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Characteristics of river flow in the Transylvanian Basin

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Abstract

One of the largest depression in the Romanian Carpathians, the Transylvanian Basin, occupies the central part of Romania, being a typical upland region. The river flow characteristics in the Transylvanian Basin have been pointed out as a result of data processing and interpretation activities carried out at 24 hydrometric stations. The humidity contrasts as a consequence of the territory exposure to the advection of oceanic air masses coming from the west are reflected by the distribution of the components of the hydrological balance, which has been presented in detail in the first section of the present paper. The second section focuses on the way in which the effects of the climatic demarcation influence the temporal distribution of the flow, the frequency flow rhythms, as well as on the territorial distribution of the types and subtypes of regime.

1 Introduction

The Transylvanian Basin is the widest and the best individualized area with negative morphology in the Carpathian range, which covers 10.5% of the Romanian territory (237,5000 km2). Because of its central position in the Carpathian-Danubian-Pontic area, the Transylvanian Basin is a place of convergence for several geographical elements, among which the rivers and the human potential are especially important. The transition from the intra-Cartpathian hills to the mountains is accomplished through couloirs and depressions, which run in an almost uninterrupted line at the extremity of the central unit; this has a plateau configuration and is subdivided into three distinct units: The Somes Plateau, the Transylvania Plain and the Tarnave Plateau. The junction between the mountain frame and the depression, with its geo-morphological, geological and climatic particularities is reflected by the

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differentiation of the drainage system on the two categories of rivers: foreign and local, highly different as far as both the volume of water transported and the leakage regime is concerned. The river system from the basin has three main collectors, all with a different orientation: Somes to the north, Mures to the west and Olt to the south.

2 Debits and medium flows

From the point of view of the volumes of water transported, there are important differences between the local rivers and the foreign rivers which originate in the surrounding Carpathian area. In time, these contrasts have created differences between the degrees of urbanization and industrialization in the areas with peripheral passages and basins and those in the plateau. Thus, the sub-mountainous collectors from the western part of the Transylvanian Basin have rich debits. For example, in the Alba-Iulia – Turda Basin, the Aries and the Mures rivers transport high amounts of water (25.6 m3/s, near Turda on the Aries, 105 m3/s near Alba Iulia on the Mures). The situation is mostly similar in the depressions from the southern part of the Transylvanian Plateau: Fagaras (61.4 m3/s on the Olt at Fagaras) and Sibiu (15.3 m3/s on the Cibin at Talmaciu). Much more reduced amounts water are transported by the sub-mountainous collectors from the northwest (1.09 m3/s on the Agrij at Romanasi) and the southwest of the depression (2.43 m3/s on the Secas at Cunta). In the area adjacent to the marginal hills and depressions on the eastern wing of the Transylvanian Basin, most of the collectors which descend from the Oriental Carpathians have an east-western orientation and transport less than 10 m3/s annually (7.76 m3/s Bistrita at Bistrita, 8.14 m3/s Gurghiu at Solovastru, 9.65 m3/s Tarnava Mare at Vanatori, 6.37 m3/s Tarnava Mare at Sarateni). The Mures is, however, an exception, with a mean multi-annual debit of about 37 m3/s (37.4 m3/s at Glodeni) at its access in the plateau. On the other hand, the sub-mountainous collectors transport fewer amounts of water, that is, under 5 m3/s (3.90 m3/s at Rupea Gara on the Homorod and 1.55 m3/s at Domnesti on the Sieu). Throughout the Transylvanian Basin there appear clear contrasts between the amounts of water transported by the local rivers (between 0.100 and 3.6 m3/s) and the foreign rivers (47.7 m3/s at Beclean on the Somesul Mare, 22.4 m3/s at Salatiu on the Somesul Mic, 27.4 m3/s at Mihalt on the Tarnava. For the mountainside flow, were calculated the values of the specific mean flow and of the flow stratum, the results of which were subsequently used as indices of comparison for the hydrological potential of various areas. The relationship established between the specific mean flow and the mean altitude of the areas surveyed by the 24 hydrometric stations (which make the object of our study) facilitated the territorial generalization of the flow. The variation of the flow with the altitude was studied in five areas specially configured for this purpose, in each of them the values obtained were different. The lowest values (1-2 l/s.km2) were reported to have been measured in the west of the Transylvanian Basin where the effects of the descending movement of foehn air masses are more pregnant. As we move east – northeast, the specific mean flow values are

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progressively higher. The isorheea of 4 l/s. km2 generally differentiates the plateau from the eastern sub-Carpathian zone. Also, the values of flows from the southern passages and depressions towards the Middle Carpathians, are higher. Thus, the specific mean flow reaches 6-7 l/s.km2 at the junction between the piedmont platform and the Fagaras Mountains. Generally speaking, in the northern regions of the Transylvanian Basin, the specific mean flow values raise from west (2-4 l/s.km2) to east (5-8 l/s.km2), where the land is favourably exposed to the advection of wet masses of air from the west. The low interstream areas form the Transylvanian Basin are characterised by reduced quantities of water, as results from the territorial distribution of the mean flow. The surplus of water from the periods of humectation is collected and retained by built-up terraces, some of them dating back as early as the 16th century. In the river beds, the water is stocked through permanent accumulations (fisheries and water supply) and non-permanent accumulations (flood-prevention).

3 Hydrological balance

The humidity contrasts imposed by the differences in the exposure of the surveyed area to the advection of oceanic wet air masses from the west are in direct relation with the distribution of the hydrological balance components (Table1). The relatively easy access of the wet air masses to the low northwestern part of the plateau determine a more intense water circuit on the western slopes of the Oriental Carpathians and in the sub-carpathian region of transition; here, the mean quantity of rainfall has a constant limit of 700 to 1000 mm, and the flow, does not exceed 100 to 300 mm. Towards the southern part of this area - less exposed to the wet mass advection from the west - the intensity of the circuit decreases . The lowest values for the components of the hydrological balance have been recorded in the "precipitation shadow" of the Apuseni Mountains from the western part of the depression; here the mean quantity of precipitation falls below 550 mm and the flow remains constant between 30 and 60 mm. The Transylvanian Basin has been included within the central –European region of hydrological balance, the surrounding mountainous region being considered a variety of this province. The most important factors in defining the components of the hydrological balance were the oro-aero-dynamic and hydrodynamic characteristics of rain formation in the surveyed area, because of their major influence on the behavior of the all the water circuit elements. The Transylvanian Basin and the surrounding mountainous area has been divided into five sub-regions with relatively distinct features of the balance elements (Table 2). For their corresponding areas, see Figure 1. The Transylvanian Basin and the surrounding mountainous area has been divided into five sub-regions with relatively distinct features of the balance elements (Table 2). For their corresponding areas, see Figure 1.

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Table 1: Elements of the hydrological balance recorded by the main hydrometric stations (1950-1994).

River	Hydrometric Station	Xo (mm)	Yo (mm)	Eo (mm)	Uo (mm)	Wo (mm)
Ilisua	Cristestii Ciceului	842	308	524	92	616
Dipsa	Chirales	675	112	563	25	588
Meles	Rusu de Jos	660	102	552	23	575
Nadas	Mera	680	110	570	27	599
Borsa	Borsa	665	98	567	23	590
Fizes	Fizesu Gherlii	620	84	536	20	556
Almas	Hida	649	92	557	32	589
Comlod	Band	641	77	564	21	585
Paraul de Campie	Ludus	611	62	549	16	565
Raul Alb	Simonesti	789	185	604	48	652
Laslea	Laslea	692	104	588	38	626
Secasul Mic	Colibi	625	46	571	17	588
Cohalm	Homorod	643	75	568	21	589
Hartibaciu	Agnita	712	109	603	29	632
Somes	Dej	777	245	532	78	600
Mures	Glodeni	786	268	518	85	603
Mures	Alba Iulia	721	169	552	54	606
Olt	Hoghiz	759	192	557	66	623
Olt	Sebes Olt	798	221	577	72	649

Xo – precipitation; Yo – global flow; Zo – evapotranspiration; Uo – subterranean drainage; Wo global humectation of the area.

Table 2: Sub-areas of hydrological balance and the values of the balance elements (1950-1989) (after *C. Konecsny*, 1997).

Code	Name of Sub-area	Xo (mm)	Yo (mm)	Zo (mm)	Uo (mm)	Wo (mm)
I	Northern	919	259	660	64	724
II	Eastern-Central	844	240	604	81	685
III	Oriental	842	198	644	56	700
IV	Middle	961	306	655	103	758
V	Western	777	182	595	48	643

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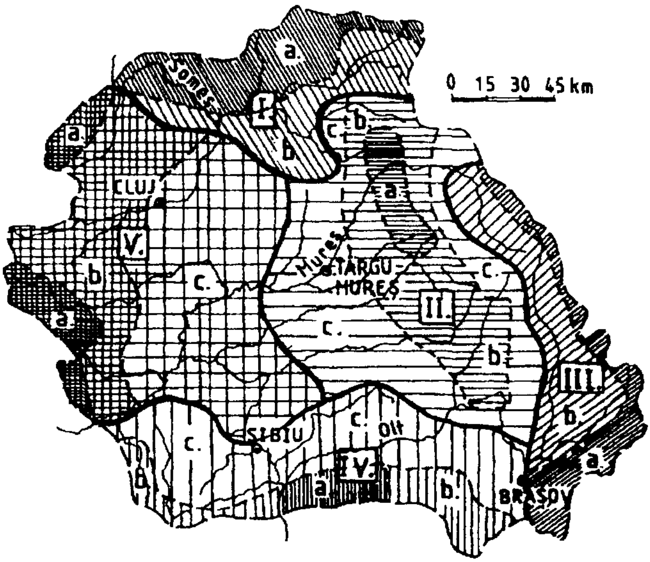

Figure 1: The limits of the sub-areas (I-V) and of the districts of hydrological balance

4 Annual flow distribution

The combination of the main feeding sources is reflected by the flow distribution throughout the year.

4.1 Winter flow

Wintertime the largest volumes of water are transported by the rivers in the north-western part of the Transylvanian Basin and they represent from 28 to 30% of the annual flow. In these areas, the rivers are more likely to be fed from the melting snow, as a consequence of warm air masses advection, whereas, in the south-eastern part, where winters are more steady, the percentage is lower - between 19 and 20.

4.2 Spring flow

Spring is the season characterized by the highest volume of flow which is conditioned by the melting snow/ defrosting, by the relatively high amounts of rainfall and by the low evapotranspiration .The rivers from the eastern and southern surrounding areas transport the highest volumes of water (between 44 and 47% of the annual mean volume), while the lowest volumes are transported by the rivers in the central and southern part of the depression (37-40%).

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4.3 Summer flow

In summer, the warming of the air and the coming out of the vegetation intensify the process of evapotranspiration, this being reflected by a important decrease of the flow. The mean annual flow does not exceed 17-28%, although the rainfalls record their maximum values during this season, the mean annual flow does not exceed 17-28%.

4.4 Autumn flow

Autumn has the weakest contribution to the mean annual volume (10-15 %), although the amount of rainfall is almost twice as much as it in winter. According to the distribution of the monthly mean flow, there is a minimum in September. The lowest values are registered in September (2-5%) because of the low amounts of precipitation, the drying up of the subterranean water reserves and the still intense evaoptranspiration.

5 Types of hydrological regime

Two principal types of hydrological regimes were identified in the Transylvanian Basin and in its surrounding area: Carpathian and peri-Carpathian – as well as a number of sub-types, according to interaction between certain flow attributes, namely, the daily, monthly or seasonal, etc. rhythmicity, characteristic phases and periods, duration, frequency, and variability of some of the hydrological parameters, or the contribution of the feeding sources, etc.)/

5.1 The types of Carpathian regime

This regime types are characterised by the vertical distribution of the components of the hydrological regime. Thus, the higher the altitude, the longer the period with poor winter waters and the lower the incidence of winter floods. However, the period with rich, nivo-pluvial spring waters is longer and their outset is gradually delayed. The types of Carpathian regimes differ from a spatial point of view according to the slope's exposure to the advection of wet air masses from the west and to the altitude of the area drained by the rivers from the given category. The Transylvanian Carpathian type is characteristic of the foreign rivers which originate at altitudes below 1600-1800 m on the western slopes of the Oriental Carpathians, east of the Apuseni Mountains and north of the Middle Carpathians. In winter prevail the periods with poor waters, the nivo-pluvial floods have now a low incidence, of only 10-20%. This is a transition type, a combination between the western and the eastern Carpathian type. Thus, on the eastern slope of the Apuseni Mountains, in the Upper Aries basin, the instability of the winter flow is much higher than that from the Upper Mures, Gurghiu or from the two Upper Tranava. The masses of subtropical air, quite frequent in the Aries and Ampoi basins, cause floods, occasionally with catastrophic effects in winter. The Ierii, Somesului Rece, Somesului Cald

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valleys, situated north of the Aries and characterized by a more constant winter regime, with late defrosting, reach their maximal monthly debit in May. High volumes of flow are recorded in summer (30-32% of the annual volume), generated by the abundant, frontal or convective, rainfalls of June and July.

5.2 Peri-Carpathian regime type

Typical of the foreign rivers which cross the Transylvanian Plateau, is the transition from the Transylvanian Carpathic type towards the river type which is characteristic of the area they cross. Two types of hydrological regimes have been identified for the rivers which originate from the Transylvanian Basin (Figure 2).

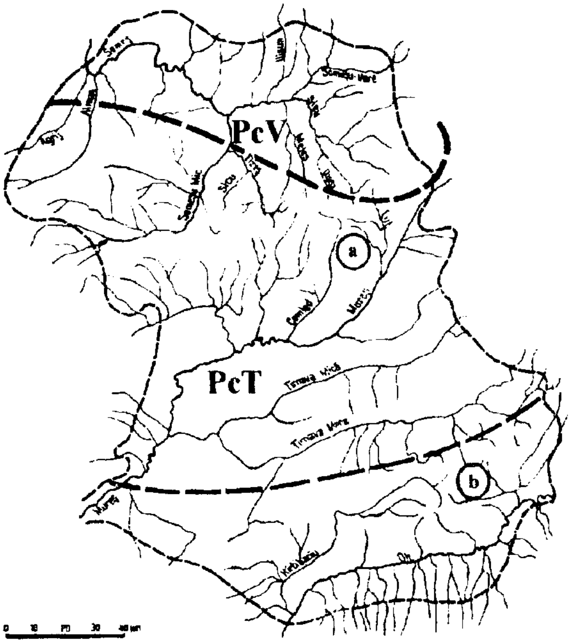

Figure 2: Map of the hydrological regime types distribution for the rivers in the Transylvanian Plateau.

5.2.1. Western peri-Carpathian regime (WpC)

In the north-eastern part of the Basin prevails the *Western peri-Carpathian regime* (WpC). It is characterized by a rich flow in winter and spring and a high incidence of floods in winter (30-40%).

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5.2.2. The Transylvanian peri-Carpathian regime (TpC)

The Transylvanian peri-Carpathian regime (TpC) is widespread in the central and southern part of the Transylvanian Basin and is characterised by rich, short-lived, nivopluvial and short-lived flows in March and by floods especially in the period between May and July. The feeding is pluvionival, and the continental character of the regime increases from north to south (Geography of Romania, Vol.I., Physical Geography, 1983). In what regards the feeding sources, the Transylvanian peri-Carpathian type is sub-divided into: the northern sub-type (a) dominates the central and north-western part of the plateau and has a pluvionival structure (the proportion of snow water feeding keeps between 40 and 50%); the southern sub-type (b) is characterized by a moderate pluvial feeding (defrost feeding between 30-40%).For most of the local rivers, the dominating flow is in March and the most reduced flow, usually in September. The characteristic periodicity in surface flow is represented by: winter floods, more frequent with the WpC and TpC regimes (a), rich spring flows (February- March), poor spring flows (April-May), late-spring and early-summer floods (May-June), autumn floods with a low frequency, poor winter and summer-autumn flows, with a duration of sometimes over three months.

6 Variation of flow in annual context

The year with the richest flow in the entire surveyed period, was 1970. Similar values were recorded in 1981 and 1980. For the rivers from the northern and southern part of the Transylvanian Basin, the poorest flow was recorded in 1990 and for the rivers in the southern part, in 1987.The variable humidity specific for the surveyed territory is in direct agreement with the high values of the annual flow variation, influenced, in turn, by the dimension of the basin. Thus, the annual coefficients of variation are much higher for the local streams (0.50-17), especially in the plateau, where the continental character is becomes more dominant along the east-west direction of the basin. On the other hand, however, the year to year variation of the local rivers' flow is lower (Cv = 0.20-0.40), these being the main sources of drinking and industrial water on the surveyed territory. The multi-annual variation of the annual flow has been observed on periods of 11-12 years: 1954-1965, 1976, 1977-1987. Other authors who used the spectral analysis, such as, I.Haidu, Z.Tilinca, F. Syocs, 1987) or those who used the Fourier-ARIMA model, such as, I.Haidu, P.Serban, Marinela Simota, 1987) also mention them. During the surveyed period, most stations reported a tendency of remission in river flow, more evident on the rivers in the central part of the Transylvanian Plateau. In the southeastern part, however, the flow kept within constant limits (Figure 3). A study of the chronological fluctuation of the mean seasonal debits has revealed a fairly evident synchronicity (Figure 4). Thus, the highest levels of flow were recorded during the winters when the conditions are favorable for rich precipitation and successive defrosting. Such years were: 1978/1979, 1969/1970, 1981/1982. During the winters with persistent anticyclone character, reduced precipitation and low temperatures (1953/1954, 1963/1964, 1971/1972), the values of flow were 20 to 25 times

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lower then the limits characteristic for the winter period. It has been noticed that the chronological variation of the winter

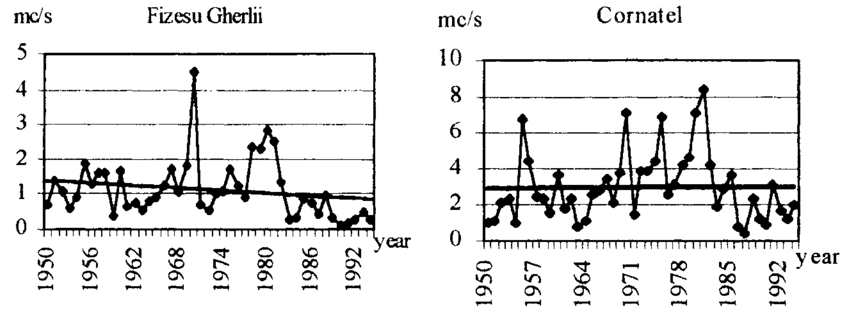

Figure 3: The multi-annual flow variation and trend.

flow observes an 11-year periodicity. 1970 and 1981 were the years with the highest records of spring flow, while for 1971, 1974, 1983 and 1984 the values are the lowest recorded so far. In summer, the convective and frontal rains generate a high flow, which were the cause of the 1955, 175, 170 and 1980 high-scale floods. The lowest summer flow is characteristic for the years with reduced cyclone activity. It happens that for two consecutive years, the summer flow is

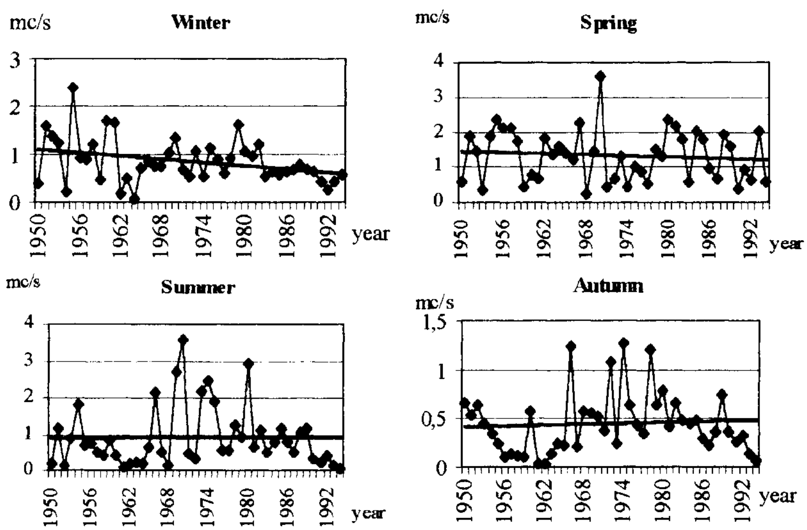

Figure 4: The seasonal flow variation and trend.

poor (1971-1972, 1976-1977, 1983-1984). The richest autumn flow was recorded for the years 1972, 1974, 1978 and 1980, years marked by long periods of

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precipitation and, consequently, with notable hydrological effect. 1961, 1971 and 1983 were reported as being the years with the poorest autumn flow because of the long intervals in which the rainfalls were totally absent, this resulting in the exhaustion of the subterranean reserves. Most stations which analyzed the variation of the seasonal flow have noticed a general tendency of abatement, which is stronger, however, for winter and summer. There are exceptions, too, namely a few rivers from the south of the Transylvanian Basin manifest a slight debit increase in summer and autumn. Studies of the monthly variation for a period of one year, point out the existence of a maximum in May, recorded by the hydrometric stations which monitor the rivers in the Somes Plateau and the Transylvanian Basin, and in September and October for the rivers in the eastern and western areas of the Transylvanian Basin. Minimal values of the monthly variation have been recorded for the months of April and March.

7 Conclusions

Every year, from the Transylvanian Basin is evacuated a volume of about 8110 billion m3 of water, out of which, 72.8% is of mountainous origin and only 27.2 is formed in the plateau (*I. Ujvari and collab., 1982*). As a consequence of the variable humidity, characteristic of the surveyed territory, the debits of the rivers fluctuate between very wide limits in multi-annual profile; a solution was the setting up of accumulation basins in the surrounding mountain areas which cater for the different categories from the Transylvanian Basin. In spite of the apparent constancy of flow formation and evolution in the Transylvanian Basin, at a careful analysis two areas with distinct hydrological characteristics could nevertheless be outlined.

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