Hydrographic description of the Körös/Criş[1] riversystem

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Introduction

Concerning the dimension of their catchment area, the Körös Rivers, situated in the western system of the Erdélyi Szigethegység/Munții Apuseni, are the second among the tributaries of the Tisza/Tisa River. The catchment area collects the waters of 27,537 sqkm.The backbone of the river-system consists of five rivers running together like the form of a fan: they are the Fehér-Körös/Crişul Alb, the Fekete-Körös/Crişul Negru, the Sebes-Körös/Crişul Repede, the Berettyó/Barcău and the Hortobágy-Berettyó, of which the first four get their water from the western slopes of the Erdélyi Szigethegység, whereas the last carries off the waters of the Tiszántúl (the plain east of the Tisza River). The highest peak of the Bihar/Bihor Mountains, which forms the main bulk of the Erdélyi Szigethegység, is the 1849 m high Nagy Bihar/Curcubăta, but Vigyázó/Vlădeasa, situated at the northern edge, isn't much lower either, with a height of 1838 m. In the western part of Nagy Bihar, at a height of 1460 m, the Fekete-Körös River rises, and towards the south, on the slopes of Erdélyi Érchegység/Munții Metaliferi, at a height of 980 m the Fehér-Körös River rises.

The distribution of the catchment area according to height is 0.2% high mountain (2900-1600 m), 0.5% mountain of medium height (1200-400 m), 20.5% hill (400-200 m), 52% plain (100-70 m). The size of the catchment area is 27,537 sqkm, total length of the rivers is 3345 km, of which the length of the Fehér-Körös River with its tributaries is 645 km, that of the Fekete-Körös River with its tributaries is 910 km, the length of the Sebes-Körös together with its tributaries is 80 km. The Körös Rivers, the Fekete-, the Fehér- and the Sebes-Körös, are significant rivers flowing across the western part of the Erdélyi Középhegység. They collect and transport the waters of the Réz/Plopisului Mountains, Vigyázó, the Bihar Mountains, Királyerdő/Pădurea Craiului Mountains, Béli/Codru Mountains, Erdélyi Érchegység, and the Zarándi/Zarandului Mountains)[(1 9)].

1 The first name is Hungarian and the second Romanian.

In the east the catchment area is separated from the Szamos/Someş River and the Aranyos/Arieş River, a tributary of the Maros/Mureş River, by the Bihar Mountains. The eastern part of the mountain range dips steeply into the Transylvanian Basin; to the west, however, it sends out huge branches towards the Tisza River. In quite a lot of places the watershed runs not along the peaks of higher mountains elevated by volcanic eruptions and broken by chasms, but along the more smoothly-sloped ridge of the lower ancient mountain range (Fig. 1.).

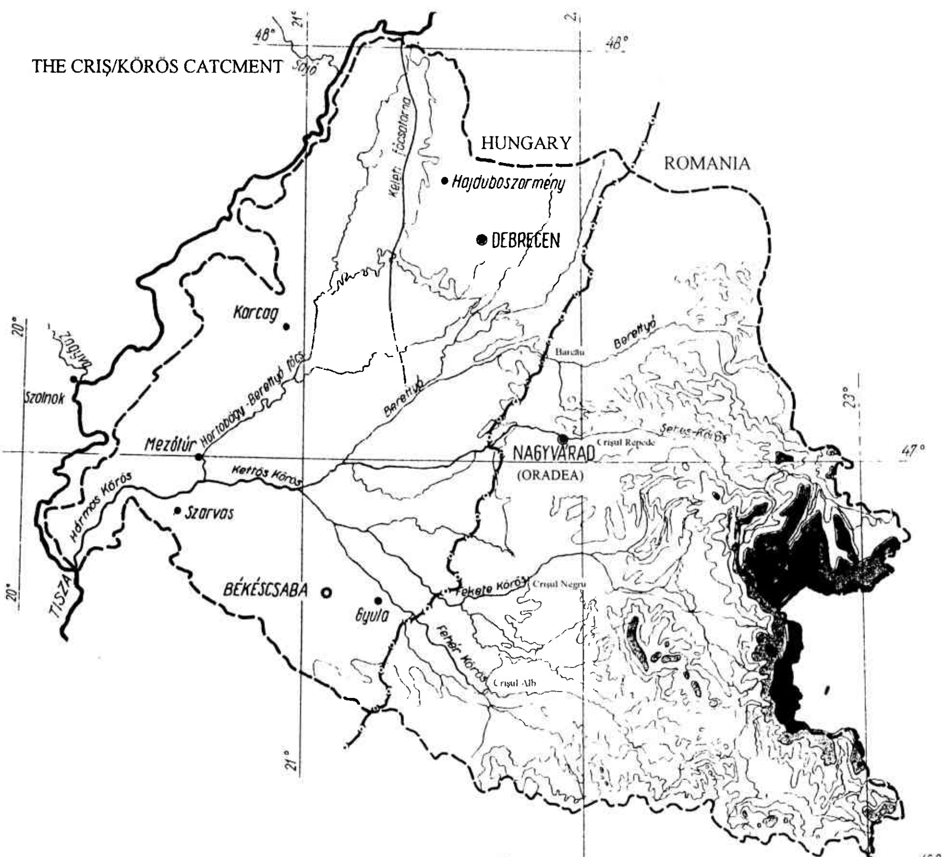

Fig. 1. Catchment of the Körös river system (by VITUKI)

The orographical and geological features of the river-system

The regional relief of the mountains have a structure distinct from one another. the Transylvanian Szigethegység is characterised by a rock mozaic, which consists of mainly crystalline, volcanic and sedimentary rocks. Structurally it consists of three parts:

1. Bihar Mountains.
2. The Béli Mountains in the north-western regions.
3. The mountain chain consisting of sedimentary rocks, along the Maros River in the southern regions.

The central parts of the mountains are the crystalline mass of Bihar (1849 m) and the Gyalu crystalline rock featuring a so-called 'Öreghavas' granite intrusion. The rock has suffered clotting and tectonic restructuring. Its surface is sporadically covered by Upper Palaeozoic, Tertiary , Jurassic and Lower-Cretaceous epicontinental sedimentary patches amongst Permian-Cretaceous formations [1 11 15 16].

Orographically, the Bihar autochton is divided into two parts by the Vigyázó banatite massif. Neogene intramontaneous sedimentary basins can be found between the bare Meszes/Mereşului and Réz Mountains in the north west as well as the Mesosoic topped Királyerdő crystalline formations. The sedimentary cover of the southwestern part of the autochton is divided by transversal faults forming uplifted blocks in the north and downthrown ones in the east. These blocks have a step-like structure with a general slant to the west. The highest step in the Northeast is the ravine of the Meleg-Szamos/Someşul Cald, the second Southwest bound one is the chalk of the Pádis/Padiş block.

The final structural touches of mountain-formation were added by the Upper Cretaceous movements of the Earth's crust. In the Laramian the mountains acquired an uplifted position, followed by vast erosion. According to our present knowledge, during the Palaeocene this area must have been dry land. That is when the first tropical, a wetter and warmer denudation phase must have taken place.

Banatite magmatism, playing a major role in the structural evolution of the mountains began after the Laramian and lasted until the end of the Eocene. In the Neogene (Badenian) the mountains became dismembered, intramontane depressions were formed Báród/Borozel, Belényes/Beiuş and Zanárd/Zărand Depressions into which a Middle Miocene brackish sea intruded [1 11 19 22].

Thus, the era of the major mountain-formation is the Upper-Tertiary. This 'Carpathian Orogenesis' wrinkling the outer ring of today's major ranges in Central Europe was only capable of causing faults in the inner mountaneous areas. It was during the formation of these faults that the large interim body forming the inner area of Hungary subsided and gained its present relief, including, among other inner mountains, the Bihar Mountains.

There are two dominating fault orientations in the mountains, one stretching from the Northwest to the Southeast, the other from the Northeast to the Southwest, the latter being predominant in the mountain's formations. Such is, for example, the Drăgan fault line,

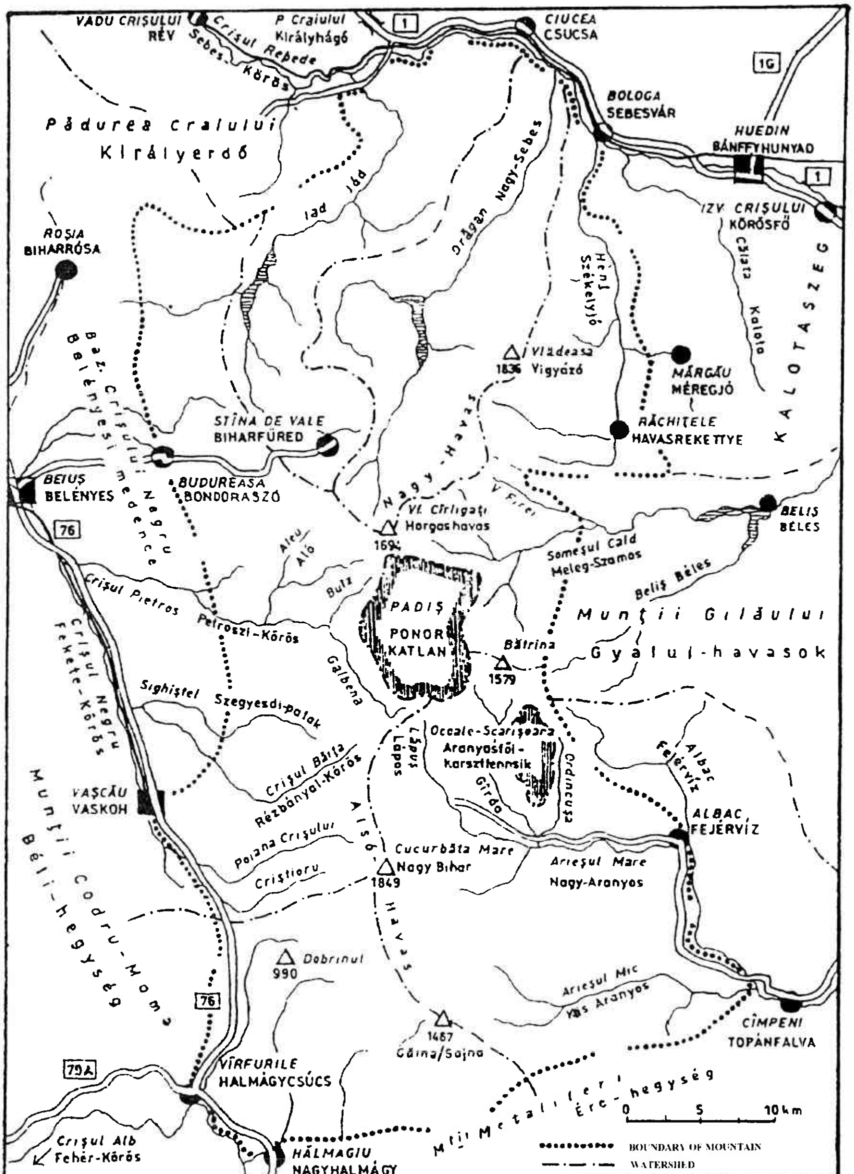

Fig. 2. Catchment areas of the Bihar Mountain (by Mátyás V.)

separating a crystalline slate area in the Northwest from the Vigyázó dacite-andesite eruption domain. These two diagonal orientations, predominant within the whole of the Carpathians with faulty structure, are especially apparent in the Hungarian Range. The fact that the Northeast - Southwest oriented faults can only be traced in the internal structure of the Bihar Mountains, whilst Northeast—Southwest bound ones can be found in the marginal areas of the depressions with Pliocene sedimentation as well, allows the conclusion that the latter is the younger one.

Another direction that can be traced in the outer areas of the mountains rather than in the inner formations is the north - south oriented subsidence of the central part of the Bihar Mountains, the so-called Nagybihar, towards the Fekete-Körös Basin. Here the boundary between the older formations and the Neogene basin sedimentation is so clear-cut and straight, the western slope of the mountains drops so steeply from a height of 1800 m to the basin of about 300 m that the only phenomenon we can think of here is a normal fault [16].

The fault adjacent to the Fekete-Körös Basin can further be traced northward up to the ravine of the Sebes-Körös. Here, locally, it takes on a West-Northwest—East-Southeast orientation and the depression is filled with Miocene sedimentation.

Hydrologically speaking, the directions of these structural faults are in close association with the karstic plateau in the Apuseni mountains. One of the most imposing of them is the 'Pádiş' Plateau, spreading over about half of the plateau area and is considered to be the largest hydrographic depression in the north (Fig. 2.). The depression is surrounded by 1200 to 1600 m high mountains with highly impermeable rocks which are not pierced by walleyes; Kék Magura/Măgura Vânătă, Varasó-havas/Vărăşoaia, the Boga/Boga Mountains, the Oşel, Tămaşca and Biserica. The smaller and larger stream like the Catirol, Reghii, Arsurii, Tringhieşti and Gârjoaba originate here to create karstic features on the surface, later, mostly unseen to the curious eye, under the ground [8 19 22].

These streams, having covered a couple of kilometres through the foothill terrain covered with talus debris arrive at the limestone plateau to disappear in their own gullies easily finding simpler of more complicated routes under the ground and surface in the form of karstic springs (Fig. 3.).

Significant limestone plateaus can also be found in the Bél mountains, the Király Forest and the Torockó/Colţii Trascăului Mountains. In these limestone ranges can be found a significant amount of caves, the longer one is the Szelek/Vânturilor Cave in Királyerdő, with a length of 31,338 metres. Until the June of 1977 455 cavities were known in the Bihar Mountains with 367 caverns and 88 caves. A total of 66,552 m of channels have been traced with a 5,076 m difference in height (Fig. 4.) [8 19].

The geological, tectonic and structural features of the Transylvanian Mountains with the limestone terrains had a considerable effect on the hydrographic scenery. The depressions formed during the tectonic subsidence in the northern and western foothills of the crystalline massif to a great extent have predetermined the direction of the brooks and along with the structural rearrangements several isolated mountains were formed of the so-called 'Magura' type.

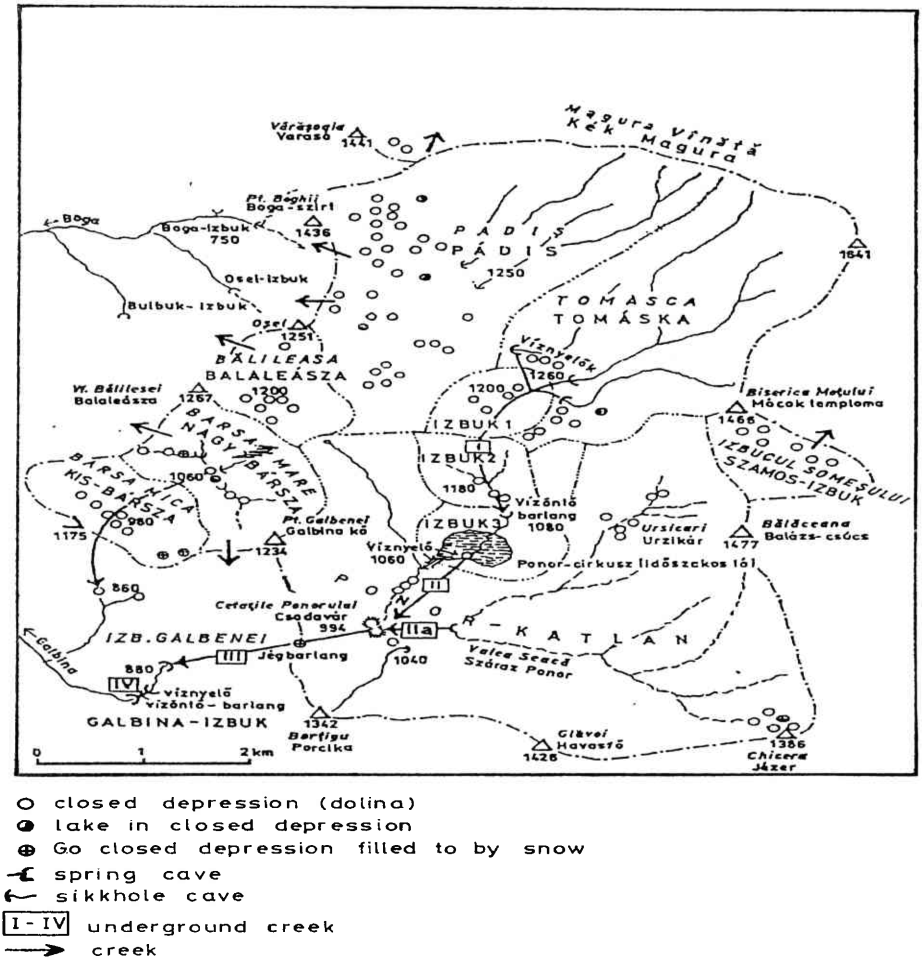

Fig. 3. Water system of the Padiş-ponor

The low mountains of the foothills between depressions of the relief gradually transgress into a low hilly countryside. This hilly countryside can be traced from the Northwestern foothills of the Réz Mountains southwards, down to the Zarándi Mountains. The hilly area surrounding the mountains has been vertically pierced by the gullies of the rivers (Fehér-Körös, Fekete-Körös and Sebes-Körös), flowing from the mountains. The valleys predominantly run from the Southeast to the Northwest but there are ones stretching

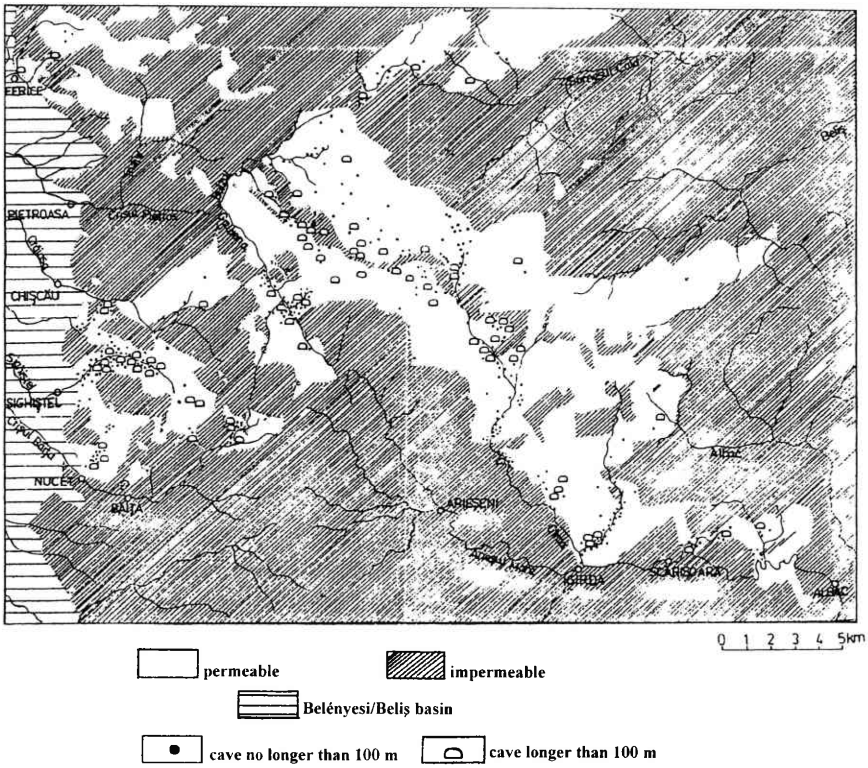

Fig. 4. Location of caves of the Bihar Mountain (by Bleahu)

from the east to the north. The flood areas of the valleys is sculptured by the andesite and andesite breccia from the country rock. The height of the terrain seldom exceeds 300 m and the country rock of the sedimentary rocks is not deep. The rivers of the mountains and foothills play a very important role in the valley-formation. Most of the valleys can be subdivided into three parts; the upper one is in the mountains, the second one is in the hilly area, and the lower section, especially in the case of larger rivers is the Great Hungarian Plain or other wider plains in the ravines [13 15].

The development of the ravines is most precisely reflected in the formation of terraces. In the Transylvanian Mountains it resulted in 5 to 7 terraces. Chronologically the terraces are pedestals of the evolution of the surface. Terraces and ravine plains can be found all along the Körös Rivers with the exception of the mountainous stretches and canyons. In the isolated intramontaneous and in the Great Hungarian Plain there are several areas with non-agitated waters, peat and peat bogs. In view of the dip of the ravine and several basins it is necessary to drain these areas and make use of the land [10 13].

West of the foothills to the ravine of the Tisza River lies the plain of the Körös water system. In Romania the western hilly area is not a separate unit, since its relief is transitional between a mountainous and a plain one. In its deep structure, thermal springs along the fault lines peg out the direction of the faults. The expansion of the plain parts in the foreground of the Bihar Mountains is a flat terrain, typically 20 to 60 km wide where the dip of the rivers is very small, waters here flow very slowly, in several areas they do not flow at all. They try to sort out the difficulty by excavating drainage canals, but, in spite of the effort, there are several vast bogs in the region. The stretch in the Plain is characterised only by two areas; the lower and the higher plain parts of insignificant area (e.g. the 140 m high Nagykároly/Carei plain with sand-hills and dunes and the southern Arad and Vinga plains at an altitude of 100 to 112 m) [9 20].

In the plain section of the Körös Rivers there are terrains of considerably lower altitude of 80 to 100 m and this relief has been a problem from hydrographic and hydrological point of view.

Climatic Features

The catchment area of the Körös Rivers is under the effect of air currents from different climatic centres. The most frequent one is the Atlantic impact called the western, oceanic cyclone which has an effect throughout the year and lasts, in an alternating fashion, several days. It is responsible for 45% of the total of the impact. In wintertime it softens the bite of the frost and brings ample precipitation. In summer it brings about changeable weather with ample precipitation especially in the northern parts of the catchment area.

The polar current is Southeast bound and is responsible for 30% of all the climatic changes. Mixed with moist air flowing from the northern regions of the Atlantic Ocean results in the drop of the temperature, cloud formation and local showers. Occasionally, its northern variation spreads over Transylvania in spring, summer and autumn. On these occasions temperatures drop considerably. In winter, it causes extreme cold in the intracarpathian basins. It is accompanied with blizzards and high winds blowing at 100 to 150 km.p.h.

Tropical warm currents are responsible for 15% of the total of the impact. They result in the considerable rise of the temperature. Its southern - south-western variety is a body of air, carrying wet, 'Mediterranean' cyclones, whilst the south-eastern variety is an anticyclone, responsible for the dog days of the summer. The Mediterranean cyclone is more frequent in winter, but it sometimes appears in autumn in the Southwest. It is most influential in the Bánság/Banat, which is manifested in ample precipitation.

In winter, air from over the Mediterranean makes the weather milder and, on several occasions, causes heavy snowfall in Transylvania. The varied relief of the Körös catchment area significantly influences and modifies the effect and characteristic features of these currents. The effect of the relief is twofold; on the one hand, due to the differences in altitude, at levels of 100 to 1840 m vertical climatic temperature belts are formed. These differences in relief and climate are reflected in fauna stratification of different composition. On the other hand, the mountains and ranges like dikes tower in the way of the air flow. This effect is especially apparent in the case of air flow towards the Ocean. On the western side of the mountains the air rises, clouds roll and orographic precipitation is formed. In the eastern part towards the Transylvanian basin downward dry winds prevail.

The ravines and depressions in the varied mountainous and hilly terrain alters the direction and effect of the air currents. Temperature inversion, dry downward winds and the varying intensity of radiation on the slopes facing west are very frequent.

The constituents of the weather and climate, namely the sunshine, temperature, winds, pressure, moisture content and the distribution and manifestation of precipitation show a varied picture against the varying terrain. The amount of sunshine on the plain of the Körös Rivers is 120 to 122 kcal/cm^2, in the hilly area it averages 115 to 117 kcal, and, on average, it is lower in the mountaneous regions due to the deeply dissected terrain and mountain slopes.

According to the terrain, the temperature varies, too. It is the coldest at alpine levels of the high mountains, where above an altitude of 1,800 m the mean annual temperature is 2 degrees centigrade. In mountains of medium height it is 2 to 6 degrees. In the inner fore-mountains and foothills it is 6 to 8, approaching the plain of the Tisza River it is 8 to 10 degrees, and, finally, in the Berettyó - Körös depression the annual mean temperature is 10 to 11 degrees centigrade. The distribution of the precipitation in the mountainous regions also depends of the terrain; 800 to 1200 mm in the mountains, 600 to 800 mm in the hilly part and 500 to 600 mm in the Plain.

The climatic factor is manifested in ample precipitation. This is coupled with the rock quality on the surface. These two factors are responsible for the density of the water systems which, in the west, is 1 km/km^2 with the exception of the karstic areas where the density is much lower, not exceeding 0.7 km/km^2 even in the eastern parts of the mountains[14].

Water output is not very high, but considerable hydroelectric systems have been established collecting the waters of several local brooks.

The area of the Körös Rivers in Hungary belongs to the warm, moderately dry climatic belt with hot summers[120]. As compared to the central parts of the Plain, the climatic effect of the Transylvanian Mountains is rather apparent here. This effect is seen in the extra amount of precipitation, in the higher number of cloudy winter days, higher percentage of moisture in the air, but can be seen in the regional air flow as well. For example, the channel effect between the Apuseni Mountains and the North Hungarian Range sets the predominant wind direction. Furthermore, in anticyclonic position, a mountain - valley circulation may occur between the verge of the Hungarian Plain (Sárrét), and the mountains.

Due to the position of the Körös catchment area in the Plain, it receives a considerable amount of energy; 106 kg cal/cm^2. At the same time, a considerable percentage of the energy is used to evaporate the water from the relatively moist surface, thus, the temperature here is not indicative of this extra amount of energy. The annual number of hours of sunshine is in close relationship with the amount of cloud. The average annual amount of cloud in the area is 55 to 60 percent. This figure means that our locality belongs to an area in the Plain with relatively more cloud.

From the point of view of temperature the area is characterised by extremes. It belongs to an area in the Plain with colder winters. Winters are much more severe here than in the central and western areas of Hungary. Sometimes, when a cyclone is going across the Carpathian Basin from the Adriatic, mild subtropical bodies of air drift northward across the area east of the Tisza River, the Transdanubean area is inundated with cold air on the back side of the cyclone from all around the Northern Carpathians, the Körös catchment area is 12 to 15 degrees milder than the Transdanubean region. The water output of the rivers is highly dependent on the distribution of precipitation in time and space, as well as its amount. The Körös system is characterised by an extreme variability of water output, and an irregularity of the variations. Within the 25,000 square kilometre catchment area of the Körös rivers. The Szigethegység play an important part. The water output of the rivers flowing from the mountains and the foothills varies according to the amount of precipitation in different catchment areas.

The most important catchment areas relevant to the Körös catchment area are as follows: the locality of the Ér/Ier River at 90 m, the Réz Mountains at 700 m, Királyerdő at 900 m, the Bihar Mountains at 1800 m, and the Béli Mountains at 1100 m. Since the major ravines in the mountains are open in the direction of the flow of the rivers, the latter mainly flow from the west to the east. In such an open ravine system straight river valleys are formed with a significant dip which flush the Plain with large quantities of water. Because of the ease of the water flow, the water output of the rivers changes quickly according to the amount of precipitation. High spring-time water tables are normally the result of snow melting after winter and not that of immediate precipitation. If the snow in the mountains melts quickly the resulting considerable amount of water increases the water output of the rivers dramatically at times triggering disastrous floods, like in the years 1872, 1874, 1919, 1925, 1932, 1966 and 1970. But if thawing takes a while then the slow and gradual increase of water output does not pose the threat of floods. Analysing the annual amount of precipitation over the catchment areas the quantity of precipitation doubles in the higher mountains thus contributing to the water output with a larger amount. Since the amount of precipitation over the catchment areas is linked to certain periods rather than seasons, floods do not display any close seasonal variation.

The distribution of precipitation over the Plain areas is of continental character. The amount of precipitation reaches its peak in July, and its lowest point in January. In spite of the insufficient precipitation devastating downpours are not unprecedented in this area (160 mm of rain in Sarkad, on 18 July, 1938). The annual amount is about 560 mm, slightly higher than that in the Hármas-Körös area, not reaching amounts in the Southeast of Békés - Csanád [23].

Precipitational trends have not changed considerably since the turn of the century. Besides the general distribution of the precipitation it is important to know its extremes, intensity and frequency. It may generally be pointed out that large quantities of precipitation occur at the end of springtime and the beginning of summer. However, this does not mean that the amount of precipitation is always sufficient for the agriculture (Table 1.).

Table 1.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
1.	17	21	28	17	14	17	32	30	39	30	19	20
2.	4	7	12	5	4	2	11	12	15	11	6	6

The probability, as a percentage, of dry periods of more than 5 days (1) and more than 10 days (2) from 1930 to 1990

According to the table dry periods are more likely in March, July, August, September and October, when there is much demand for water, therefore irrigation systems and modern agricultural technology is a must in this region.

A Hydrographic Description of the rivers

The four of the most important rivers of the system, the Fehér-Körös, the Fekete-Körös, the Sebes-Körös and the Berettyó River, drain the waters of the Bihar Mountains. The Fehér-Körös drains the waters of the Zarándi and Béli Mountains, the Fekete-Körös drains the waters of Zarándi and Béli Mountains, as well as those of Királyerdő, the Sebes-Körös drains the waters of Királyerdő and the Réz Mountains, the Berettyó River collects the waters from the Northern slopes of the Réz Mountains. Their long-term annual water output when reaching the country is as follows: Fehér-Körös 40m^3/sec; Fekete-Körös 40m^3/sec; Sebes-Körös 20 m^3/sec; and for the Berettyó it is 9.2 m^3/sec.

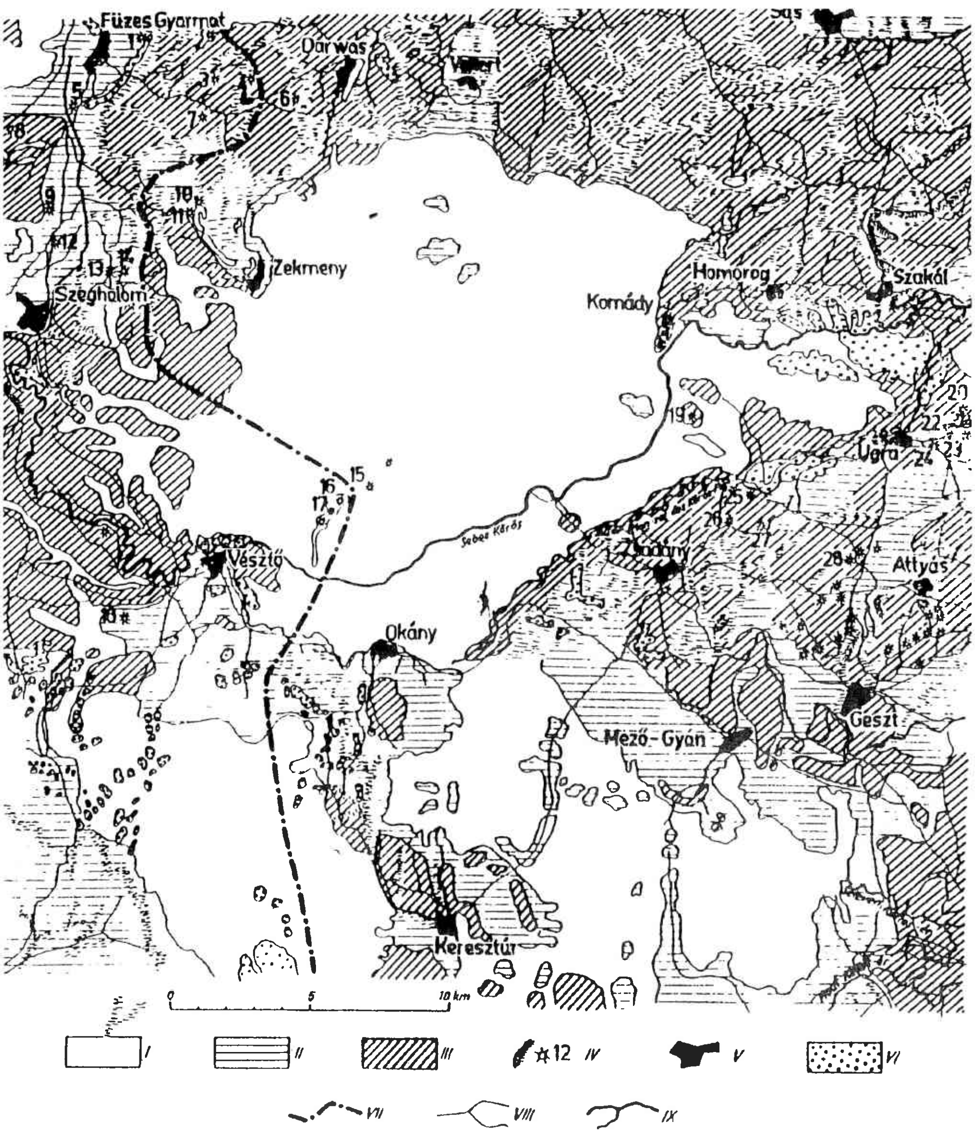

Fig. 5. Map of the Vésztő area from 18[th] century (by Andró M. edit.)
I. Wetland; II. Meadow and pasture; III. Dry area; IV. Barrows (Cumanian Hills); V. Settlements; VI. Forests; VII. County boundary; VIII. Roads; IX. Streams

The catchment area of the Berettyó and Körös Rivers flowing through the Hungarian Plain is beyond this country;

- 93% of the 4,275 km^2 catchment area of the Fehér-Körös River;
- 97% of the 4,645 km^2 catchment area of the Fekete-Körös River;
- 65% of the 9,119 km^2 catchment area of the Sebes-Körös and Berettyó Rivers;
- 75% of the 19,505 km^2 catchment area of the Sebes-Körös and Kettős-Körös Rivers is in Rumania, 80% of which is a mountainous and hilly region. The initial catchment area of the Hármas-Körös River is 19,500 km^2 takes on an additional 8,037 km^2 on the Plain, which amounts to a total of 27,537 km^2.

The mountaneous water system has a unique feature, e.g. the ranges of the Réz Mountains, Királyerdő and Béli Mountains are mainly stretching from the east to the west or Southeast to the Northwest. The surface waters flow onto the Plain through wide gates dropping sharply among the mountains. The above rivers, forming a 120 km wide front deliver the waters of the mountains to the centre of the Plain seem to jointly trying to wipe off the Plain Vésztő and its surroundings before they reach Gyoma.

The area is roughly a simple network. The four rivers enclose a triangle with one of its points in the west, east of Gyoma, where the Sebes-Körös and Berettyó rivers meet the united Fehér and Fekete-Körös. Within this triangle we find a jumble of rivers and back-waters. All four of the rivers have several branches, all of them have meandered a great deal up and down the area leaving behind their old dry beds which get filled with water during the floods. There are a lot of bogs without drainage; an effort is being made to drain their waters through canals. Vastly spread peat bogs can also be found here, like the Nagy-Sárrét, and the Kis-Sárrét. They are surrounded by muddy and argillaceous areas enclosed by highly alkaline soil. Before the canals and dikes this area had been a wonderful paradise (Fig. 5.).

According to the character of these rivers, the largest one is the Fekete-Körös, the most torrent one is the Sebes-Körös, the Fehér-Körös is slower and the Berettyó is the slowest. The Ér and Hortobágy rivers only have a periodical existence; they dry out in dry autumns(1 6 9 21).

The catchment area of the Körös Rivers is a meeting-point of extremes; steep dips adjacent to plain areas with almost no dip at all; high water output in springtime is followed by arid periods in autumn.

The Fehér-Körös/Crişul Alb River

The river originates in the surroundings of the Aranyos spring on the south-eastern slope of the Bihar Mountains. Its spring area is fed by a number of mountain brooks. The water, flowing from an altitude of about 1,000 to 1,200 m forms a wild mountain brook running as far as the Ribicza/Ribiţa River. Its dip along this stretch is 17.5 m per one

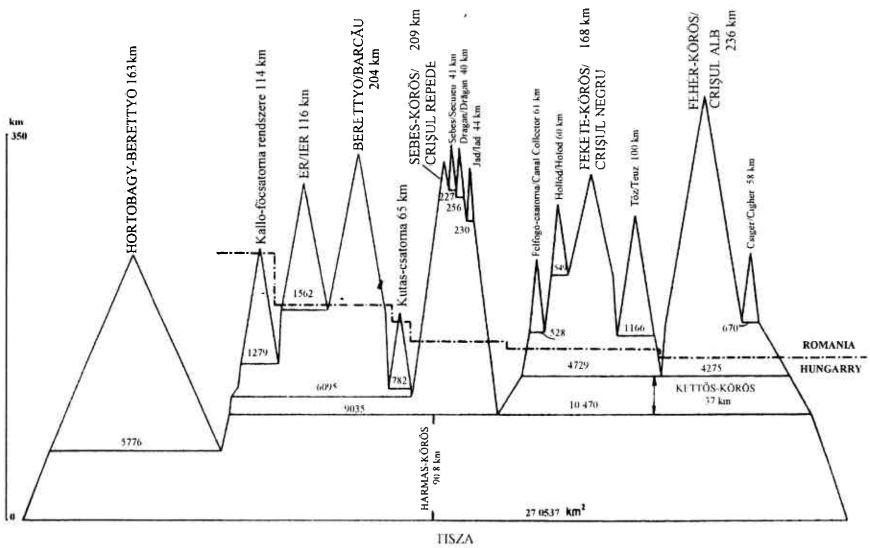

Fig. 6. Water system of the Körös catchment (by Lászlóffy)

kilometre and it abounds in water. From here, its dip decreases and at Borosjenő/Ineu, where the river enters the Plain it is only 50 cm per kilometre, at Gyula it is 20 cm a kilometre. Along the 4.7 km stretch from Gyula to the Fekete-Körös its dip increases to 45 cm a kilometre (Fig. 6.).

Its total length from the spring to the river Fekete-Körös is 235.6 km. The catchment area is 4,275 km2, 298.3 km2 of which lies in Hungary. Before the river regulation it had had a lot of off-shoots and bends. During a flood, vast areas got covered with water due to the extremely small dip of the river. For example the area of the settlements of Gyula, Kétegyháza and Doboz were frequently flooded. Since the river has been regulated it meets the Fekete-Körös River in Szanazug in the neighbourhood of Doboz. Once the two rivers met under Békés, since the river Fehér-Körös used to flow in the bed of today's 'Élővizcsatorna' past the settlements of Gyula, Békéscsaba and Békés.

Plans for the regulation of the river Fehér-Körös were made as early as the 17th century. According to these plans a canal would have been built above Borosjen between this river and the Fekete-Körös River. This plan has not been completed. Instead, in the 19th century several canals were dug along the river in Arad county to make waters flow faster. This resulted in large floods and bogs along the lower section of the river. As the first step of river regulation watermills' dikes have been transferred into the purpose-built József-Nádor canal and, simultaneously, riverbeds were cut and parallel levees built [23].

In Békés county this regulation resulted in a 'state of emergency', so here, too, the river had to be regulated and the riverbed cleaned. The plans compiled in the year 1855 involved mainly the regulation of the Békés county section of the Fehér Körös River. The plan has not been perfectly accomplished, due to the major flood of 1855 in the area of Gyula. Then the Körös River flowing across the town was transferred into a straight bed outside Gyula. With the Gyula-Békés riverbed having been completed the authorities of Gyula and Békéscsaba are doing their utmost to obtain fresh water. In 1896 the Gyula dam was built, the underdam section of which has several times been extended and in the year 1920 a new underdam canal was built and the dam is still not working perfectly since the walls of the canal have been eroded to such an extent that the dam itself and the parallel levees are also endangered[(123)].

In the 1950s the dam was reconstructed and is in good working condition today. The typical figures of water output are 605 m^3/sec at its peak, 23 m^3/sec - an average and 0.001 m^3/sec at its lowest. The extreme variation of water output is typical of the river. In extremely dry summers the riverbed occasionally dries out between the dam and the estuary. At present the river's alluvial transport is insignificant, it only transport fine clay, hence the name 'Fehér'.

The Fekete-Körös/Crişul Negru River

It springs from three brooks called Polyána/Poiana, Rézbánya/Băița and Petróczi/Petruț. It is fed by a lot of brooks along its section in the mountains. It leaves the Apuseni Mountains between Urszád/Ursad and Belényes/Beiuş and enters the foothill area of the Plain where on the alluvial slope it has a very changeable water output. First, the river heads Southwest - west then turns Northwest and flows around a very high number of bends. Under Tenke/Tinca the Gyepes (in the surroundings of Fekete-Tóti/Tăut) shoots off the main stream in a northward direction, like Szárazér off the Maros River, it is still water today but once it must have been a major river as it can be seen from the large bends and flood areas. Having left Tenke the river enters the depression south of Gyepes, and, strengthened by numerous intricately flowing streams, it flows into the Fehér-Körös and continues to flow towards the Sebes-Körös along a 37 km long route, under the name Kettős-Körös[(137)].

Before the regulation the Fekete-Körös used to be 236 km long. With its 80 new straightened sections under Gyanta/Ginta and the abandoned riverbed under Szanazug its length has been reduced to 160 km, 139 km of which is outside the country, along a 5 km stretch its a border river and then covers 16 km in Hungary. The altitude 63 km above the country border at the Hollod is 123 m, 89 m at the border and 87 m at the estuary.

Along its 14 km stretch in Hungary it is characterised by middle-section features, where the accumulation of alluvial sedimentation is very strong. The dip of the river is about 10 cm a km here. Water output is more balanced than that of the Fehér-Körös, but during floods it channels more water than the Fehér-Körös.

The Kettős-Körös River

The Fekete-Körös and Fehér-Körös, having covered 168 and 236 km respectively meet in Hungary to be named Kettős-Körös. The catchment area of this river is 9,004 km^2. The parent Köröses' water output is stamped on the character and water output of this new river. As far as the Békés section, the dip of the river is only 8 cm a km. After Békés the dip is further decreased to 6 to 7 cm a kilometre. Before the river regulation this area used to be almost without any drainage at all. The river is still very curvaceous and before the regulation it used to meander the whole area of Kissárrét. Today it flows into the curvaceous Sebes-Körös above Gyoma. The two parent Köröses are mainly responsible for its water output. As to its average water output, that of the Fehér-Körös is increased to 23.0 m^3/sec, the 29.0 m^3/sec initial water output of the Fekete-Körös is increased to 60.2 m^3/sec. The rest amounting to 8.2 m^3 is supplied by creeks, brooks and canals. At its lowest the water output is about 2.3 m^3/sec. At its peak it is 800 to 900 m^3/sec., which is an evidence of extreme variability.

The Berettyó/Barcău

The Berettyó enters the country from Romania at Kismarja and it flows into the Sebes-Körös under Szeghalom. Its length is 204 km and the extension of the catchment area is 6,095 km^2. Forty percent of the riverbed, 74 km is in Hungary and 44% of the catchment area is also in this country. On its right bank at 68 km it takes on the Ér River and at 23 km the river Kálló.

The regulation of the Berettyó started along with that of the Körös rivers in the middle of the 1850s. The riverbed was straightened mainly in the 1860s and most of the levees were completed in that decade.

The character of the river changed significantly when the Szeghalmi Canal was opened in 1865. Before that time the Berettyó flew into the 460 km^2 Nagysárrét under Bakonszeg and left it at Bucsa to curvaceously flow into the Hármas-Körös. Today it meets the Sebes-Körös under Szeghalom.

The largest bog in the Berettyó - Körös region used to be the Nagy-Sárrét surrounded from all sides by rivers. Its expansion started only half a thousand of years ago (Fig. 7.).

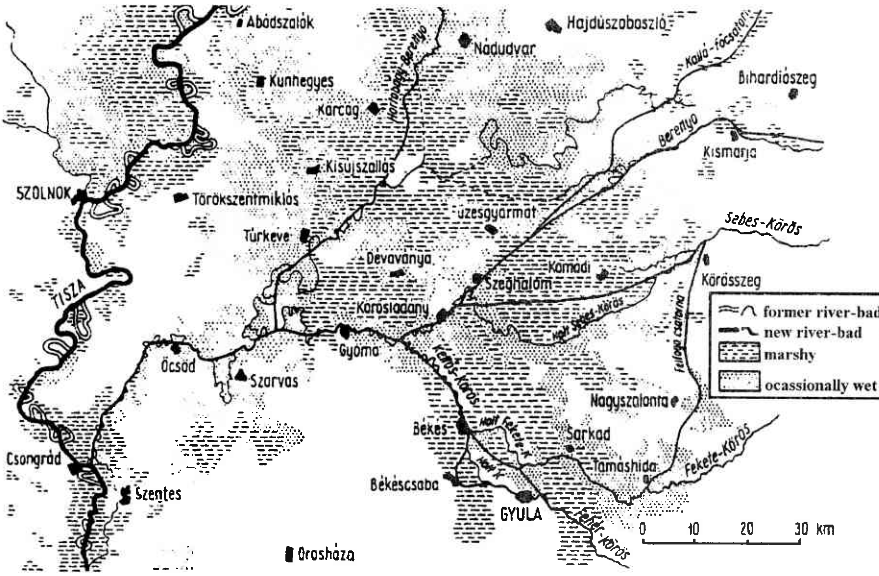

Fig. 7. Regulation of the Körös rivers and Berettyó rivers (by Papp A., edit.)

The basin mainly accommodated the waters of the Berettyó. Before the regulation, the Berettyó turned west at Bakonszeg and spread all over the basin. A lot of water was supplied by the Kálló stream, leaving the Berettyó at Esztár, also bringing water from the Southeast of the Nyírség. It entered the bog west of Biharnagybajom. The Nagysárrét bog was also supplied with water through the Ér and Berettyó by the Szamos/Someş and Kraszna/Craşna. During floods water from the Tisza River used to flow here along a number of creeks[2,8,14].

As soon as the basins of the Sárrét were formed they started to acummulate sedimentation from the alluvium of the several rivers here as a result of which the bottom line of the bogs rose gradually to occupy an ever growing area. Simultaneously, the depth of the water gradually decreased, the whole process leading to the formation of bogland. During high water levels the water in the basin of Kis-Sárrét had access to Nagy-Sárrét along several creeks and streams and southward it was connected to the bogs of the Kettős-Körös. This was a temporary reservoir of water accumulated over an area of 13,900 km^2.

The Hármas-Körös River

Hármas-Körös is the name of the river conceived by the Kettős-Körös and Sebes-Körös, flowing in a wide bed with over-developed bends, variegated by abandoned ones. This river bed was mutually formed by the ancient Szamos, Ér and Körös. This was the stretch that needed most work during the regulation after which the river gained speed, its dip was increased. Although its water output is second to that of the river Maros, due to the dams built its economic value is more significant. In 1942 the Békésszentandrás dam was built to facilitate the irrigation of 15,000 ha of land. Since 1945 the development of the irrigation system has been given utmost attention.

The Sebes-Körös/Crişul Repede River

The most important river of the area is the Sebes-Körös. Its catchment area is a rather elongated one stretching between the Berettyó and the Fekete-Körös. It springs as ground water at 700 m at Körösfő/Izvoru Crişului in Cluj county, Romania. Initially it is an insignificant brook, downwards, having taken on the Sebes, Dregán/Drăgan and Jád/Iad it deserves the name Sebes-Körös. It is rather torrent and capable of rolling large boulders along a narrow bed towards Nagyvárad to flow on in a sandy bed as far as Körösszakáll. Before the regulation the river bed followed the southern verge of Kis-Sárrét from Körösharsány. Due to the accumulated sedimentation the floods spread in the bog. That the reason why a completely new, 35 km canal was built from Köröshársány to the Fok Bridge. It is not only suitable to drain the floods of the Sebes-Körös but drains the other waters of the Kis-Sárrét. The Sárrét section plays an important part in the life of the river. No artificial river-bed has been dug, the formation of the bed was done by the river itself. But contrary to the expectations, the river failed to cut a deep bed, instead, it has filled it up with sedimentation. That is exactly what happened to the flood area as well. Sedimentation today is not as fast as it used to be in the course of the decades after the construction of the Sárrét canal.

It meets the Berettyó between Szeghalom and Körösladány. From this point it flows fast along a wide alluvial flood area between high levees to meet the Kettős-Körös. It is very important in the river's life that along its initial stretch above the border the dip of the river is 19 times bigger than that of the lower section in Hungary. In this way, the Sebes-Körös is considered to have a big dip as compared to that of the other rivers of the area. Between 110 and 209 km it drops about 500 m, so the average dip here is 5 m/km. This dip is counterbalanced by the lithological features of the catchment area, which bring down the water output. On the Plain the dip is considerably decreased, but it is still the largest among the Köröses[1 7 23].

	Little-water	Large-water
Csucsa—Nagyvárad	3.53 m/km	
Nagyvárad—Köröstarján	1.51 m/km	1.40 m/km
Köröstarján—Körösszállás	0.41 m/km	0.38 m/km
Körösszakál—Foki-Bridge	0.26 m/km	0.24 m/km
Foki-Bridge—Körösladány	0.20 m/km	0.02 m/km
Körösladány—Hármas-Körös	0.18 m/km	0.01 m/km

Since the water in the river comes mainly through karstic springs from precipitation there is a close relationship between the water level and the chronological and quantitative distribution of the precipitation. The mean annual amount of precipitation over the upper catchment area is between 1,000 and 793 mm, at the astuary this amount is only 600 mm.

Winter precipitation is the main source of the water output. The winter accumulation of the precipitation starts in the beginning of September and lasts about 152 days. The snow falling here over this period provides ample water for the river. The annual variation of the water output is irregular. There are very dry and very wet years as well. Accordingly, water output varies extremely.

Section (rkm)	Bottom level (a.s.l. Adriatic) (m)	Dip (cm/km)	Note
	84	0	Hungarian stretch of low dip
57	95	19.3	
110	148	100	Romanian stretch of high dip
160	352	409	
175	465	754	
209	700	545	
0—209	700—84	271	Average

Due to its high speed flow the river carries a lot of alluvial particles but the larger-grain fraction is sedimented outside Hungary. Today's landscape was created by 24 straightened bends and the construction of the Sárrét canal. The old Sárrét section plays a very important part in the river's life. No bed has been excavated here. The river itself was to form her own bed along a small canalette between two levees. Instead of cutting herself a bed the river deposited sedimentation and a lot of it. The rate of sedimentation is somewhat slower today, but considerable effort is needed in the form of excavation and levee maintenance.

Hydrological Description of the Körös Interstice

The Kis-Sárrét and the Nagy-Sárrét used to be among the boggiest areas in the Plain. At times, when precipitation was ample, flood waters were trapped in an area of low dip, surrounded by alluvial fans. Due to this fact the area evolved into a watery flood area interwoven by back-waters and river beds. The Kis-Sárrét must have been a swamp among the settlements of Mezőgyán, Ugra, Szeghalom, Vésztő, Békés, Gyula and Sarkad [2 5 9].

Water was fed into the bog by the Sebes-Körös and its side-waters. The remains of the meandering jumble of ancient river-beds can still be found on the verge of Sárrét. In the depression, conforming to the rules of alluvial fan formation troughs of little drainage were brought about, Kis-Sárrét would be an example. The rivers were seeking their beds around giant loops and they frequently changed direction. The Sebes-Körös, for example had no fixed route across the Kis-Sárrét. Because the rivers in the Körös area kept changing their direction due to structural reasons and alluvial deposition bogland thrived, facilitated by unforeseeable economic activity. Deforestation, for example caused the amplitude of flood waves to rise, and watermills built on low-dip rivers further worsened the situation.

The formation of the bogland must have taken place in the oak or beech phase of the Holocene when the Sebes-Körös acquired its Biharugra - Zsadány - Okány - Vésztő direction. The unfavourable character of the river system made regulation work a priority in this area in the last century, although permission to build dikes had been issued by Mátyás II as early as 1613.

During the Turkish Rule the population dropped, and it was only in the 1800s that the expansion of agricultural land was necessary. Drainage started in 1790 and was only of small scale, to channel the swamp water through the Sebes-Körös bog. In 1810 a 6 km canal was built at Szeghalom to drain the water of the swamp. As a result, the amount of agricultural land grew[5 6 23].

The preconditions of the drainage did not exist until the year 1815. Huszár Mátyás compiled a plan to regulate the Köröses which was used for the compilation of new plans in 1879. The principle of the regulation was that the floods of the Köröses must be channelled away before that of the Tisza River. The plan and the realisation was good. As a result the low water dip of the lower section grew from 1.5 cm to 4 cm/km, that of the high water from 1 cm to 4 to 6 cm/km. In the course of the regulation of the Sebes-Körös most difficulty was due to the drainage of the vast swamp stretching from Körösszakál to Szeghalom.

The regulation of the Köröses was not without difficulty. Due to the small dip of about 20 mm/km of the Tisza plain the Körös Rivers were unable to create a bed deep enough to accommodate the water of larger rivers as well. The situation was complicated by the fact that the Danube had a water-level raising effect on the Tisza River up to Csongrád, the Tisza River had a similar effect on the Körös River up to Békés. Before the regulation high waters prevailed along the Tisza River for a month, it took them two months to shrink to medium levels, small water levels lasted five to six months. If summer floods occurred then the water from the Tisza and Köröses was spread over the lowland between the Tisza River as well as Kisjenő and Körösszakáll all year round.

It is evidenced that the Tisza River only carries half of the amount of arriving water, the other half is stored in the flood areas. Quite often the highest water level of the Körös Rivers was 5 m higher than the lowest one, and every 25 years it is 6.3 m higher.

The regulation of the rivers was completed at the turn of the century. Due to the cuts through the bends and the appearance of dikes dips increased and river beds became deeper. Floods are channelled away quicker and the level of low water is 1 m deeper today. To tackle inland water pumps were installed and canals constructed in the course of river regulation. Due to such large-scale work the original hydrographic picture has changed considerably. Not later than the beginning of the 20th century the underpopulated Körös region, with its worthless land covered by flood waters from spring to autumn became available for agricultural use.

References

1. Andó M. (1994) A Tisza folyó vízjárásának hidrológiai, geográ.fiai, geológiai és környezettechnikai összetevői. — Akad. doktori értekezés, kézirat
2. Andó M. (1982) Vésztő és környéke természeti földrajzi viszonyai in: Vésztő története. — Vésztő
3. Andó M. (1974) Békésmegye természeti földrajza. in: Békésmegyei gazdasági földrajza Békéscsaba
4. Andó M. (1964) A DK-Alföld természeti földrajzi adottságainak jellemzése. — Kandidátusi értekezés kézirat
5. Babos Z.-Major L. (1939) Az ármentesítések, belvízrendezések és lecsapolások fejlődése Magyarországon. — Vízügyi Közlemények. Bp.
6. Galacz J. (1896) Monográfia a Körös-Berettyó ármentesítésérôl I-II. kötet. — Nagyvárad
7. Korbély J. (1916) A Körösök és a Berettyó szabályozása. — Vízügyi Közlemények
8. (1987) Geografia României III. Carpații Româneşti şi Depresiunea Transilvaniei (Geography of Romania III Romanian Karpathian Mountains and Transilvanian Basin) Bucureşti

9. Lászlóffy W. (1982) A Tisza. Vízimunkálatok és vízgazdálkodás a tiszai vízrendszerben. — Akad. Kiadó.
10. Molnár E. (1963) A Sebes-Körös, Fekete-Körös közötti határmenti területek vízrendezési kérdései. — Víziterv. Ért.
11. Mátyás V. (1988) Bihar-hegység Túristakalauz. — Sport Bp.
12. Nagy Gy. (1960) A Körösök vízrendszere és szabályozása. — Földrajzi Közlemények. Bp.
13: Nagy Gy.(1975) A Körös vidék lefolyási viszonyainak alakulása. — Vízügyi Közlemények. Bp.
14. Papp Á. (1956) A Nagy- és Kissárrét vidékének régi vízrajza. — Acta Univ. Debrecen
15. Papp K. (1905) Geológiai jegyzetek a Fehér-Körös völgyéből. — Magyar Királyi Földtani Intézet évi jelentése. Bp.
16. Rozlozsnik P. (1936) A Bihar hegycsoport tektonikai helyzete a Kárpátok rendszerében. — Mathematikai és Természettudományi Értesítő LV. kötet. Bp.
17. Sümeghy J. (1956) A Há.rmas-Körös közötti holocén medence. — Földtani Intézet Évi Jelentése. Bp.
18. Sümeghy J. (1941) A Hármas-Körös közötti holocén medence — Földtani Intézet Évi Jelentése. Bp.
19. Szatmári J. (1993) Padis fennsík karsztjelenségei. — Szakdolgozat. Szeged
20. Tövissi J. (1993) Erdély természeti földrajza. — Főisk. Jegyz. Nyíregyháza
21. Újvári J. (1972) Geografia apelor României Editura Ştiintifică. Bucureşti
22. M. Valcea V-Sasu Alex: (1981) Geografia Carpaţilor si a Subcarpaţilor româneşti Ea. did.Ped. Buc.
23. VITUKI (1965) Magyarország vízvidékeinek hidrológiai viszonyai (Szerk. Goda L.) Bp.

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