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GEOMORPHOLOGICAL STUDIES OF JOVAN CVIJIĆ IN BULGARIA

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Abstract: The geomorphologic studies of Jovan Cvijić in Bulgaria are crucial for many Earth scientists from the beginning of the 20th century. Cvijić laid the foundations of the morphotectonic division of the Balkan Peninsula, clarified a number of tectonic and glacial processes and offered proof that there were traces of the Wurm glaciation in Rila Mountain. His findings on the geographical scope of the last glacial period on the Balkan Peninsula are largely based on his research in the Rila and Pirin mountains in Bulgaria. He is the first scientist to define the snow line altitude during the Wurm glacial stage in Balkan Mountains and discover the glacial origin of high mountain lakes there. Many of his theories on relief evolution in the region remain very important to the development of geology and geomorphology in all Balkan countries. In this paper, we provide a review of some publications by Jovan Cvijić that relate to the territory of Bulgaria and analyze the impact of his findings on the work of Bulgarian geologists and geomorphologists.

Key words: Bulgaria, geomorphologic studies, Jovan Cvijić

Introduction

By the end of the 19th century, Bulgaria had been a subject of periodic studies by some European geologists and geomorphologists, primarily Austrian, Hungarian and German. Immediately after the Liberation of the country, geographical research of the Bulgarian lands and the Balkan Peninsula continued to be carried out by foreign scientists, but scientists from the Balkan countries became increasingly involved. One of those scientists was Jovan Cvijić. Bulgaria had completed the first stage of geological surveys at the time, led by scientists such as Amie Boue, Felix Kanitz, Franz Toula, Bulgarian geologists Georgi Zlatarski, Georgi Bonchev and Lazar Vankov had already began systematic stratigraphic and petrographic studies in Bulgaria, but tectonic studies were still missing. That knowledge gap attracted the research interests of Jovan Cvijić to Bulgaria. In this article, we look at Cvijić’s basic geological, geomorphological and tectonic studies in the region.

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Studies of Jovan Cvijić on Tectonic and Geology in Bulgaria

Jovan Cvijic toured a number of routes in North-Western and Western parts of Bulgaria, in the Fore-Balkan Mountain's valleys and in the Rhodope Massif, in order to explain their tectonic and geology. He paid great attention to the geologic structure and plate tectonics of Western Stara Planina and Kraishte.

The report "Die Tektonik der Balkanhalbinsel" (Cvijić, 1904) was published in 1904 together with a report by Bulgarian geologist Stefan Bonchev that had been presented at the "Congress of Serbian Physicians and Naturalists" (Bonchev, 1904). Both reports covered the same topic: "Tectonics of the Western Balkan". These two publications mark the beginning of tectonic studies in Bulgaria. In contrast to the view of a calm folding construction of Western Stara Planina held by Cvijić, Stefan Bonchev argued for a much more complex, convoluted-thrust structuring. Bonchev's view was validated by research in the following decades.

Jovan Cvijić focused his investigation on the Plate tectonics in Kraishte region and its special features (Cvijić, 1904). He discovered that, unlike the Middle Balkan Range, the south and west of West Stara Planina contain a 40–60 km wide belt, mostly of Mesozoic rocks, which is tracked from the city of Sofia, Dupnitsa and Samokov to Danube River and in the Mesozoic zone of Banat. In this Mesozoic zone Cvijić distinguished the following tectonic elements:

A group of folds can be traced from the South and West to the depressions of the cities of Sofia, Pirot, Byala Palanka and Nis. Like Paleozoic core of Western Stara Planina, they also bend off the West-East in a Northwest direction.

A second group folds south of the previous one, which are not a part of the Westbalkan bend zone and have a straight NW–SE direction. In the west these folds are at an acute angle to the folds of the first group. Between these two sets of folds, there is old Lower Cretaceous or even older graben with Gosavski sediments with intercalation of andesite tuffs, which have been folded during Oligo-Miocene flexing (Cvijić, 1904).

Cvijić concludes that we should not look for a direct link to the Carpathian Mountains and the Stara Planina Mountain (Cvijić, 1904).

Nearly thirty years later, the first basic regional geological studies from Bulgarian scientists (Dimitrov, 1931; Beregov, 1935; Yaranov, 1935; Bonchev, 1936) were carried out in the same region.

Famous Bulgarian geologist and geomorphologist Dimitar Yaranov comments on the findings of Jovan Cvijić: “Despite the inaccurate dating of andesite rocks, the tectonic division put forth by Cvijić completely fits the Bulgarian part of the region, and we will continue to be surprised by the insightful work of this researcher”. (Yaranov, 1960).

In his work “Struktura i podela planina Balkanskoga Poluostrva” (Structure and division of the Balkan peninsula mountains), Jovan Cvijić investigated the orogenic and tectonic processes in the Rhodope Massif. He observed two main discordances — an old and a young one. The older discordance was in the crystalline shales or in cretaceous-paleogene sediments, and the young one was between Paleogene and Neogene. In the crystalline shales of the system he found evidence of folding and tectonic processes that had taken place in the cretaceous sediments (Cvijić, 1901). Cvijić explicitly pointed out that the Rhodope massif had been submerged in the northern part of the Paleogene seas, which deposited sandstones, positioned horizontally on the crystalline shales. From this position he concluded that “folding processes had been completed fully before the Eocene” (Cvijić, 1900). This view had been accepted without question until the 20s of the last century, when a number of Bulgarian and foreign scientists (Jaranoff, 1940; Gallabov, 1941; Bontchev, 1946; Petrashek, 1921), proved the existence thrust movements in Central and Western Rhodopes after the Eocene.

Cvijić’s studies on the geology of Pirin Mountain discovered that the base of Pirin Mountain consists of granites, which track west to the Kresna Gorge (Cvijić, 1906–1911).

Geological Survey of Bulgaria and of neighboring countries through the beginning of the 20th century provided enough data to allow Jovan Cvijić to create the first tectonic division of Bulgaria (Cvijić, 1904). This initial schematic contained the primary tectonic units that were later described in more detail and had their borders refined. Cvijić distinguishes the following major tectonic zones in Bulgaria: 1) Rhodope Massive; 2) Transitional zone; 3) Balkan folded zone with significant differences between Western and Eastern Stara Planina Mountain and 4) Bulgarian plate.

On the basis of this division and the geo-historical development of the region, Dimitar Yaranov (1960) proposed the following three big geostructural units on the territory of Bulgaria: 1) Plate of Mizija with its border depressions — corresponds to the “Bulgarian plate” (after Cvijić, 1904). 2) Rhodope Massif with its border depressions — corresponds to the “Rhodope Massive” and

“Transitional zone” (after Cvijić, 1904) and 3) Balkanides – corresponds to the “Balkan folded zone” (after Cvijić, 1904).

Jovan Cvijić laid the foundations of the morphotectonic division of the Balkan Peninsula, and helped clarify the main tectonic characteristics on the territory of Bulgaria.

Studies of Jovan Cvijić on Geomorphology in Bulgaria

Jovan Cvijić very thoroughly dealt with geomorphological and paleogeographical development of the Balkan Peninsula specifically within the territory of Bulgaria.

In his foundational works “Geomorfologija”(Geomorphology) in two volumes (Cvijić, 1924; Cvijić, 1926), Cvijić explains the morphography of the Balkan Peninsula and its main watershed, which for the most part passes through the territory of Bulgaria.

In the study on the denudation surfaces in Bulgaria, Cvijić describes the upper-Eocen-Neogene denudacion surface the initial “Main Rhodope surface” and links it to planation processes in the Miocene. This hypothesis was confirmed by a number of subsequent studies (Cvijić, 1901; Louis, 1930; Yaranov, 1960; Gallabov, 1966; Lilienberg, 1971; Vaptzarov & Mishev, 1997).

Dimitar Yaranov (1960), in his fundamental work “Tectonics of Bulgaria”, pays particular attention to the views of Jovan Cvijić on the evolution of sedimentary basins and on denudation surfaces in the Neogene on the Balkan Peninsula: *“As early as 1836 Amie Boue found in many places in European Turkey, i.e., in many places in the Balkans, and especially in its central parts, including in Southern Bulgaria, the presence of young lake sediments. But he didn’t try to connect them. And later, at the beginning of 20th century, in spite of the obvious traces of such young lake basins, nobody thought to connect them in one system. Even Cvijić hesitated to do so until 1903, when he wrote that “in the oligo-neogene time old massive was torn by numerous faults, which are sunk grabens”* (Cvijić, 1904).

Afterwards, however, Cvijić turned his attention to study the individual hollows on the Balkan Peninsula in detail. He was impressed by the ubiquitous presence of neogenic sediments, generally poorly denivelated, as well as numerous planes in relief on different height. He assumed that they represent abrasion lake terraces formed by the same freshwater lakes that had created the neogene sediments. Based on these observations, Cvijić concludes that the lakes were

interconnected via narrower or wider “Lake inlets”, all related to a big freshwater lake at the site of today’s Aegean Sea. That’s why he refers to a “Neogene Aegean Lake”, whose remnants are today’s numerous lakes in Macedonia (Cvijić, 1911).

These palaeo-geographic reconstructions were not confirmed and supported in the studies of geologists and geomorphologists such as Penk (1925) and D. Jaranoff (1940) and had no further development.

In 1908 Cvijić put forth the idea of the existence of Fore-Balkan Mountain Pliocene valleys, oriented in the Sub-Equatorial direction along to a morfolineament and with Black Sea drainage. At the end of the Pliocene, it is torn apart by active radial movements of the Earth’s crust and the individual valleys separate under the differentiating impact of the left tributaries of Maritsa River.

The Bulgarian geographer Zheko Radev (In Batakiev, 1934) was the first to challenge the common Fore-Balkan Mountain Pliocene paleo-valley idea. Later, Penk (1925) and Yaranov (1935) also rejected it. Yaranov (1935) suggested that Fore-Balkan hollows are result of the crossing of longitudinal and transverse faults. In recent times, different geological, geomorphological and tectonic studies prove that the valleys are sinkholes formed in place of the so-called “pool-appart basin” area of extension and movements by strike-slip faults, and are not part of paleovalley.

The geomorphologic studies of Jovan Cvijić in Bulgaria are fundamental for the development of the Bulgarian geomorphology in many ways. His contribution to the understanding of Bulgarian high mountains is essential, as he provided evidence for the presence of glacial forms in Rila and Pirin Mountains. Cvijić carried out the first scientific study of Rila Mountain, the first completed work on its orography, hydrography and morphology. Jovan Cvijić is the first who defines the eastern border of Rila with Rhodope Mountain by the deep and narrow saddle east of Musanov Chal.

J. Cvijić first explored the problem of glaciations in Rila Mountain, Bulgaria in 1896 (Cvijić 1897, 1898). The expedition consisted of Jovan Cvijić and three Bulgarian explorers: geographer Dimitar Ilkov, writer Petar Daskalov, and teacher Ivan Velchev. On July 10/23, 1896, they study the area of the Seven Rila Lakes, situated between 2,095m and 2 535 m a.s.l., in the North-Western part of Rila Mountain. An accident in that area nearly cost the life of Jovan Cvijić. Dimitar Ilkov recounted that they had to go down a very steep (59°) icy slope, about 1 km long, leading straight to the Bliznaka Lake. Cvijić wanted to save

time and descended down on the ice, but fell and sustained serious injuries. On the next day, 11/24 July, they discovered obvious signs of Pleistocene glaciation between Lakes Babreka and Bliznaka (Nikolov, 1999). After that Cvijić continued to work in the area of Urdini Lakes on the other side of the ridge and found more evidence for glaciations. He conducted further glacial investigations not only in Rila, but also in Pirin, Stara Planina and Vitosha Mountains. He described 32 cirques and 192 glacial lakes in Rila, and 40-50 lakes in Pirin. Cvijić determined the lowest altitude of the front moraine in the valleys of Beli Iskar (1,092 m a.s.l.) and of Cherni Iskar (1,600 m a.s.l.). A more systematic review of the glacial studies in Balkan Peninsula is presented by Cvijić (1920) in the article *“Ledeno doba i glacijalni oblici Balkanskoga Poluostrva”* (*Ice age and glacial forms of the Balkan Peninsula*) Cvijić conducted his glacial investigations also in the upper areas of Stara Planina and Vitosha Mountain. Cvijić first examines the problem of glaciation of the Stara Planina mountain in his article *“Novi rezultati o glacijalnoj eposi Balkanskog poluostrva”* (*New results on the glacial epoch of the Balkan Peninsula*) (1903). After exploring the Čiprovka and Berkovska Mountains and the valley of river Cherni Osam, he concluded that Stara Planina Mountain did not have typical Alpine glaciation.

At the same time when Cvijić first noticed the glaciations of Rila Mountain in 1902, Bulgarian geologist St. Bonchev also released his paper *“Contribution to the question: Were there traces of glaciers on the Balkan Peninsula”* (1896–98).

Cvijić discussed the subject of glaciation of Vitosha Mountain in his article *“Novi rezultati o glacijalnoj eposi Balkanskog poluostrva”*, (*New results on the glacial epoch of the Balkan Peninsula*) in which he also addresses the aforementioned work of St. Bonchev. Cvijić wrote: *“Although the study shows that Bonchev made careful observations, his conclusions are wrong. None of the listed blocks, which I know in great details, has a connection with the old glaciers”*. Describing his observations when climbing a mountain with prof. Zlatarski and prof. Morfov, Cvijić noted: *“I’ve not noticed traces of old glaciers. The masses of river sediments in Bistritsa and its eluvium suggest heavy snowfall on the mountain, which however did not lead to the development of glaciers.”* Bulgarian geographer Zheko Radev later expressed the same opinion in his publication *“Is There a Trace of Diluvium Icing of Vitosha Mountain”* (1926).

Conclusion

Although Jovan Cvijić has made significant contributions to many areas of study in geomorphology, geology and plate tectonics, we wanted to focus on his

impact on the development of these fields of science in Bulgaria. His research added to the body of knowledge for the territory of Bulgaria and the Balkan Peninsula and laid the groundwork for continued exploration and scientific discussion among his Bulgarian colleagues.

Looking back today, 150 years after the birth of this eminent scientist, we clearly see many reasons to express our respect and gratitude for his pioneering work.

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