50 years University of Mining and Geology "St. Ivan Rilski"
Annual, vol. 46, part I, Geology and Geophysics, Sofia, 2003, pp.

CHARACTERISTICS OF EXTREME VISOCICA RIVER FLOW RATE – INFLUENCE OF HYDROGEOLOGICAL CONDITIONS

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ABSTRACT

It is common that the specific outflow rate of the water current (q) decreases as its basin area increases. Characteristic example which deviates previous rule is river Visocica, which enters the Serbia from the Bulgaria near Donji Krivodol. At the downstream water gage profiles (Visocka Rzana and Paklestica) the specific outflow rate is two times greater comparing to the upstream profiles (Izatovac and Brajćevac). The maximal (Q_{max}) and minimal (Q_{min}) flow rates of the Visocica are indicative too. The fact that the part of the Visocica flow in its river source area in the Bulgaria was moved to the adjacent basin, was considered through the observing of the mentioned example. In this paper, as one of the main causes for mentioned unique case, hydrogeological characteristics of the part of the Visocica basin at the southwest hillside of the Stara Planina are pointed out. Through the general review of the climatic, hydrological, geological and hydrogeological characteristics of the Visocica basin up to the water gage profile Paklestica, hydrogeological conditions influence on the extreme flow rates is interpreted, as well as the inverse relation of the specific outflow rate

INTRODUCTION

In natural conditions there are numerous factors that influence the extreme outflow rate of the water currents. It is unbeatable fact that climatic factors and phenomena such are heavy rainfalls, snow melting, or the combination of these phenomena, determine intensive and maximal outflow rates. Minimal flow rate is common in dry periods, and its value depends on the quantities of accumulated water in hydrogeological collectors in the past period. However, one of the main factors of extreme outflow rates are geological and hydrogeological factors at the river basin area with Visocica river as characteristic example of that.

Visocica river is located in southeast Serbia and belongs to the Nisava river basin, i.e. South Morava river basin. Visocica originates in the Bulgaria below the mountain peak Kom (2016 m) on the Stara Planina mountain. It enters Serbian territory near the village Donji Krivodol. There are two parts of the Visocica river basin (574 km^2) that are clearly distinguished. In the first one, downstream of the water gage profile Paklestica, accumulation reservoir with the dam "Zavoj" is formed. The second part of the river basin which extends upstream of the Paklestica is observed in this paper. This part is specific due to the existance of numerous phenomena caused by the geologic structure and tectonics and its influence on hydrogeological characteristics of river basin area. This is very significant for the Visocica outflow regime.

At the part of the Visocica river basin area which extends on the Bulgarian territory, there were performed hydrotechnical works which enabled the capturing of the certain quantity of the water. This water is later moved to the adjacent river basin area. According to M. Ocokoljić (1987) 1/3 of the average annual flow rate (measured on hydrological station Brajcevci) is captured. However, way back in 1896, J. Cvijić found out that in the summer period, the real source of the Visocica is spring "Jelovicko vrelo" which lies in Dojkinacka reka basin river, and not the part of the Visocica which inflows from the Bulgaria. Since there are appropriate data in the literature, certain corrections of outflow are done, as well as the attempt of interpretation of the extreme outwlow rates of the Visocica river.

GENERAL CHARACTERISTICS OF THE RIVER BASIN

Visocica river basin area which extends up to the water gage Paklestica is 446 km^2 and 26% of it is in the Bulgaria. River basin area is surrounded from the northeast by Stara Planina mountain (peaks: Kom 2016 meters above sea llevel, Srebrna Glava 1932 m asl, Dobro Jutro 1678 m asl, Tri Kladenca 1967 m asl), from the southwest by mountail Vidlic (peaks: Gradište 1088 m asl, Goli Vrh 1371 m asl, Basarski Kamen 1377 m asl), from the northwest by the watershed which connects mountain peaks on the north from Tri Kladenca, over Mramor (1760 m asl) to the Basarski Kamen on the south. The climate is continental (mountain type). The average temperature for the long time period is 8,4°C. In the table 1, some precipitation characteristics (n – number of the years for monitoring, P_{sr} – average precipitation amount for the long time period, δ_{n-1} – standard deviation, P_{max} – greatest registered annual precipitation amount, P_{min} – smallest registered annual precipitation amount).

Table 1. Some precipitation characteristics from the rain gage stations in the Visocica river basin

Rain gauge	Dojkinci	Visocka Rzana	Velika Lukanija
Altitude	880 m asl	700 m asl	600 m asl
n (year)	50	36	32
P_{SR} (mm)	931,4	719,11	720,23
δ_{n-1} (mm)	168	140,4	108,59
P_{max} (mm)	1334	1055,3	948,5
P_{min} (mm)	577,9	466	576,7

Annual rewiev of the precipitation amount shows that may (13% of total annual sum of precipitation) and june (12% of total annual sum of precipitation) are the months with the highest average precipitation amount, while october (6% of total annual sum of precipitation) is the month with the lowest average precipitation amount. Uneven distribution of precipitation is noticable, with high precipitation amount on the mountain area compared to the valley area of the river basin.

General direction of the river flow is from southeast to northwest. Visocica river basin area is tipical example of asimetric river basin. The left valley side placed on the northeast hillside of the mountain Vidlic is very narrow and steep, without any significant water currents. The right valley side developed on the southwest hillside of the Stara Planina mountain is jagged, intersected by numerous streams and rivers. More significant tributaries from the right side (from Serbia–Bulgaria border up to Paklestica) are: Kamenicka river, Rosomacka river and Dojkinacka river.

Relatively long period of "small water" which sometimes lasts untill November is tipical for the Visocica river. During the recession period, upstream from Dojkinacka river mouth, Visocica dries for cca 10 days.

Apart from water gage Paklestica, on the river Visocica, there are water gages Izatovac, Brajcevci and Visocka Rzana as parts of the RHMZ (republic hydrometeorological buerau) of Serbia net. Some of the basic data and the values of extreme flow rates measured on mentioned water gages are given in table 2.

GEOLOGICAL STRUCTURE OF THE RIVER BASIN AREA

The oldest rocks at the river basin area are quartz–albite–muscovite–chlorite shales of Cambrium age (Cm) which builds the core of the vast antiform of Stara Planina mountain (Anđelić, et al., 1975). The cambrium shales are overlied by the thick clastite complex of perm and lower triasic age (P,T_1) built of fragments of various rocks with grain size of 0,1 cm alevrites to 20 cm (conglomerates). The next stratum is thick limestone–dolomite complex of middle triasic age (T_2). Mixture of pure, high fractured rate thick–bedded limestone with dolomitic limestones, dolomites and marls of low fracture rate is typical. The next overlying stratum are sandstones, conglomerates, shales of low metamorphic rate and marls of lower and middle Jurassic age (J_1,J_2). The youngest rocks of Jurassic age are limestones with cherts, sandbar and marly limestones of upper Jurassic age (J_3). This limestone complex is also fractured but in lower rate. The youngest rocks in Stara Planina antiform are marls, sandy limestones, carbonate sandstones and shales of lower Kretaceous age (K_1). All mentioned Kretaceous rocks are mutually intersected, sometimes in the rhytm which is characteristic for flysch. Finally, over these rocks, along the bottom of the Visocica cut, lies quarternary alluvial and terrace sediments.

Table 2. Some of the basic data of hydrological stations and the values of extreme flow rates (group of authors, 2002)

Hydrological station (H.S.)	Starting year H.S. (year)	Magnitude A (km^2)	Zero point "0" (m asl)	km from confluence (km)	Q_{max} (m^3/s)	Date	Q_{min} (m^3/s)	Date
Izatovac	1963	156	753,11	38,6	88	10.07.1967.	0,000	10.08.1963.
Brajcevci	1963	227	447,07	37,8	118	10.07.1967.	0,000	10.08.1963.
Visocka Rzana	1958	403	684,90	33,8	202	20.04.2002.	0,176	15.08.2000.
Paklestica	1959	458	610,46	21,0	241	08.06.1966.	0,350	13.09.1965.

All sediment series in the lap of the Stara Planina antiform have mild slopes, rarely greater than 20°. Therefore, horizontal projections of the thin formations stand out, which is very significant from the hydrogeological aspect. Large ruptures are rare, but the sediments are very fractured and imbued with small cracks and fissures.

HYDROGEOLOGICAL TERRAIN CATHEGORIES OF THE RIVER BASIN AREA

Three hydrogeological cathegories of the Visocica river basin area are distinguished on the basis of porosity, permeability and the presence of aquifers (Čubrilović and Nikić, 1999). The sizes of these hydrogeological cathegories areas, expressed in percentages are given in the table 3. The basic characteristics of the distinguished hydrogeological cathegories from the aspect of Visocica outflow are the following:

Terrains hydrogeologically typically cathegorized as aquifers of intergranular porosity (A) are: alluvial and terrace sediments of Visocica river and slope detritus on the northeast hillsides of the Vidlic mountain. These hydrogeological units are of secondary significance for interpretation of extreme outflow rates of the Visocica river.

Terrains hydrogeolocically cathegorized as aquifers in carst and carst–fissured porosity (C) are limestones and dolomites of middle Triassic age and limestones with cherts of upper Jurassic age

Middle Triassic limestones and dolomites are highly karstified which is confirmed by the existance of large karst springs, sinkholes, caves and sinking rivers. Due to favourable geological and hydrogeological conditions, large karst aquifer is formed in these limestones. Underlying formation of this aquifer is built of clastic sediments of lower Triassic age. The aquifer recharges through the infiltration of the precipitation, and through surface water currents–sinking rivers which inflow from the non–karst terrains. The aquifer discharges through the Jelovicko vrelo in the river basin of Dojkinacka river. This rock complex has hydrogeological function of reservoire–conductor. The complex is highly significant in the forming of small water outflow of Visocica river.

The second carbonate complex–limestones of upper Jurrasic age, do not participate in the forming of extreme outflow rates of Visocica river due to the space placement and considerably less karstification rate.

Table 3. Percentage of present hydrogeological cathegories surfaces at the river basin areas of water gage profiles

Hydrological station	Area of hydrogeological categor (%)		
	A	C	E
Izatovac	8	30	62
Brajcevci	6	29	65
Visocka Rzana	4	25	71
Paklestica	4	26	70

- Terrains hydrogeolocically cathegorized as "waterless" (D) are Paleosoic shales, Perm–lower Triassic clastites, lower and middle Jurassic sediments and lower Kretaceous flysch. This terrains have hydrogeological function of bedrock and overlying isolator, as well as lateral barrier for ground water in the karstified middle Triassic limestones. Mentioned lithological complexes take up large part of the river basin area of all water gage profiles, mostly they are impermeable, so there is no possibility of any importance for infiltration of atmospheric precipitation. This is the main reason for high rate of surface run off. Water currents have torrential character and terrain erosion processec are developed. "Waterless" hydrogeological cathegory does not contribute to the quantity of small water outflow of Visocica river, but is essential for the forming of its maximal flow rate.

THE ROLE OF THE HYDROGEOLOGICAL CONDITIONS FOR THE FORMING OF EXTREME FLOW RATES OF THE VISOCICA RIVER

Formerly presented characteristics of the Visocica river basin terrain are essential in the clarifying of the the role of the hydrogeological conditions for the forming of extreme flow rates and the specific outflow rate of the river. Significant fact is the existance of favourable space placement of porous and permeable karstified limestones and dolomites of middle Triasic age which are undrlyied by impermeable bedrock.

Visocica river basin area, from river source in Bulgaria to the water gage profile Paklestica, encompasses the river source areas of all the right tributaries (Krivodolstica, Kamenicka reka, Rosomacka reka, Dojkinacka reka) at the Stara Planina hillsides. All these rivers have steep slope, precipitation amount is high, and the snow retains untill April. Rich with water, these rivers come across karstified limestone and dolomite area where they sink through numerous sinkhole zones and concentrated sinkholes (Čubrilović and Nikić, 1999). On the parts of the brooks Karibanje and Gradisnica, there are sink zones which are few hundred meters long. Concentrated sinkholes are typicall for the Vodevička and Rosomacka rivers.

During the period of small water, all water that inflows sinks completely and the riverbeds are dry over the time period of several weeks and it directly influences Visocica river flow rate. Sinking takes place also in the period of high water, but due to steep slopes and high flow rates all rivers reach and inflow into the Visocica river. Due to favourable space placement and high rate of karstification of middle Triassic limestones, sinking rivers are directed to the 6 km distant karst spring Jelovicko vrelo which belongs to Dojkinacka reka river basin. Maximal yield of Jelovicko vrelo is cca 5 m^3/s, while minimal is cca 200 l/s. In the Dojkinacka reka river basin there are other numarous large springs as well

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During the recession period large quantities of water outflow from Jelovicko vrelo, while quantities of water that inflows from Bulgaria through Visocica river becomes very small, or

completely dries up. Jelovicko vrelo, then, represents the real source of Visocica river. This is illustrated with figure 1 which shows specific outflow rate (q) in four water gage profiles at the Visocica river.

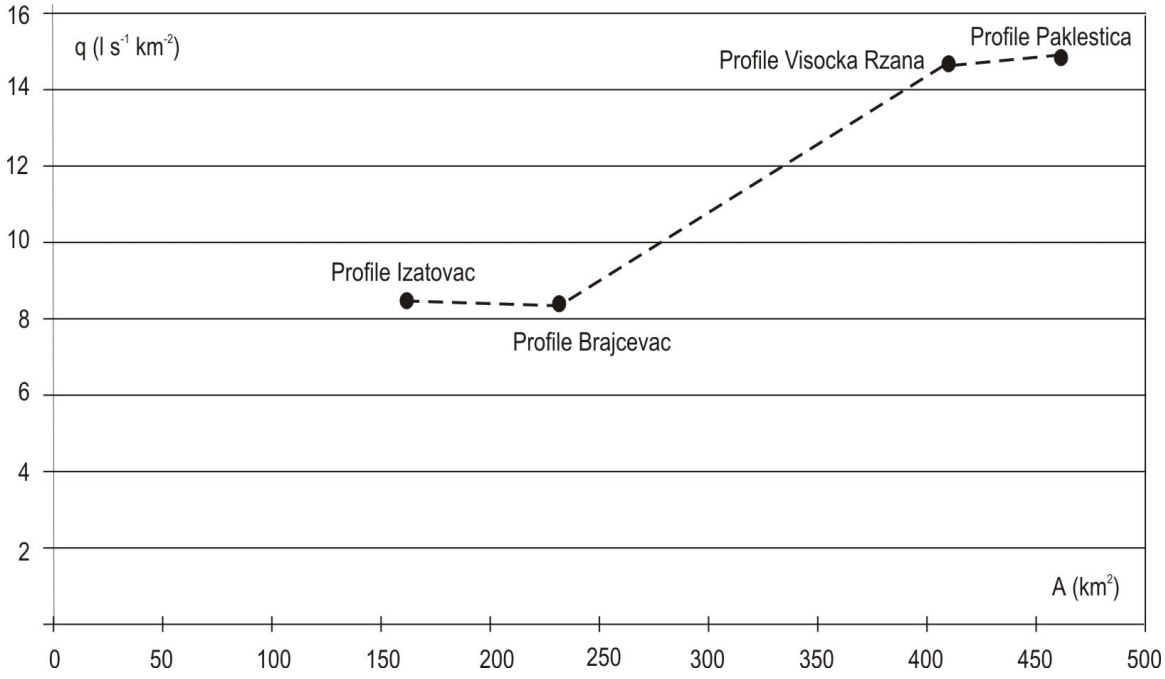

Figure 1. Specific outflow rate of theVisocica river measured on water gage profiles

CONCLUSION

On the analyzed part of the Visocica river basin area, hydrogeological conditions have significant influence on the forming of extreme and specific runoff. It is reflected in the time and space distribution of the water resources.

Space distribution is carried out by redirection of some quantities of the right treibutaries water which sink in the part of the flow over the middle Triasic karstified limestones. Sinking unables its inflow into Visocica river. Sinking rivers are directed to the 6 km distant karst spring Jelovicko vrelo and inflows into Visocica river through the Dojkinacka river.

Time distribution is carried out due to the considerable accumulation–retardation abilities of the karst and dolomite aquifer of the Triasic age. Therefore, during the recession period, the predominant outflow of the Visocica river is performing through the Jelovicko vrelo and Dojkinacka river.

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