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NATURAL BRIDGES ON THE VRATNA RIVER (EASTERN SERBIA) AS THE LAST REMNANTS OF A FORMER CAVE

NARAVNI MOSTOVI NA REKI VRATNI (VZHODNA SRBIJA) KOT ZADNJI OSTANKI NEKDANJE JAME

JELENA ĆALIĆ-LJUBOJEVIĆ[1]

[1] Geographic Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Djure Jakšića 9, YU-11000 BELGRADE, YUGOSLAVIA, e-mail: jcal@sezampro.yu

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Jelena Ćalić-Ljubojević: Naravni mostovi na reki Vratni (Vzhodna Srbija) kot zadnji ostanki nekdanje jame

Reka Vratna, ki ima porečje na zahodnem robu dačanske kotline, je desni pritok Donave. Od skupaj 22 km dolgega toka teče v dolžini 3,5 km skozi sotesko, vrezano v titonijske apnence. Preko soteske se pnejo 3 naravni mostovi, ki skupaj pokrivajo 94 m rečnega toka. Zelo verjetno sta 2 od teh mostov ostanek nekdanjega jamskega stropa. Zaradi denudacijskih procesov in porušenega ravnotežja se je skoraj ves jamski strop udrl, razen dveh delov. V soteski je tudi nekaj kratkih jam in spodmolov. Najdaljša jama (305 m) je ravno za največjim od mostov.
Ključne besede: geomorfologija krasa, naravni most, udor, jama, reka Vratna, Karpato-Balkanidi, Vzhodna Srbija.

Abstract UDC: 551.435.8(497.11)

Jelena Ćalić-Ljubojević: Natural bridges on the Vratna River (Eastern Serbia) as the last remnants of a former cave

The Vratna River is a right-side tributary of the Danube and its drainage area is situated at the western rim of the Dacian Basin. Along its 22 km long course, the Vratna flows through a 3,5 km long gorge cut in Tithonian limestones. Across the gorge there are three natural bridges, which shelter, in total 94 metres of the river course. There is a strong assumption that two of the natural bridges are the only remaining parts of roof of a former cave. Due to the process of surface denudation and to the disruption of stability, the cave roof almost completely collapsed, with the exception of these two sections. Several short caves and rock shelters exist in the gorge, and the longest cave (305 m) is situated next to the biggest of the three natural bridges.
Key words: natural bridge, collapse, cave, Vratna River, Carpatho-Balkanides, Eastern Serbia.

INTRODUCTION

The Vratna River is a right-side tributary of the Danube (feeding into the Danube downstream of the Iron Gates), on the western rim of the Dacian Basin. It is only 26 km long and its drainage area is partially situated on the eastern slopes of the Carpatho-balkanides mountain range (Mt. Veliki Greben).

During the Pliocene, the Dacian Basin was filled with water, but the morphological outcomes of that lacustrine period are not preserved in the present time. The upper part of the Vratna drainage area is developed in crystalline schists, while the lowest part is composed of marls and clayey and sandy sediments. In between those two parts, taking the central position, there is a karst area developed in Tithonian limestones, covering about 10 km^2. The limestones are clearly stratified and have an eastward inclination. A portion of 3,5 km of the Vratna valley is entrenched in these limestones, as gorge about 150 m deep.

MORPHOLOGY OF THE VRATNA GORGE

The sides of the Vratna Gorge are very steep, nearly vertical, and abound in numerous rock shelters and short caves, as well as scree slopes. The river bed is in some places dissected by waterfalls and potholes.

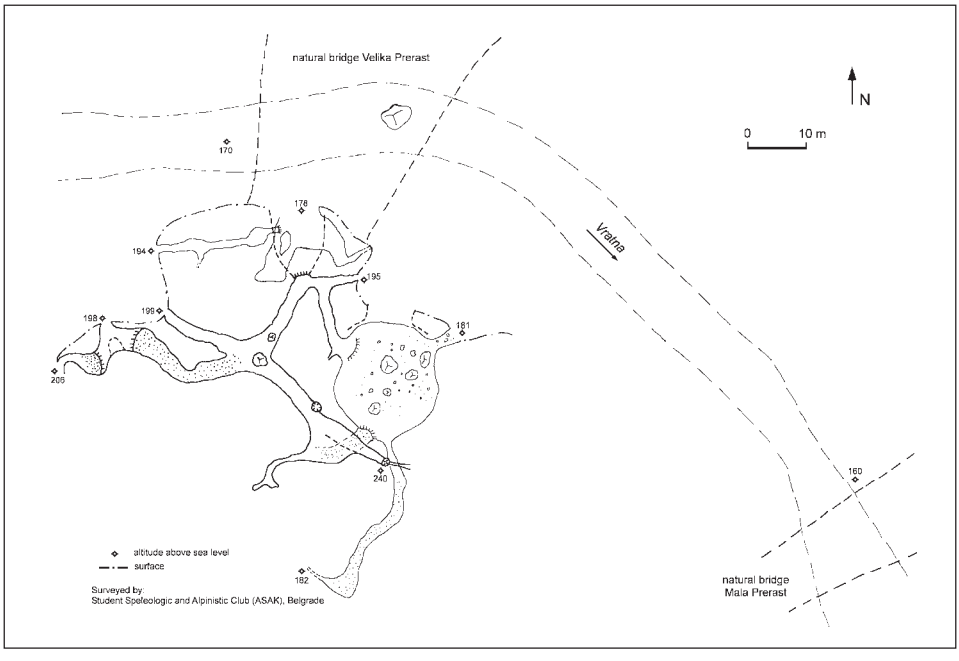

Fig. 1: The cave Pećina u Velikoj Prerasti and the position of natural bridges.

The outstanding characteristic of the gorge are three natural bridges - Mala Prerast (meaning "small natural bridge"), Velika Prerast ("big natural bridge") and Suva Prerast ("dry natural bridge"). When summed up, they shelter the river course for a length of 94 m. Velika Prerast and Mala Prerast are situated close to each other, at the final downstream part of the gorge, while Suva Prerast is 3 km upstream. Mala Prerast shelters the river for of 15 m. Its opening is about 30 m wide and high (respectively). Only 100 m upstream from Mala Prerast, there is another natural bridge - Velika Prerast. It is 45 m long, with an opening of approximately 25 × 30 m. The rocky arch has the considerable thickness of 30 m (Petrović & Gavrilović 1969). The upper part of the arch has the form of a peak - the very top of it is 65 m above the river bed.

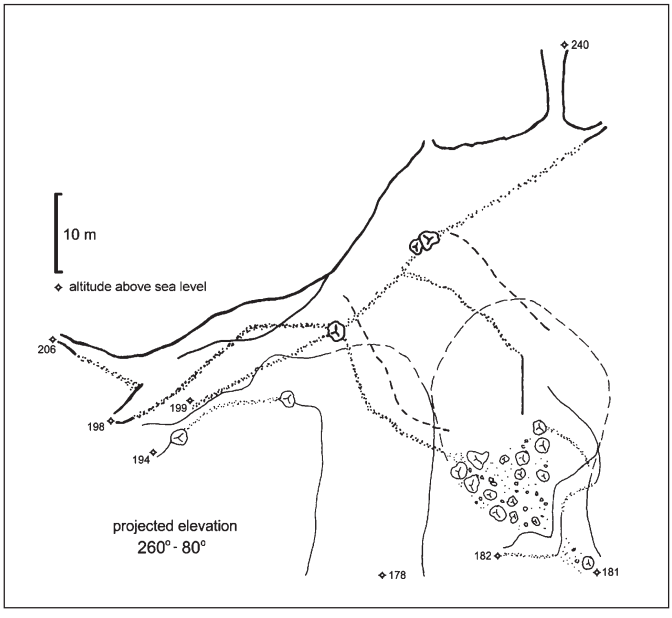

Fig. 2: Projected elevation of the cave Pećina u Velikoj Prerasti.

This natural bridge is characterized by existence of caves in its walls, the longest of which is 305 m in length and a 61 m range of level. The cave is named Pećina u Velikoj Prerasti and has several entrances (Fig. 1, Fig. 2). Its lowest passages are about 8 m higher than the Vratna river bed, while the highest passages (very steep or vertical) reach the surface near the arch of Velika Prerast, as well as upstream and downstream from it. The cave system in the plan view resembles a small labyrinth.

Suva Prerast, the third natural bridge, is located in the most upstream part of the gorge. It is 34 m long, with an opening of about 20 × 15 m. The name "dry natural bridge" originates from the fact that in the late summer all the water from the Vratna disappears in a streamsink 50 m upstream from Suva Prerast.

DEFINITION AND GENESIS OF NATURAL BRIDGES

Generally speaking, there are two theories on genesis of the natural bridges. One of them refers to situations when a river flowing across a thin limestone ridge cannot entrench into the ridge, but sinks at the contact and resurges on the other side. This is called "local sinking" (as suggested by Petrović 1969). On its short flow through the ridge, the river enlarges the underground conduits

Fig. 4: Half-tubes between the two natural bridges (photo: V. Ljubojević).

Fig. 3: Natural bridge Velika Prerast (photo: V. Ljubojević).

and continues entrenchment below the remaining rocky arch. The second theory was elaborated by Cvijić (1918) and relies on the former presence of a cave whose roof collapsed, leaving only tiny stone arches - natural bridges ("Cave ceilings are first to be opened, then they collapse and the caves are revealed. Various phases of such evolution can be easily seen in all karst terrains. The first phase is opening of the cave ceiling, by deepening of dolines and partial breakdown of cave ceiling near the bottoms of dolines. In the later phase, almost the whole cave ceiling is broken down (as the case of the Vratna River, tributary of the Danube). It happens that dry caves from the uppermost hydrographical zone are completely roofless and that caves filled with calcite concretions are revealed after denudation of the karst surface" - (Cvijić 1918).

There is still an unclear morphometric and morphogenetic difference between natural bridges and through ("tunnel") caves. Some authors (Gavrilović 1998) suggest the mathematical definition - that for the natural bridges the ratio between length and height should not exceed 1:2,5 (exceptionally 1:10), while for the tunnel caves the ratio is bigger. However, this definition is not genetically approved. By applying the mathematical method of distinguishing natural bridges and tunnel caves, it can happen that two genetically identical features with slight differences in dimensions are classified as different forms. Therefore, an exact method of classification cannot be set up, and the determination should be made for each particular feature, depending on the wider geological and geomorphological conditions of its formation.

Very close to the Vratna, in the same geological formation of Tithonian limestones, there is an interesting example of the form which is "something in between" natural bridge and through cave. That is a so-called "tunnel cave on the Zamna River", 155 m long, with the dimensions of the passage (whose bottom is the river bed of the Zamna) of approximately 20 × 20 m. This cave has a relatively thin roof (average 20 m) with two big daylight holes - openings to the surface, formed by the roof collapse. It can be expected that with the continuation of the collapse processes, only natural bridges will remain. After the comparison of the Vratna and the Zamna phenomena (Petrović 1971), it turns out that they are morphologically different, but genetically the same forms in different stages of morphological evolution. While the Zamna tunnel cave is the beginning, the Vratna natural bridges represent the end of the process of the formation of natural bridges due to collapse of cave roof.

GENESIS OF VRATNA NATURAL BRIDGES

There is a strong assumption that the natural bridges Velika Prerast and Mala Prerast represent the only remaining parts of a former cave, whose length was about 150 m. The present cave PeŠina u Velikoj Prerasti (in the wall of Velika Prerast) was a kind of an affluent passage to the former cave. A characteristic feature of this final portion of the Vratna Gorge was the simultaneous existence of surface and underground streams, which were connected by numerous swallow holes. The underground stream was permanently active (as the Vratna is nowadays), while the surface stream was active only periodically, in wet parts of the year (when the underground cavities could not receive all the water). Due to the process of surface denudation and consequent, disruption of stability, the cave roof between the two natural bridges collapsed over a length of 100 m.

Most of the swallow holes are not preserved in at present time due to collapse, but several of them still exist near the arch of the natural bridge Velika Prerast, although they have no of hydro-

logical function. Several vertical channels of the cave Pećina u Velikoj Prerasti, which reach the surface, are preserved fossil swallow holes. At several places between the two natural bridges, characteristic parallel erosional half-tubes can be seen on the rock (Fig. 4). As they are presumed to be typically underground features, it can be considered that this supports the above-mentioned hypothesis.

A different opinion was given by Gavrilović (1998), who regards the cave system Pećina u Velikoj Prerasti as a proof that there was no cave between the two natural bridges ("This cave system, which has a great vertical development and is partially filled up by fluvial pebble, confirms that the Velika Prerast and Mala Prerast were formed primarily due to local sinking of the Vratna River, and not due to breakdown of the long cave"). However, it is not quite clear why the existence of the cave system in the wall of the natural bridge should be in disagreement with the concept of genesis of the natural bridges due to breakdown of the former cave. Furthermore, it would be hard to explain how it was possible that local sinking occurred twice at so close distance (why would the stream resurge after the first sinking, and afterwards sink again after only 100 metres, within the area of the uniform geological composition?).

If we suppose that the sinking occurred upstream of the present Velika Prerast, and that the resurgence occurred downstream of the present Mala Prerast, this can also be called "local sinking" (as the length of the portion is relatively small - less than 200 m), but it again implies prior existence of the cave between the present natural bridges.

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NARAVNI MOSTOVI NA REKI VRATNI (VZHODNA SRBIJA) KOT ZADNJI OSTANKI NEKDANJE JAME

Povzetek

Obstojata dve teoriji o nastanku naravnih mostov. Prva se nanaša na primer, ko teče reka preko tankega apnenčevega slemena, a se ne more vrezati vanj, pač pa na stiku z apnencem ponika in na drugi strani spet izvira. To imenujemo "lokalno ponikanje", kot predlaga Petrović (1969). Vzdolž svojega kratkega podzemeljskega toka reka širi svoj kanal in nadaljuje z vrezovanjem pod skalnim

obokom. Drugo teorijo si je zamislil Cvijić (1918) in se naslanja na nekdanjo jamo, katere strop se je zrušil in je ostal samo skalni obok - naravni most. Je še nekaj morfometričnih in morfogenetskih razlik med naravnimi mostovi in jamami-predori. Nekateri avtorji (Gavrilović 1998) predlagajo matematično definicijo - za naravni most razmerje med višino in dolžino ne bi smelo presegati 1:2,5 (izjemoma 1:10), medtem ko mora biti za jame-predore večje. Vendar se pri matematični metodi razlikovanja naravnih mostov in jam-predorov lahko zgodi, da dve genetsko enaki obliki z majhnimi razlikami v velikosti uvrstimo v različni skupini. Torej ne moremo uporabljati natančne metode, ampak moramo določiti tip vsaki obliki posebej, glede na širše geološke in geomorfološke okoliščine, v katerih je nastala.

Domneva, da sta naravna mostova Velika in Mala Prerast samo ostanek nekdanje, okoli 160 m dolge jame, ima trdne osnove. Jama Pećina u Velikoj Prerasti (v steni Velike Prerasti) je bila neke vrste pritočni rov nekdanje jame. Značilna oblika zadnjega dela soteske Vratne kaže na nekdanji obstoj tako površinskega kot tudi podzemeljskega toka, ki so ju povezovali številni ponori. Zaradi procesov površinske denudacije se je porušilo mehansko ravnotežje in se je med obema mostovoma udrl jamski strop v dolžini okoli 100 m.