

JOVAN CVIJIĆ'S HYDROLOGICAL RESEARCH OF THE TIMOK RIVER BASIN (EASTERN SERBIA)

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ABSTRACT: In the late 19th century, Jovan Cvijić laid the foundations for the scientific study of the hydrological evolution in the Timok basin and eastern Serbia. In terms of hydrology, eastern Serbia is very diverse and significant in Cvijić's scientific research. He devoted great attention to the study of karst hydrography - underground waterways, wells, springs, waterfalls. In papers and monographs he presented scientifically valid and lasting knowledge of this area. The work shows his most important investigations and conclusions in this area, which are the result of field observations and measurements he performed. Even today, the research and works of Jovan Cvijić represent the basis for further study of hydrological and morphological phenomena and problems. Almost all studies in this issue after Jovan Cvijić are related to specific local phenomena. This paper is an attempt to present his work relating to the Timok basin and the Timok Region and beyond, the territory of Eastern Serbia.

Key words: Jovan Cvijić, hydrology, Eastern Serbia, Timok River

INTRODUCTION

Jovan Cvijić achieved most of his scientific work in the field of geomorphology. Given that water is one of the agents of creation and evolution of the various forms of relief, he also studied hydrographical objects. S. Stanković (2006) states: "He dealt with water in karst in details which enabled him to hypothesize about three hydrographical areas and thereby solve the evolution of dry, periodically and continuously flooded karst fields, define

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permanent, periodical and occasional springs, prove mismatch between orographical and hydrographical watersheds in the basins of numerous karst rivers, all with constant appreciation of the relationship between man and karst, which can be identified with the relationship and conditionality between human and water". In numerous papers and books he presented the results of his scientific research obtained by examining the expanses of eastern Serbia, and therefore many hydrographical phenomena, processes and structures in the Timok basin.

In terms of hydrology, eastern Serbia is very diverse and significant in Cvijić's scientific research (Stanković, 2006). The first important observation about the eastern parts of the country, mainly about the Kučaj Mountains, and about the Tresibaba and Tupižnica Mountains, he noted even during the students' scientific excursions with Jovan Žujović (Stojadinović, 2015). He returned to these regions several times, which resulted in the publication of numerous scientific papers on the karst terrains of eastern Serbia. This paper does not involve writing of Cvijić's biography or presentation of the whole of his work, but an attempt to present his work relating to the Timok basin and the Timok Region and beyond, the territory of Eastern Serbia and thus give a modest contribution to the celebration of the 150th anniversary of the birth of Jovan Cvijić.

SCIENTIFIC CREATIVITY DEDICATED TO THE TIMOK BASIN AND EASTERN SERBIA

The subject of Cvijić's research was often hydrography of the karst terrains. The most important of his works dedicated to, among other things, various hydrological phenomena and processes in the basin of the Timok are as follows:

- Ka poznavanju krša istočne Srbije (Towards the Knowledge of Karst of Eastern Serbia), Prosvetni glasnik, Belgrade, 1889
- Pećine i podzemna hidrografija u istočnoj Srbiji (Caves and Underground Hydrography in Eastern Serbia), Glas Srpske kraljevske akademije nauka, volume XLVI, page 1–101, Belgrade, 1895
- Izvori, tresave i vodopadi u Istočnoj Srbiji (The Springs, Peat Moors and Waterfalls in Eastern Serbia), Glas Srpske kraljevske akademije nauka, volume LI, page 1–122, Belgrade, 1896
- Površine rečnih slivova i dužine reka Kraljevine Srbije (Surface of river basins and rivers length of the Kingdom of Serbia) (with E. Cvetić, T. Radivojević, P. Janković and A. Maksić), Spomenik Srpske kraljevske akademije, volume XXXV, page 1–31, Belgrade, 1900

At the end of the nineteenth century J. Cvijić published two studies "Caves and Underground Hydrography in Eastern Serbia" (1895) and "The Springs, Peat Moors and Waterfalls in Eastern Serbia" (1896) and laid the foundations for the scientific study of the hydrological evolution in this field.

He devoted great attention to the study of karst hydrography - underground waterways, wells, springs, waterfalls, and presented their classification and names in extensive work: *The Springs, Peat Moors and Waterfalls in Eastern Serbia* (Serbian: *Izvori, tresave i vodopadi u Istočnoj Srbiji*). About the names of springs, he wrote: "They are most commonly called springs, source springs and small springs. Common names are given by way of rising or the spring form, such as: *klok, prskavac, samovrelica, vir, bezdan, grlo (grla)*; by sound: *buk (bukovi), bobotalo, ropot*; by the smell of water: *smrdan*, by low and high temperatures: *studenac* and *studenka, banja* and *banjica*, and *banja* is always warmer than *banjica*. If they are caught in hollow tree trunks or underpinned, they are called wells and fountains, while they are *šopur, šopurići, šopke*, if they flow through ditch, and finally troughs, if they are beneath the channel in which water collects" (Cvijić, 1896).

Studying springs in Eastern Serbia, Cvijić singled out three types. Most numerous belong to ordinary springs that emerge from the caves or cracks and flow away normally. Other, much less common, are the springs at the bottom and the sides of the closed resurgence basins which they fill with water. In the third group of springs Cvijić includes quite rare springs - intermittent springs, which are related to cavities and curved channels in the limestone from which water flows intermittently and stops.

At the first group of springs of limestone mountains in eastern Serbia, the source springs that emerge from the caves and cracks in the limestone are most common. They appear at piedmont and the slopes of the limestone mountains. They are actually the underground rivers that come into view in the form of strong springs. These are the springs of the largest rivers of eastern Serbia, including the spring of the river *Crna Reka* or the *Crni Timok* (Figure 1). A common feature of these springs is that the anhydrous limestone masses end by escarpments and beneath them there are one or more cracks and caves from which the entire river flows out. Apart from these, the rivers created in this way usually have no other springs or if they have them, they are much weaker than the main spring so that it can be no doubt about the original spring of the river. Today, many settlements in the *Timok* basin are water supplied from such springs; *Knjazevac* is among them, and the *Sinji Vir* spring at the foot of *Tresibaba* is impounded for its water supplying.

In the first group of springs J. Cvijić also included the springs at the contact of limestone and impervious rocks. He considers that the most numerous and standard springs of this kind are in those mountains the slopes of which are characterized by escarpments where the contact between limestone and impervious rocks is denuded at great length. He presented the Svrljiški Timok as an example, which has two headwaters, one called the Paješka River and other the Kozjanska River. He states that the first one rises under the Paješ karst on the border between the limestone and sandstone. Similar is the spring of the other headwater which rises beneath the Rinjska Mountain.

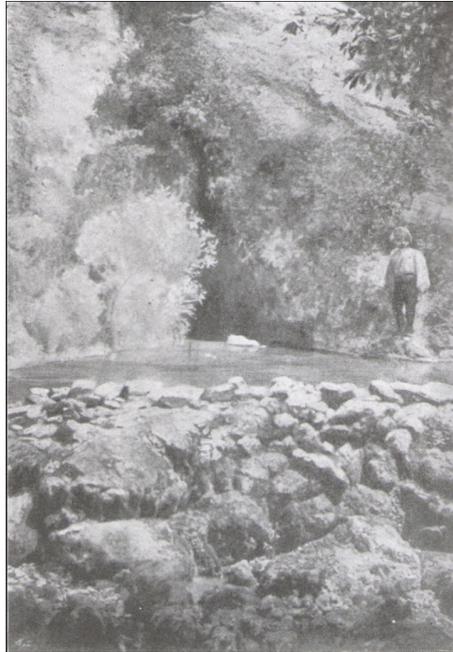


Fig. 1. The Crna Reka source spring (Crni Timok). Cvijić, 1896

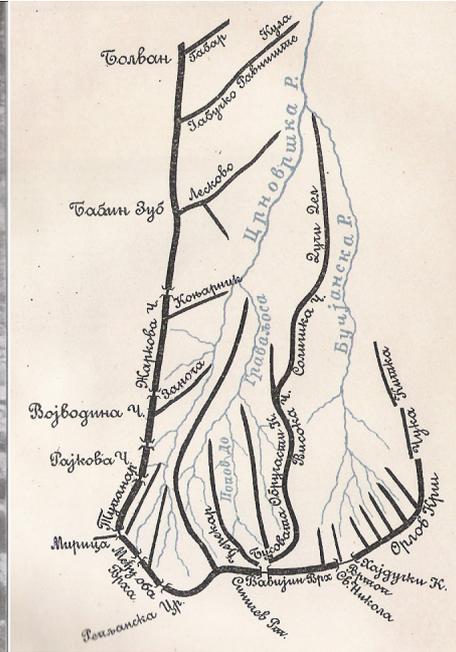


Fig. 2. The source spring of the Crnovrška River. Cvijić, 1896

Springs in impervious rocks are the weakest, but most numerous springs of the first group emerging in the impervious rocks. Many rivers of eastern and southern Serbia have the springs of this kind, including the Trgoviški Timok. They have many springs from which small streams are flowing through deep valleys, making a confluence of several major headwaters, and the whole system of these streams and rivers builds true source springs. They are often framed by ranges and slopes. J. Cvijić presented an outline of the headwaters of the Crnovrška River, one of the main headwaters of the

Korenatac (Figure 2). The source spring of the Korenatac consists of three main headwaters: the Crnovrška River, the Čoštica and the Stanjanačka River. He states that the first river is richest in water and physically its original spring, starting with a source spring that lies in the cirque. In the hinterland of the cirque there is a part of the range of Stara Planina Mountain. The Crnovrška River begins with three headwaters: the Bučjanska River, the Gravaljosa and the Sokolova River, each of which is further composed of many smaller streams and all these water sprouts strongly erode the inside of the cirque. Cvijić concludes that for this reason our slopes of the Stara Planina are steeper than the Bulgarian.

“Cvijić presented tabularly the data for 164 springs stating the name of the spring and location, type of rock from which water rises, the absolute height and the water temperature” (Sibinović, 2015). Based on the conducted research, J. Cvijić recorded: “The Stara Planina is the richest in running water of all the mountains in eastern Serbia. The mean temperature of its springs, which are at a height of 1000–2 000 m, is 6.4 °C ... The height of the springs of eastern Serbia has prevailing influence on their temperature, and it can rarely be seen as it is seen on the range of Stara Planina “ (Cvijić, 1896). Springs around Rtanj are of uniform temperature from 9 to 10.5 °C. Of all the springs, the springs of the Lukavica and Mirovištica are the strongest. The Lukavica spring is under the western branch of Rtanj, and water comes out at the contact between limestone and sandstone. The Mirovištica spring is semi-circular basin, on which limestone edges water comes out of the temperature of 10.5 °C, filling the basin and flowing away as a strong river. Mean temperature of the observed springs of the Svrljiške Mts. is 10.5 °C. On the north side of the Svrljiške Mts., springs emerge either at the contact between limestone and phyllite with sandstone or from resurgence depressions and caves (Cvijić, 1896).

As the second type of springs, J. Cvijić singled out resurgence water basins, i.e. springs with small basins at the place where springs emerge to the surface. As a representative of this type of springs he mentioned Bare on the Svrljiške Mountains above the village of Gulijana.

Almost all the waterfalls in eastern Serbia are detailed in this monograph. Among other things, Cvijić also gave a description of the waterfall Bigar on the same small river, a tributary of the Stanjanačka River, which is one of the source spring headwaters of the Trgoviški Timok. From the spring to the mouth of the Stanjanačka River, the Bigar river valley is inclined by 80 m and whole filled with tufa. “The biggest waterfall 35 m high is located at the place where the tufa valley faces the Stanjanačka river valley In this little inclined escarpment, three snow white canvases of

foamed water can be seen, and three water mills among them. This is one of the most beautiful waterfalls in eastern Serbia, which moved by itself and artificially" (Cvijić, 1896). The Crnovrška river bed, the main headwater of the Trgoviški Timok, is characterized by many rapids that turn into cascades, and the biggest one is called Bobak. Its escarpment is 7 m high (Cvijić, 1896).

In the scientific study "Caves and Underground Hydrography in Eastern Serbia", the author points out the main characteristics of the movement of ground waters in karst of eastern Serbia and their relationship with the origin of the caves and the morphological evolution of the limestone terrains (Cvijić, 1895). Hydrographical features of caves J. Cvijić took as one of the criteria for their classification. He divided the caves into the river and dry. For the first he says that "ground waters are circulating through them and these waters are their main feature. Among the caves of this type there are those through which underground rivers are flowing the entire length, and these are the river caves ... All river caves have two openings: the upper in which the river sinks and is called the sinkhole and the bottom, from which the river rises and is called spring. These caves are, therefore, passable the entire length and the river that runs through them is called the underground river" (Stanković, 2006).

Cvijić noted that the dry caves are located mostly on the sides of the river valleys and escarpments of limestone mountains, sometimes in the escarpments below the highest mountain peaks. He believed that water was very important factor in the formation of these caves, which drained from the surface, and on the basis of sand, gravel and clay in some caves he concluded that streams and underground rivers flowed through them, too.

A separate section of the book is devoted to the manner of the emerging of springs and sources, estimation of the minimum and maximum abundance, morphometric data, data on water temperature. Among others, he investigated the Crni Timok spring, the Zlotska, Radovanska and Crnoljeviška springs.

In the paper *Ka poznavanju krša Istočne Srbije (1889)* (Towards the Knowledge of Karst of Eastern Serbia), J. Cvijić is dealing with karst relief and presents significant data on Prekonoška cave and underground course of the Svrljiški Timok. He devoted an entire chapter to the rivers in karst, concluding that one of its basic characteristics is anhydrous surface and the abundance of water in the depths of limestone mass. Based on the hydrological evolution and morphology of limestone terrains, several types of the river valleys are singled out (cut in the source spring, in the lower part closed - blind, half-closed, dry).

Table 1. *Surface of river basins and long rivers*

River	River length (km)	River basin surface area (km ²)
Beli Timok	105.8	2 161.72
Crna Reka	71.0	1 003.15
(Veliki) Timok	79.2	948.62
Svrljiški Timok	56.0	719.94
Trgoviški Timok	50.0	519.96
Grezanska	15.0	79.12
Žukovska	18.0	82.02
Zlotska	28.0	130.45
Vražogrnska	32.5	363.17

Source of data: Cvijić et al., 1900.

In article "Surface of river basins and rivers length of the Kingdom of Serbia", are divided two separate parts: surface area of the Kingdom of Serbia and rivers length in the Kingdom of Serbia ". Measurement river basin areas in Serbia was carried out in special sessions of the General Staff map of the Kingdom of Serbia, scale 1:75000. River lengths in km were measured with the curvimeter in the abovementioned special map of the Kingdom of Serbia (1:75000) created by General Staff. "Exceptionally is measured the entire Timok river basin in Serbia and also in Bulgaria" (Cvijić et al, 1900). In table 1 are presented morphometric data in Timok river basin, contained in mentioned article (Cvijić et al., 1900).

CONCLUSION

Jovan Cvijić has left a permanent mark on the culture, science and public life of Serbia. His works are a kind of legacy of the future.

He was a great connoisseur of relief and waters of eastern Serbia, which was his main attraction for scientific research for natural resources, the conservation of nature and ethnic specifics. In papers and monographs he presented scientifically valid and lasting knowledge of this area.

At the end of the nineteenth century, publishing voluminous works and studies, he laid the foundations of the scientific study of the hydrological evolution in this part of our country. Great attention he has devoted to the study of karst hydrography - underground waterways, wells, springs and waterfalls. The material he collected in the field was basis of his scientific work. The wealth of information on hydrographic facilities that he collected and gathered, even today is extremely useful to scientists in field research and cabinet studies.

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