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CAVES BELOW COLLAPSE DOLINES - CASE STUDY OF TISOVA JAMA (EASTERN SERBIA)

JAME POD UDORNICAMI - PRIMER TISOVE JAME (VZHODNA SRBIJA)

JELENA ĆALIĆ-LJUBOJEVIĆ[1,2] & VLADIMIR LJUBOJEVIĆ[2]

[1] Geographic Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Djure Jakšića 9, YU-11000 BELGRADE, YUGOSLAVIA
[2] Student Speleologic and Alpinistic Club (ASAK), Studentski trg 16, YU-11000 BELGRADE, YUGOSLAVIA

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Jelena Ćalić-Ljubojević & Vladimir Ljubojević: Jame pod udornicami - primer Tisove jame (Vzhodna Srbija)

Tisova jama (-235 m) je na gori Beljanici (Karpato-Balkanidi) v Vzhodni Srbiji. Vhod vanjo se odpira v dnu udornice (180 × 160 m), pod katero je podzemeljska dvorana z do sedaj največjo znano površino (11 374 m^2) in prostornino (približno 170 000 m^3) med jamami v Srbiji. Tako velikost si je mogoče razložiti s prisotnostjo močnega podzemeljskega toka v nedostopnih delih jame. Odnašanje gradiva je porušilo stabilnost kamnine pod vrtačo, kar je povzročilo podiranje in poglabljanje vrtače.
Ključne besede: kraška geomorfologija, udornica, jamska dvorana, Beljanica, Karpato-Balkanidi, Vzhodna Srbija.

Abstract UDC: 551.435.83(497.11)

Jelena Ćalić-Ljubojević & Vladimir Ljubojević: Caves below collapse dolines - case study of Tisova Jama (Eastern Serbia)

The cave Tisova Jama (-235 m) is located on Beljanica Mountain (Carpatho-Balkanides, Eastern Serbia). Its entrance pit is situated at the bottom of a great collapse doline (dimensions 180 × 160 m), below which there is a chamber with the greatest surface (11 374 m^2) and volume (approx. 170 000 m^3) so far known among Serbian caves. Such dimensions can be explained by the presence of a strong underground stream in the unreachable part of the cave. Removal of the material disrupts the stability of the rock below the doline, which leads to breakdown and deepening of the doline.
Key words: karst gemorphology, collapse doline, cave chamber, Beljanica, Carpatho-Balkanides, Eastern Serbia.

INTRODUCTION AND GEOLOGICAL SETTING

Beljanica Mountain, which belongs to the mountain range of the Carpatho-Balkanides, is one of the largest karst areas in Eastern Serbia. As a structural unit, Beljanica Mt. is an anticline (or pericline, according to Antonijevic et al., 1970), with an axis in N-S direction. It is composed mainly of Jurassic and Cretaceous limestones, whose average thickness is about 400 m. On the west, the limestones are covered with the nappe of red Permian sandstones, while on the eastern side there are igneous rocks belonging to the geological unit of Andesite massif of Eastern Serbia. The northern margin of Beljanica Mt. is the basin Žagubička kotlina, filled with Neogene lacustrine sediments up to a height of 300 m a.s.l. In the central part of the mountain there is an outcrop of Palaeozoic schists, which represents the core of the anticline, after limestones were denuded (Fig. 1).

Although hydrological and other settings indicate the presence of a developed network of karst conduits in Mt. Beljanica, the number of significant caves known so far is relatively small. There are direct proofs that considerably karstified limestones extend far below the bottom of the Neogene basin on the north. At the northern foothill of Beljanica, there is a karst spring of the Mlava River (0,29-14,8 m^3/s, Stevanović 1986), at 310 m a.s.l., with the spring siphon more than 70 m deep (proved by diving; Milosavljević 1996). Similarly, at the western foothill of Beljanica, on the

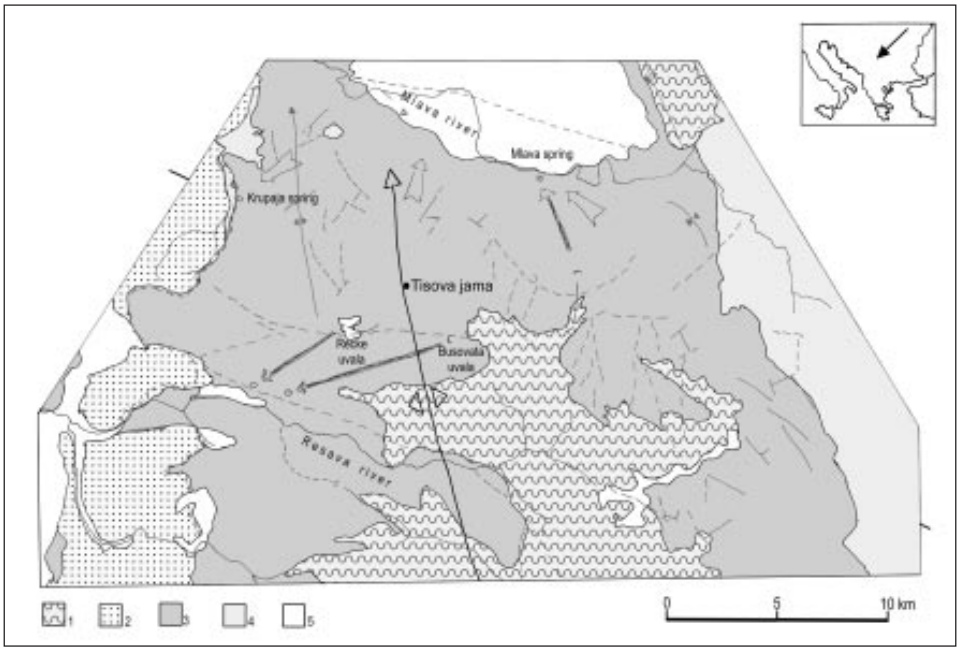

Fig. 1: Geological settings on Beljanica Mt. 1 - Palaeozoic schists; 2 - nappe of red Permian sandstones; 3 - Jurassic and Cretaceous limestones; 4 - igneous rocks; 5 - Neogene sediments (after Stevanović 1986, adapted).

contact of Cretaceous limestones and the nappe of red Permian sandstones, there is a karst spring of the Krupaja River (0,38-2,8 m^3/s, at 340 m a.s.l.), emerging from a more than 70 m deep siphon.

POSITION AND MORPHOLOGY OF THE CAVE TISOVA JAMA

The most remarkable of Mt. Beljanica caves is Tisova Jama, which was explored by the Student Speleologic and Alpinistic Club from Belgrade in 1988 and 1999. Tisova Jama is situated on the northern slopes of Beljanica Mt., at the elevation of 920 m a.s.l, about 4 km to the north-west of the Busovata Uvala, and 7 km to the south of the village Suvi Do at the rim of the basin Žagubička Kotlina. The cave is formed in Malmian limestones, whose thickness at this location exceeds 400 m. With a depth of 235 m, Tisova Jama is the fifth deepest cave in Serbia, but also significant because it has the biggest chamber and ice accumulation among Serbian caves. Due to the great dimensions of its entrance, it is marked on all topographic maps.

The entrance to the Tisova jama is a huge doline of elliptical shape, with diameters of 180 by 160 meters. The doline is situated on a broad karstified area spotted with a great number of dolines of similar dimensions. Its volume is estimated at 550 000 m^3 - approximately, it is an inverted cone with a depth of 72 m, a radius 85 m, and a circumference 540 m (Fig. 3, Fig. 4).

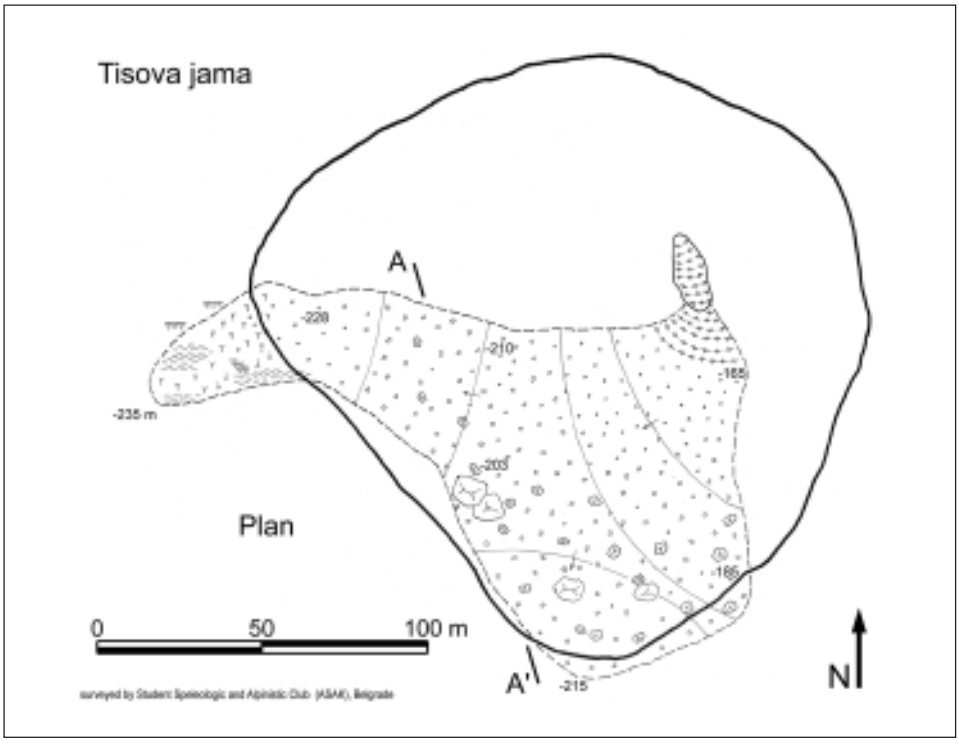

Fig. 3: Plan of the cave Tisova Jama.

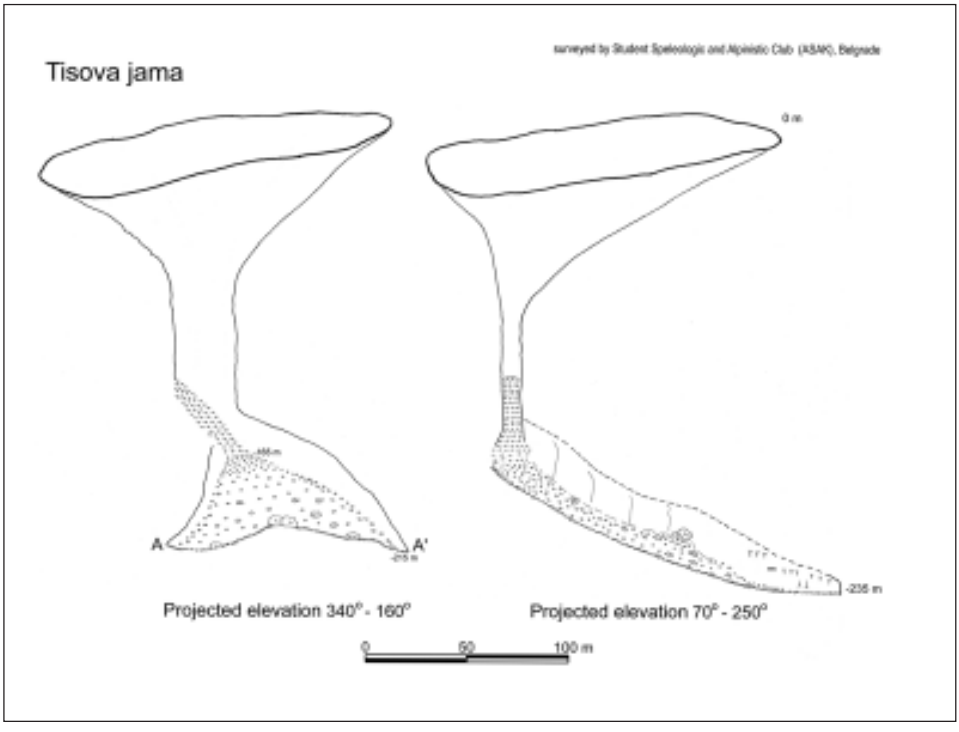

Fig. 4: Projected elevations of the cave Tisova Jama.

The eastern and southern sides of the doline are of steep inclination or nearly vertical, while the northwestern side has a gentler slope. Down to the depth of 150 m, the sides of the pit are in daylight, thanks to the great width of the entrance. On southwestern sides of the pit, between 40 and 90 m of depth, there are several rock shelters, formed due to strong frost erosion. It is only in this part of the Tisova Jama that fossil erosional gutters and a layer of travertine are visible. Their origin is not quite certain - they could have derived from a kind of former water flow or from the snow-melt water that trickles down the walls of the pit. In other parts of the cave there are no erosional forms of microrelief (karren, gutters, scallops), because the walls are damaged by frost erosion and, in deeper parts of the cave, by breakdown.

At the depths from 130 to 145 m, still at the daylight, there is an accumulation of snow and ice, 50 m long and inclined southwards at the angle of 40 degrees. At its foot there is an entrance to a collapse chamber. Thicker and colder air remains in the chamber and enables the permanent presence of snow. At the visible profiles, the thickness of the accumulation exceeds 10 m, so its volume can be estimated at about 5000 cubic metres.

At a depth of 150 m, there is the entrance to the collapse chamber, which is the final morphological unit of the Tisova Jama. The dimensions of the chamber are 181 m in the direction west-east, and 105 m in the direction north-south. The surface is 11 374 square metres. Although the height of the ceiling in a great part of the chamber exceeds 20 m, it can be considered that the

average height is 15 m, which gives an approximate volume of 170 000 cubic metres. The height difference between the highest and the lowest point in the chamber is 80 m and the floor is almost entirely covered with a great scree of limestone boulders and debris, with average inclination of 30 degrees. The final, most western part of the chamber, at the depth of 235 m, has a flat bottom without much debris. That part is rich in white calcite speleothems, shallow dry rimstone dams and brownish cave pearl fields.

GENESIS OF THE TISOVA JAMA

The cave Tisova Jama is situated on the top of the anticline, which partially influenced its present morphology. The entrance pit, which connects two main morphological units (doline and chamber), developed along the tension joints that follow the top of the anticline. The chamber follows the dip of the bedding, along which the collapse occurred. The presence of an underground stream below the cave is responsible for removal of the collapsed material and formation of the chamber. In that sense, it can be said that the evolution of the Tisova Jama can, to some extent, be compared to the evolution of a kukava (Šušteršič 1998). The assumption is that the stream below the Tisova Jama is not at great depth below the bottom of the cave, because according to geological maps the non-carbonate base is relatively close (Fig. 2).

Although it can be assumed that at some time production and removal of the material in the cave were in dynamic equilibrium, it is evident that at this moment production is greater. One of the indications for that is also the very bottom of the chamber, which is flat, with no smaller (secondary) inverted cone. Moreover, the production of the material is boosted by strong frost erosion. The decrease of mass removal is caused by a decrease in quantity of water. In present conditions, the catchment area of Tisova Jama is relatively small, and also the precipitation is small (less than 1000 mm per year). Being situated on the northern slopes of Beljanica Mt., the stream below the cave can receive groundwater only from the south, where, on the distance of about 4 km, there is a contact with impermeable Palaeozoic schists. The streams formed on the Palaeozoic bedrock sink in the uvalas of Busovata and Rečke, and go in the opposite direction, to the springs in the valley of Resava River (Fig. 1), which was proved by dye tracing (Stevanović 1986).

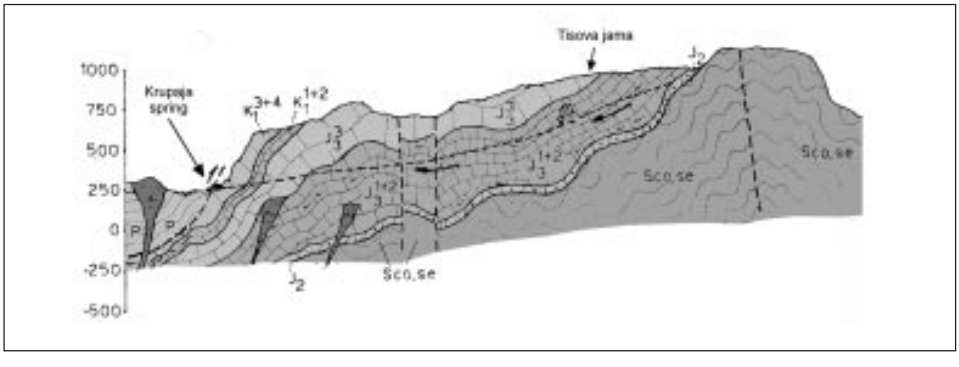

Fig. 2: Cross-section of Beljanica Mt., direction NW-SE (after Stevanović 1986, adapted).

Taking into account all these facts, it can be said that the genesis of the cave took place while the surface relief as well as groundwater flow were completely different to now, maybe even before the present degree of uplift of Beljanica Mt. If that is so, the period of weaker stream and greater breakdown lasted relatively long, so it can be assumed that the cavity in the past had much greater dimensions than are now visible. As a consequence of the disrupted dynamical equilibrium and domination of production, it can be expected that in the next phases of cave evolution the chamber will be completely filled up with rocky material.

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Povzetek

Tisova jama je najpomembnejša med jamami v gori Beljanici. Vhod vanjo je ogromna vrtača eliptične oblike na obsežnem kraškem svetu, posejanem s številnimi vrtačami podobnih velikosti. V globini 150 m je vhod v podorno dvorano, končno morfološko enoto Tisove jame. Velikost dvorane je 181 m v smeri zahod - vzhod in 105 m v smeri sever - jug. Podzemeljski tok pod jamo je lahko odstranil podorno gradivo in omogočil nastanek dvorane. V tem smislu bi bilo mogoče reči, z določenimi omejitvami, da je razvoj Tisove jame podoben razvoju kukave (Šušteršič 1998). Čeprav lahko domnevamo, da sta bila nastajanje in sočasno odnašanje podornega gradiva nekaj časa v dinamičnem ravnotežju, je jasno, da danes nastajanje tega gradiva prevladuje. Eden od dokazov za to je tudi dejstvo, da je dno dvorane plosko, brez manjšega (sekundarnega) lijaka. Lahko rečemo, da je jama nastala v času, ko sta bila tako površje kot tudi podzemeljski tok popolnoma različna od sedanjega, morda še preden je bila Beljanica dvignjena v današnji položaj. Če je tako, traja obdobje, v katerem je tok relativno šibkejši, podiranje pa močnejše, razmeroma dolgo in lahko domnevamo, da je bila jama v preteklosti precej večja od te, ki jo vidimo danes. Kot posledico porušenega ravnotežja in prevladovanja kopičenja podornega gradiva lahko pričakujemo, da bo jama v naslednjih razvojnih fazah popolnoma zapolnjena s podornim kamenjem.