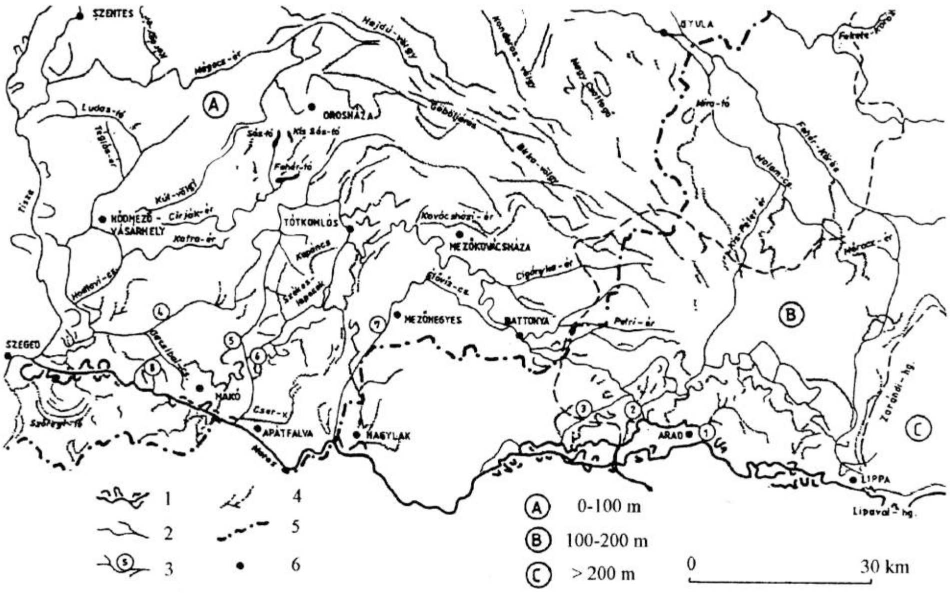

Fig. 2. The river system of the Hungarian Plain section of the Maros 1. The present bed and bends of the Maros 2. Brooks 3. Artificial canals 4. Lines of Old Holocene beds 5. Borders 6. Town or village A, B, C= m above sea level.

In the Holocene period the Maros settled in the Transylvanian basin and its horizontal bed changes became insignificant compared to the previous stages. The 5- to 10-meter-high Holocene terrace follows the river. At the same time, however, the Hungarian Plain section underwent a serious transformation due to the subsidence of the region surrounding the Criş (Körös) river. [1]. The oldest Holocene Maros reached the Tisza, the base of erosion 6., at Kürtös and Kevermes. However, the Tisza moved northwest forcefully; the Maros beds followed it on fan-like taluses. The river first followed the Békés-Kondoros, then the Kürtös-Nagykamarás-Orosháza, then the Dombegyháza-Mezőhegyes-Makó and then the Szárazér line (Fig. 3). The present bed was basically formed by the regulation of the river, since before this, in the Holocene, it also supplied the (Aranca) Aranka brook system.

Climatic and hydrographic characteristics of the Maros drainage basin

The temperature and precipitation of the Maros drainage basin is influenced by air masses from the Atlantic Ocean, the Mediterranean and Eastern Europe. Besides these, ground features also account for regional differences; for example, compared to the precipitation on the plains, in the mountain region the precipitation doubles. [2]. Similarly to the Hungarian Plain, the annual quantity drops in the Transylvanian basin as well. In the case of the latter, the lack of precipitation is the result of the climate modifying influence of the Southern and Eastern Carpathians, especially in winter.

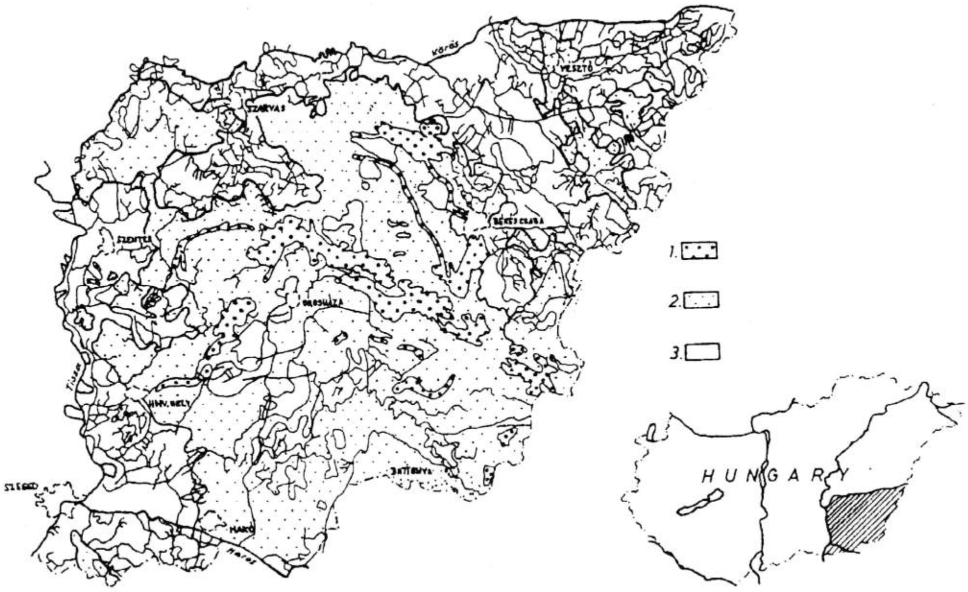

Fig. 3. Hungarian area of the Maros talus, with indications of the porosity of the sediment near the surface
1. Sediment with good water permeability (coarse and medium size sand) $K=10^{-3}-10^{-4}$ cm/sec
2. Sediment with moderate water permeability (sand, warp and fine sand) $K=10^{-4}-10^{-6}$ cm/sec
3. Sediment with poor water permeability (clay with loess and warp) $K=10^{-6}-10^{-8}$ cm/sec

Since the drainage area of the Maros is supplied with water by the western winds, there are significant differences between the quantity of the precipitation in the "luw" and "lee" sides of the surface. This is especially characteristic on the western expositions of the Călimani Mountains (Kelemen) and the Gurghiu (Görgény) Mountains where the annual precipitation is over 1,500 mm while in the Transylvanian basin it is only 500-600 mm and on the "luw" sides of the lower mountain areas it is 700-1,000 mm. The distribution of the temperature is similar; the annual mean temperatures correspond to the elevation. The annual mean temperature for the whole drainage area of the Maros is 4-11 ^{o}C. The coldest area is the Arieş (Aranyos) River region, the Maros river head and the Giurgeu Mountains (Gyergyói havasok) with 3-6 ^{o}C mean temperature. Most of the Transylvanian basin, and the Maros valley that is open to the west,has an annual mean temperature of 8-10 ^{o}C; Szeged is 11 ^{o}C.

Table 2. Range of absolute maximums (a) and minimums (b) of monthly precipitation at regions of the Maros drainage area, according to the mean values of several years. A: Cimpia Tisei; B: Depresiunea Transilvaniei; C: Muntii Apuseni; D: Lantul Carpatic interior.

		XII	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
A	a	80	50	50	80	60	100	100	100	90	80	100	50
		160	100	100	100	100	150	150	200	150	170	200	100
	b	0	0	0	0	0	5	2	0	0	5	0	0
		10	15	12	10	5	30	46	20	20	15	15	10
B	a	50	40	40	50	50	100	200	127	100	200	100	50
		100	60	80	100	100	150	250	230	180	260	200	100
	b	0	0	0	0	0	20	10	6	5	0	0	0
		5	15	12	10	10	50	40	20	25	5	10	12
C	a	150	100	100	150	100	150	150	100	150	100	100	150
		180	150	150	220	150	200	230	270	250	150	150	200
	b	10	0	0	0	10	10	20	10	0	0	0	0
		15	15	12	10	20	30	50	20	30	2	10	15
D	a	150	100	158	150	150	150	200	300	150	200	100	150
		200	150	180	200	180	200	310	470	200	340	150	250
	b	10	0	0	0	10	20	20	10	20	0	0	0
		20	15	12	10	20	30	50	30	30	2	10	10

Influencing the water level of the affluents. the regional water absorption is of great importance. This leads to significant regional differences in the different parts of the drainage area because of the great seasonal differences. For example, in the winter months the surface precipitation is mostly snow. therefore the monthly averages of the water absorption distribution can be characterized by the snow accumulation that increases with elevation. In the drainage areas, especially in the mountain regions above 1,000-1,500 m, the winter precipitation is not more than 15 mm. This also means that the water absorption in the drainage basins is the lowest in winter, which is due to snow accumulation.

In the spring, as the snow melts from March till April, the surface water absorption increases significantly. This time even 50-60 mm of water can occur on the territories 500-1,500 m above sea level. At the same time on the Hungarian Plain and in the Transylvanian basin only 15 mm water can be measured. On the surfaces of the higher mountains the water absorption begins to increase only in April, and in this period values between 100-200 mm are often observed in the mountains.

In April, on the plains and hills comprising a large proportion of the drainage basin, the total water supply comes from precipitation; in the summer this is characteristic of the whole basin. In the fall the surface water absorption significantly drops and on the territories 1,500 m above sea level the accumulation of snow begins, while in the Hungarian Plain and in the Transylvanian basin less than 30 mm precipitation occurs. This latter is mainly due to the Mediterranean climate connected to the Adriatic cyclones.

The data presented here suggest that the annual distribution of the precipitation is connected to periods and not certain seasons. Two characteristic periods can be distinguished: a "wet" period and a long "dry" one. The wet period sets in between April and August, the dry from September to March. The floods of the rivers do not exactly correspond to this temporal distribution, since the early spring flood and the high waters of the river in the spring are not caused directly by falling rains, but rather these are the consequences of the snow melt later.

In the drainage area of the Maros the melting of the snow is a quick process which significantly raises the stock of water. When the melting lasts longer, the slow and gradual water supply does not lead to floods. The Maros has two important floods in a year (spring and summer green flood), and both are equally dangerous. [2]. In the first case the snow melts in the mountains because of the strong insolation at the end of February. The river swells very quickly, but equally fast is the retreat of the inundation (8-12 days). The spring flood of the Maros precedes that of the Tisza, sometimes reaching its peak at Szeged when the inundation of the Tisza has not even culminated at Szolnok.

Since 80% of the Maros drainage basin is made up of impermeable layers and because of the significant differences in level and the significant slopes the Maros becomes a quick river. [2]. Considering the distribution of the precipitation within the drainage basin, we can approximate the dates of the floods. In the mountains and in the Transylvanian basin the quantity of precipitation increases from January to June and decreases from July to January. Therefore there are only spring and summer green floods on the Maros, and regularly it does not have a flood in the fall, as there are no larger and significant rains in Transylvania in the fall.

The precipitation of the drainage area is carried away by the dense water system of the Maros, therefore the water level of the river is influenced by the precipitation and the specific flow rate and the circumstances of the accumulation as well. The specific flow rate greatly varies, depending on the surface features, development and edaphic conditions of the given area.

In the high mountain areas of the drainage basin the specific flow rate is 30-50 $l/s/km^2$, in most of the Transylvanian basin it is 1-3 $l/s/km^2$, and on the plain it is below 1.0 $l/s/km^2$. Extremism characterizes the specific flow rate of the individual drainage basins of the affluents. For example, in the riverheads of the Arieş (Aranyos), Ampoi (Ompoly) and Geoagiu (Gyógy), the average flow rate is between 5-30 $l/s/km^2$, but the value corresponding to the highest water output is 350-1,000 $l/s/km^2$, and the lowest output is 0.8-1.1 $l/s/km^2$. The highest flow rate values are observed in the riverheads of the Sebeş (Sebes), Strei (Sztrigy) and Rîul Mare. Here the average flow rate is over 40 $l/s/km^2$, the highest output can be over 1,000 $l/s/km^2$, but the lowest output is 2.0-6.0 $l/s/km^2$. [13,14]. The affluents are characterized by the virulent changes of water level, the quick rise and the quick recession.

Hydrographically the drainage basin can be divided into two characteristic areas, a plain section and a basin surrounded by mountains. The varied territory of the drainage basin narrows down on the plain while it broadens in Transylvania. The territory of the drainage basin is expanded with asymmetric hydrographical characteristics especially east of Deva (Déva) [3]. The highest point of the drainage area is 2509 m in the Retezat (Retyezát) Mountains, the lowest point is 78 m above sea level where the Maros meets the Tisza (Fig. 1).

The Maros is a high falling river, running on elevated surfaces to its mouth and keeping its fall all along. The fall is evenly distributed. For example it falls 46 cm/km from Luduş (Marosludas) to Alba Iulia (Gyulafehérvár), 40-43 cm/km to Branişca (Braniska), to Săvîrşin (Soborsin), to Radna (Radna), and 38 cm/km from Radna (Radna) to Lipova (Lippa). On the Hungarian Plain, its fall decreases somewhat, but the number of the bends significantly increases. The development of the bends is especially important on the sections where the fall of the bed is small (Periam (Perjámos), Igreş(Egres) Cenad (Csanád), Kiszombor, Szőreg.)

On the Hungarian Plain the width of the bed also varies, for example its average width is 150 m between Radna (Máriaradna) and Pecica (Pécska), 180 m between Pecica and Csanád, and 100 m between Csanád and Tápé. The riverbed stretches out on the plains so that its water depth becomes shallow, while at other sections it narrows and deepens.

There can be distinguished four sections of the riverbed with uneven falls: l. Lipova (Lippa) - Arad, 39.8 km, 0.28 m/km fall; 2. Arad-Pecica, 23.6 km, 0.44 m/km fall; 3. P ecica- Canad , 52.6 km, 0,28 m/km fall; 4. Canad-Tápé, 37.5 km, 0.13 m/km fall.

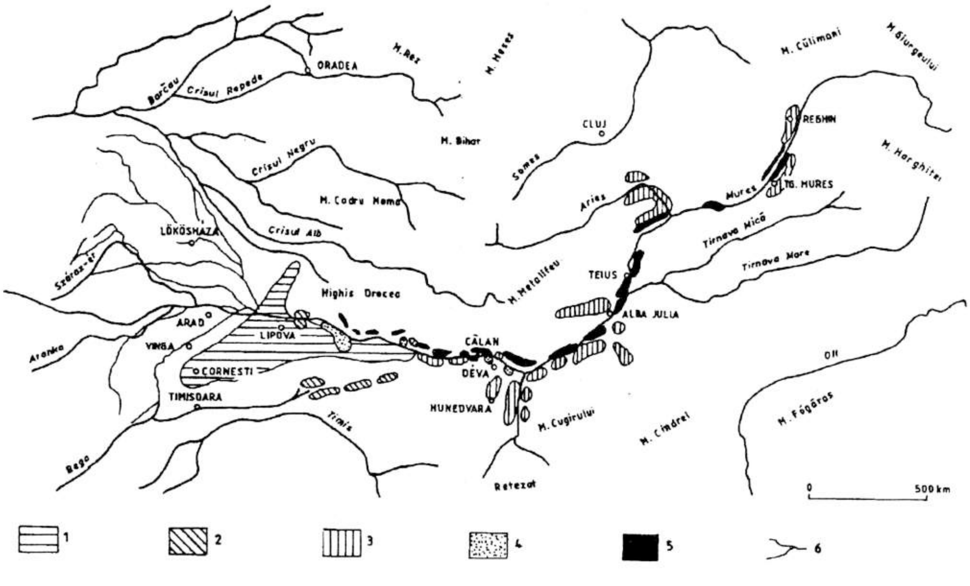

Fig.4. Terraces of the Maros in Transylvania and the traces of its old bed on the Hungarian Plain (source: OHV map). l. Levante pebble deposit; 2. Günz terrace traces; 3. Mindel terrace remnants; 4. Riss terrace remnants; 5. Würm terrace remnants; 6. Old Holocene Maros bed lines

The environment of the riverbed is varied by terrace formations of different ages. Of these, the Old Holocene terrace can be found occasionally 10 meters higher than the average water level of the river. These terraces are not covered even by the highest flood. The Holocene terrace is made up of mainly alluvium piled up in the Pleistocene, rinsed through and restructured by the floods of the river. Several upper Pleistocene terraces can be observed which do not form a continuous terrace system. (Fig. 4) These are 20 m above the river flats. A coarse pebbly layer containing loess and red clay covers the Pleistocene terraces.

In the mountain valley there are several Pleistocene terrace remnants that can be found 40-60 m above the river flats. In the mountain section different reefs of rock frequently emerge from the river sediment. Occasionally there are no terraces and the river had deepened into the bedrock (between Deva and Lipova).

On the Hungarian Plain section of the Maros a different development of the valley from the Pliocene till now has taken place. Leaving the mountains, the river built a talus which is fanning out. Only in the Holocene did the river take on a definite direction on the alluvial system and this riverbed usually coincides with the seismotectonic lines of the Hungarian Plain. [11].

On the drainage basin of the Maros the dense river system of the affluents comprise about 430 streams. [9..14]. (Fig. 5).The latest Romanian map shows only 161 streams meeting the Maros, classifying 50 of these as periodically drying up. [15]. The map in the appendix paid special attention to the brooks with permanent water. In the appendix the indication of the comprising drainage areas are evaluated according to the river parameters. We could divide the Transylvanian territorial drainage basin of the Maros into 18 mountain drainage units.

Drainage units of the Maros

The Maros riverhead

The riverhead is comprised of the short reach mountain streams of the slopes of the Harghita, Gurghiu , Giurgeu Mountains, (Hargita, Gögényi-, Gyergyói havasok). The main spring branch can be found on the territory of Izvorul Mureş (Marosfő), on the lower mountain ridge in the direction of the Harghita and Giurgeu Mountains (Hargita and Gyergyói havasok). The mountains structurally surround the Giurgeu (Gyergyói) basin, and in its axis the Maros is navigable at 15 km from its spring. The basin is covered by sediments of varied composition. The right valley slope is made up of cristalline rocks, while the left valley slope is of andesite and tufa. Several of the mountain streams are left side affluents, there are considerably less streams on the right side. The spring of the river is at 856 m above sea level. It meets a major affluent, the Toplipa (Maroshéviz), at 656 m above sea level. The territory of the drainage area is 1297 km^2 with 997 m average surface height. Since the sloping is 192 m/km, the river becomes speedy and its high water disappears from the bed in a very short time.

The Toplipa and its watershed system

The Toplipa collects the water of the slopes of the Eastern Carpathians and the Călimani Mountains (Kelemen havasok). It is one of the main right side affluents of the Maros with a 212 km^2 drainage area and 254 km/km^2 surface fall. The river is only 29 km long, but its fall is considerable, 38.7 m/km. 14.,15. The southeastern slope of the drainage area is mostly a transition between the luw and lee type slopes. Because of this, compared to the mountain areas the precipitation significantly decreases (between 500-700 mm). The density of the water system is 0.7 km/km^2, but this value is generally characteristic on the crystalline and volcanic blocks of the high mountains.

Fig. 5. 1. Border of the mountain drainage area of the Maros 2. Borders of the supplementary drainage areas 3. Surface hydrography of the major brooks and streams. Names of the major streams: a =Maros; b=Tirnava Mică; c=Tirnava Mare; d=Toplița; e=Luț; f=Comlod; g=Luduș; h=Arieș; i=Ampoi; j =Dobra; k=Cerna; l=Strei; m=Sebeș; n=Secaș; o=Niraj; p=Gurghiu; r=Almaș; s=Pîriul Mare; Names of settlements: A=Gheorgheni; B=Toplița; C=Gurghiu; D=Batoș; E=Cetatea de Balt; F=Tîrgu Mureș; G=Aiud; H=Remetea; I=Turda; J=Abrud; K=Zlatna; L=Alba Julia; M=Miercurea Sibiului; N=Deva; O=Hunedoera; R=Zam; T=Rodna; U=Lipova;

The highland Maros bed

After meeting the Toplița, the river turns west, and runs in a transversal valley between the Gurghiu and Călimani Mountains (Görgényi and Kelemen havasok). The streams running toward the highland Maros bed are short reach with consequent water. The river density is 0.7-0.8 km/km^2, the data collected over years suggest that the average quantity of water is 30-50 l/sec/km^2.

The Gurghiu (Görgényi) stream and its drainage area

The Gurghiu (Görgény) leads the waters of the Northwestern Harghita and the northern slopes of the Gurghiu mountains (Görgényi havasok) to the Maros. The drainage area is composed of a mountain and a hill drainage basin. Both surfaces are built up of impermeable (volcanic, crystalline and clayey) formations. The western slope of the highest surface of the area, Sacă (Mezőhavas), 1777 m a.s.l. has over 1,000 mm precipitation per year. This significant quantity of water develops on a 564 km^2 area the sloping of which is 216 m/km. The high speed riverbed slopes 17.0 m/km. There is also a notable average surface height of 910 m above sea level.

The Luț (Lucz) and its drainage area

The riverhead of the affluent can be found on the southwestern fore area of the Călimani Mountains (Kelemen havasok). Meeting the Batoş (Bátos) stream after a relatively short section, their bed cuts deep into the alluvial sediment of the mountain foot. Also, the lower bed is relatively deep because of its tectonic origin. The total area of the two drainage basins is 460 km^2; the Luþ (Lucz) is 42 km, the Batoş (Bátos) is 127 km long. The other hydrographical characteristics of the area are the same as those of the Cîmpia Transiveniei (Mezőség) hills.

The Cîmpia Transiveniei (Mezőség) and Dealurile Mureşului (Marosszék) section of the Maros

The drainage basin is comprised of short-reach brooks and streams. On the right side of the river lie the Cîmpia Transiveniei (Mezőség), on the left there are the Dealurile Mure°ului (Marosszék) hills. The direction of the hill line reaching across the area is parallel with the direction of the rivers running from the northwest to the southwest. The slope of the stream beds is even, their valleys are narrow, the surface of their environment is characterized by bare altitudes and badly watered rifts. The covering sediment of the drainage basin is sandy, clayey; the upper layer is of good water permeability, but below 1 m an impermeable formation can be found. Therefore, especially in springtime when there is a lot of rain, landslides occur on the valley slopes, that is, the soil fills up with groundwater and slides down to the valley. Especially cloud-bursts cause greater landslides.

The Niraj (Nyárád) stream and its drainage area

The drainage area of the stream can be found on the western slope of the Gurghiu Mountains (Görgényi havasok). The area is 609 km^2 with the average fall of 136 m/km. With its spring at 1,300 m a.s.l., the 78-km-long river collects the precipitation and snow melt of the Gurghiu Mountains (Görgényi havasok) at 13.0 bed fall. The average slope of the water drainage area is 133 m/km, but the average height is 512 m. The water-levels of the Niraj (Nyárád) are characterized by high inundations developing in the mountains which reach the lower parts of the basin causing tragic floods and damage.

The drainage area of the Comlod (Kapus) and Luduş (Ludas) brooks

Showing the same features, these brooks collect the waters of the Cîmpia Transilvaniei (Mezőség) hills. They are 60 km long, their drainage areas are similar, the two stream systems have 1175 km^2 drainage area with 120-130 m average sloping. The mouths are at 270 m above sea level, the fall of the beds is 0.5-0.25 m/km. There are several water basins (storage lake) by the bed line of Luduş in the inner and wide valleys of the hills. The drainage basin is mostly covered by impermeable sediment (sandy clay) where areal wash-off and landslides frequently occur. The area receives only 600 mm annual precipitation and the annual average temperature is 8-9 ^{o}C.

The drainage are of the Tirnava Mică (Kis Küküllő)

The branches of the Tîrnava Mică(Kis-Küküllő) river head can be divided into two parts. The northeast streams spring on the southwest slope of the Gurghiului Mountains between the Bucin (Bucsin) peak and Sacă (Mezőhavas). The southwest streams come from the northern slope. Running northwest through the Praid (Parajd) salt territory, the two branches unite at Sovata (Szováta). The stream turns southwest on the neogen rocks of the hills and merges with the Tîrnava Mare (Nagy-Küküllő) before meeting the Maros. The mountain stream is 294 km long, its drainage basin is 17,820 km^2. The spring is 1190 m, the mouthis 219 m above sea level. The average height of the drainage area is 636 m, the average slope is 176 m/km. The fall of the bed is 5.0 m/km, the average water output of the river is 8.0 m^3/sec.

The water drainage area of the Tîrnava Mare (Nagy Küküllő)

The spring branches of the river can be found at 1455 m above sea level on the slope of the Harghita (Hargita). The Somlyó Ridge stretching south divides the river head into a western and a northern territory. The streams running down the Harghita (Hargita) are abounding in water. After several streams meet, the Tîrnava Mare (Nagy-Küküllõ) first turns southwest, then west, and cuts through the Tînava Hills. On its way it receives several streams on the right side that spring on mostly trachit rock textures and then, when reaching the basin, they draw on the water supply of the neogen surface covering sediment. Of the affluents we should mention the Sărat (Sós), Fejérnyik, and Gagy streams, and the Soimuş (Solymos) border stream. On the left side of the river there are only insignificant streams, draining the water of the neogen clayey surfaces. At its mouth, the Tîrnava Mare is at 223 km a.s.l., the drainage area is 3606 km^2, with 564 m average height and 150 m/km average slope. On its lower part it carries 13.0 m^3/sec water; the water output of the united Tîrnava is 22.0 m^3/sec.

The Arieş (Aranyos) stream and its drainage area

The Arieş is one of the main affluents of the Maros, its riverhead is on the southeast slope of the Bihor (Bihari) Mountains. After its several branches meet as Arieş, the river collects the water of the southern parts of the Gilău (Gyalui) Mountains and the northern parts of the Transylvanian Mountains. The weesterly riverbed becomes quick, then it reaches the Arieş(Aranyos) hills and meets the Maros with a southeast bed. The 164 km long river has a 2970 km^2 drainage basin and a significant (215 m/km) average fall. The riverhead is 1195 m, the mouth is 263 m above sea level. Because of the different characteristics of the surface, the fall line of the riverbed varies. Compared to the previous, the fall of the bed is so even, that the fall is only 5.68 m/km. The density of the water drainage area is between 0.8-1.2 km/km^2. Since the surface gets high precipitation (between 1.000-1.300 mm), the average of the mean water output significantly increases (23.5 m^3/sec).

The drainage area of the Ampoi (Ompoly) stream

The stream collects the water of the river heads of the middle Apuseni (Nyugati) Mountains. The valley runs on mostly mountain areas where mesoic and tertiary rocks form the surface. The composition of the rocks is mainly sandstone and conglomerate with good water permeability. In the drainage basin there are several locations where Jurassic lime, augit, porphyrit and hornstone can be found. The area is 576 km^2, the stream is 60 km long. The spring of the stream is 1220 m, the mouth is 219 m above sea level. The slope of the drainage basin is significant, 253 m/km, and so is the fall of the river bed (17.16 m/km). The mean water output of this highly falling river is only 1.3 m^3/sec because of the lack of precipitation in the drainage area since the surface features produce a foehn effect on the lee side expositions.

The drainage area of the Sebeş (Sebes) and Cugir (Kudzsir) streams

The drainage basin can be found on the northwest territory of the Cugir (Kudzsiri) Mountains where several quick brooks and streams run on the high slopes. In the mountain areas the covering rock of the Cugir (Kudzsir) and Sebeş (Sebes) drainage areas is crystalline shale and other impermeable formations. The covering sediment of the hills of the northern fore area is Pannonian clay, while in the immediate Maros valley we find washland sediment.

In the dry period the high falling streams are supplied by springs only, which are quite abounding in water. After the thaw and storms the streams swell and bring large quantities of debris and blocks of stone down from the high mountains, only to leave them behind rounded in their low and narrow valley. There happens a large scale pounding because of the large fall, but these streams leave considerable amounts of coarse pebbles even in the Maros valley.

The spring of the Sebeş (Sebes) is 2060 m above sea level, its united drainage basin with that of the Secaş (Székás) stream is 1289 km^2. With its affluents, the Cugir (Kudzsir) stream north of this drainage area drains the water of similarly exposed slopes. The riverhead of this stream is 1900 m above sea level and its drainage basin is 358 m^2. Although the slope of the surface is considerable (280 m/km), the fall of the riverbed is only 28.2 m/km and the mean water output is 4.0 m^3/sec. The same characterization applies to the brook system of the Sebeş (Sebes), which has a 1800 m difference between its source and mouth. The fall of the 93 km valley is 20.1 m/km. The water characteristics of the flow in the two drainage basins are similar.

The drainage area of the Strei (Sztrigy) stream

Of all the affluents of the Maros, the highest surface stream density can be found in the stream system of the Strei (Sztrigy). The drainage area stretches out on the Northern Cugir (Kudzsuiri) Mountains, the Eastern Retezat (Retyezát) Mountains and the Northeastern Semenic (Szörényi) Mountains. The spring of the Strei (Sztrigy) is in the Cugir (Kudzsiri) Mountains 1600 m above sea level. After meeting several affluents, the 92-km-long river reaches the Maros at 170 m above sea level. Of its affluents, it is worth mentioning the Rîul Bărbat (Borbat: its spring is 1880 m above sea level), the Lapuşul Mic and Mare (Kis and Nagylápos; 2216 m), the Rîul Mare and the Rîul Secaş. The whole drainage basin, including the drainage areas of the affluents, is 1926 km^2. The streams mentioned here run across territories with an average slope of around 267 m. All the stream valleys have, on the mountain sections, torrential beds. The bed of the Strei (Sztrigy) falls 15.5 m/km; the mean water output of this quick river is 23.3 mg/sec. On the higher mountain drainage areas there are mainly crystalline shale, Crete sand and limestone, while on the hills we can find Neogen clayey formations. It is characteristic that the pebble terraces by the valleys are formations of the Pleistocene period and the sediments of the immediate washlands are recent formations. In the hills the river valleys have wide north-south washlands and along these there are wide pebble terraces to the Maros. The crystalline mountain area rises from the hills very suddenly and this accounts for the torrents and the fast flow rate of the streams.

The drainage area of the Cerna (Cserna)

The drainage area can be found on the eastern slopes of the Poiana Ruscă Mountains. After meeting its mostly east-west affluents, the river bed turns to north on the hills in the Maros valley. The spring of the 78 km long Cerna (Cserna) can be found 1.130 m above sea level and it reaches the Maros at 184 m a.s.l. This relatively short river has a significant fall (960 m), the slope of the bed is 13.15 m/km, therefore this is a stream system with a quick flow which shows extreme water levels (the mean water output is 3.3 m^3/sec). The drainage basin is 738 km^2 with 229 m/km average slope. The rock surface influencing the surface flow is similar to that of the Strei (Sztrigy) area.

The drainage area of the Dobra

Of the several short-reach streams on the northern slope of the Poiana Ruscă Mountains, the Dobra is worth mentioning. Between Deva (Déva) and Lipova (Lippa) the Maros valley narrows. The spring of the 43-km-long Dobra can be found in the Poiana Ruscă Mountains, at 1,100 m above sea level, and it reaches the Maros at 162 m. The relatively short river runs through 938 m level difference which causes a significant (21.8 m/km) fall in the system where the mean water output is only 0.95 m^3/sec.

The drainage basin of the Almaş (Almás) and the Bîrzava

From Deva (Déva) and Radna (Radna) on the right side of the Maros on the slopes of the Zărand (Zarándi) Mountains there is a system of short reach and high falling rivers.

These relatively narrow, high-gradient streams are usually seasonal with relatively low water outputs from precipitation and their springs.

The drainage area of the Pîrîul Mare

The drainage basin collects the water of the short reach valley system on the left side of the Maros, which belongs to the immediate fore regions of the Hungarian Plain. The river cut its bed on the surface into its previous Levante and Pleistocene alluvium. Mostly the springs and the groundwater supply the short reach stream system with water, because, similarly to the Hungarian Plain, the area receives a relatively small quantity of precipitation.

Summary of the main hydrographical characteristics of the Maros drainage basin

- The riverbed and the flood plain of the Maros with the 30,000 km^2 drainage basin make the river one of the most important affluents in the Tisza river system.
- On the surface of the Hungarian Plain drainage basin there are sandy and clayey formations, while in the basin and in the mountains crystalline volcanic and clayey impermeable formations occur. In the river system permeable formations can rarely be found.
- The areal rate and speed of the flow in the supplementary drainage basin is determined by the slope and the impermeable covering formations.
- The floods rising suddenly on the affluents of the Maros in spite of their quick flow are equalized in the nearly 300-km-long riverbed.
- The quick disappearance from the supplementary drainage basins leads to floods almost every time there is a large quantity of precipitation. However, the floods disappear as suddenly as they have appeared.
- The floods of the Maros can be approximated on the basis of the distribution of the precipitation in the drainage basin and the water absorption of the supplementary drainage basins.
- The distribution of the precipitation over the year in the area depends on periods rather than seasons of the year. The two characteristic periods are the "wet" (May-August) and the "dry" (September-April) periods.
- The Maros has two floods, the spring and summer "green floods". Both cause inundations on the lower section of the Tisza.
- At Szeged the flood caused by the spring thaw usually appears earlier than the Tisza inundation, therefore catastrophes are avoided.
- In the summer the Transylvanian basin receives only little precipitation, therefore on the lower Tisza the summer inundation flattens out and here spring floods are more significant.
- The river line is followed by segmented terrace formations from different periods (Holocene- Pleistocene) the average height of which is 10-80 m above the water level of the river.

- The rocks of the terraces are comprised of coarse sediments and clayey formations of surface erosion.

- In the upper regions the Maros meets spring waters containing sodium, sulfate, magnesium, iodine, bromine and ammonia, but this does not lead to natural pollution because the water of the river becomes clear due to its quick flow and the considerable amount of alluvium.

- The deterioration of the water cleanness is mainly caused by anthropogenic pollution. The industrial areas and agglomerations of human settlements are responsible for the water pollution that is especially significant in the territories of the supplementary drainage basins (Arieş, Tîrnava, Strei, Cerna) and larger towns (Tîrgu Mureş, Alba Iulia, Turda (Torda), Deva, Arad, Mezőhegyes, Makó).

- The deterioration of water quality caused by anthropogenic pollution reached catastrophic dimensions with the presence of large amounts of cyanide, phenol suspensions, ammonia, nitrate, household and other chemical materials. Although it must be noted that there is a certain self-cleansing process due to the quick flow of the river, the huge water output of its floods and the quantity of the alluvium it carries, but still, the Maros River needs effective water protection.

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Mihály Andó, Physical Geographical Institute, Attila József University, H-6701 Szeged P.O.Box 659 Hungary