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KARST FEATURES OF NARROW LIMESTONE BELTS - CASE STUDY OF THE RIDGE DŽEVRINSKA GREDA, EASTERN SERBIA

KRAŠKE OBLIKE V OZKIH PASOVIH APNENCEV - PRIMER SLEMENA DŽEVRINSKA GREDA, VZHODNA SRBIJA

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Jelena Ćalić-Ljubojević: Kraške oblike v ozkih pasovih apnencev - primer slemena Dževrinska greda, Vzhodna Srbija

Prispevek prikazuje več zanimivih oblik v slemenu Dževrinska greda (Karpato-Balkanidi, Vzhodna Srbija). Ta 20 km dolg in povprečno 100 - 300 m širok pas apnenca je prava učilnica za preučevanje kontaktnega krasa in fluviokarsta. Razen o oblikah, kot so jame-predori (skoznje), prebojne soteske, suhe in slepe doline, govori prispevek tudi o tipih kontakta (tektonski in sedimentacijski), o vplivu fluvialnih dejavnikov, o smereh podzemeljskih tokov, itd.
Ključne besede: kraška geomorfologija, kontaktni kras, fluviokarst, apnenčev pas, jama-predor, prebojna soteska, ponor, slepa dolina, Karpato-Balkanidi, Vzhodna Srbija.

Abstract UDC: 551.44(497.1-11)

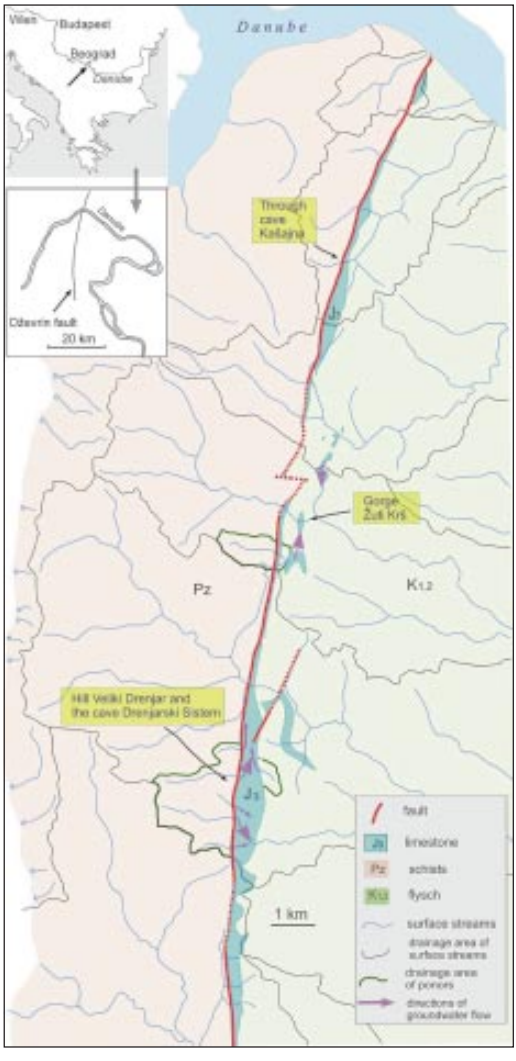
Jelena Ćalić-Ljubojević: Karst features of narrow limestone belts - case study of the ridge Dževrinska Greda, Eastern Serbia

The paper presents several most interesting features of the ridge Dževrinska Greda (Carpatho-Balkanides, Eastern Serbia). Being 20 km long and, on average, 100-300 m wide, this narrow limestone belt is a typical polygon for contact karst and fluviokarst research. Beside examples of features such as through cave, through gorge, dry and blind valleys, there is also a discussion on types of contact (tectonic and sedimentary), impact of fluvial factors, directions of groundwater flow, etc.
Key words: karst geomorphology, contact karst, fluviokarst, limestone belt, through-cave, through-gorge, ponor, blind valley, Carpatho-Balkanides, Eastern Serbia.

INTRODUCTION AND GEOLOGICAL SETTING

Areas of narrow limestone belts and outcrops differ from classical karst areas due to relatively strong fluvial influences from the surrounding non-carbonate terrains. Instead of dispersed infiltration, water enters the karst in the form of streams, which, depending on various factors, either form caves, or entrench in limestone and form short through gorges and canyons. Allogenic discharge into karst leads to the formation of fluviokarst. Caves are in many cases filled with considerable quantities of fluvial sediments, or show indications of former periods of filling.

The study area - limestone ridge Dževrinska Greda, situated near the Danube Gorge in the Carpatho-Balkanides of Eastern Serbia, stretches in N-S direction and is 20 km long (Fig. 1). Its average width is 100-300 m (maximum 700 m), while in the narrowest parts it is only several tens of metres wide. A long and narrow portion of Upper Jurassic limestone is sandwiched between the Palaeozoic crystalline schists on the west and Cretaceous flysch-like sediments (sandstones, conglomerates, shales, marls) on the east. With the total area of only about 5 km^2, the karst of Dževrinska Greda abounds in characteristic features occurring at the fluvial-karstic interface.



As the main area of regional neotectonic uplift is situated to the west of the Dževrinska Greda, all surface rivers flow towards east to the Danube, and on their courses, they face the uplifted limestone ridge. Streams which managed to entrench into the ridge keep the eastward direction, while those that sink into karst underground mainly follow the direction of the ridge - towards north or, rarely, south. Only catchment areas of several small ponors are oriented from east to west, but those waters soon mix with the sinking waters coming from the opposite direction, and head towards north as well. Directions of groundwaters and, consequently, cave passages, are highly influenced by the presence and neotectonic ac-

Fig. 1: Location of the Dževrinska Greda ridge and the presented features.

tivity of the Dževrin fault (N-S direction, western boundary of the ridge). It is clearly visible in the field and extends much further than the ridge - to the north, the fault stretches across the Danube, to Romanian Southern Carpathians (Mehedinti Plateau); and to the south, it reaches almost the north-western foothill of Balkan Mt.

TYPES OF CONTACT AND MAIN FEATURES

Various types of contact between carbonate (Upper Jurassic limestones) and non-carbonate rocks are present. On the west, contact between schists and limestone is tectonic: eastern block, with limestone, was uplifted along the conspicuous regional fault (Dževrin fault, mentioned above). In this case, tectonic contact is upstream, on the input boundary, and that is why its features are more numerous and more prominent than on the opposite contact. On the east, Cretaceous flysch is deposited over Jurassic limestone, making a superpositional sedimentary contact. This is a downstream contact, on the output boundary, except for several small streams and their ponors, which flow in the E-W direction, contrary to the general drainage pattern of the area. Different hydrological conditions in which these two types of contact occur, do not allow adequate comparison between the two types.

Through-cave Kašajna

This is a unique case on Dževrinska Greda that the allogenic stream did neither form a through-gorge nor a "classical" cave filled with sediments. The Kašajna river formed a through-cave (sometimes also called a "tunnel cave") with the length of 129 m. Nevertheless, the present high hydraulic gradient - height difference - between the input and the output point lead to formation of the new ponor in the middle of the cave, so that moderate waters sink in it and resurge through a small cavity at the cliff foot 15 m below the main passage (Fig. 2).

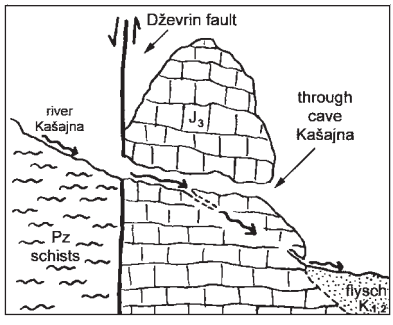


Fig. 2: Cross-section of the ridge and through-cave Kašajna (sketch, not to scale).

Through-gorge Žuti Krš

This gorge is entrenched in a small limestone outcrop (500 × 125 m), to the east from the main ridge. On the opposite sides of the gorge, there are two caves probably formed before the

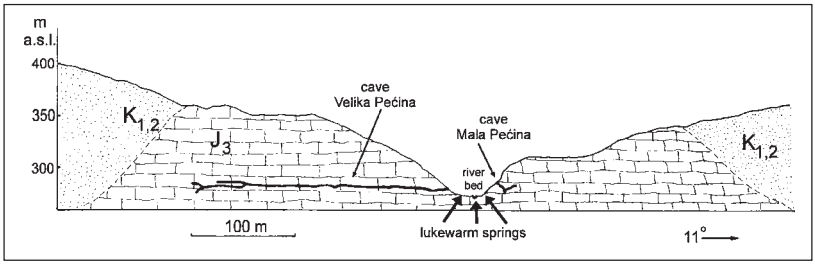


Fig. 3: N-S cross-section of the through-gorge Žuti Krš.

entrenchment. The longer one, Velika Pećina (361 m), is an outflow cave, while the short one, Mala Pećina (39 m) is dry (Fig. 3). The cave Velika Pećina is hydrologically connected with the cave Nikoliža Ponor, which is situated in another limestone outcrop, several hundred metres to the south (Fig. 4). The passages in between are formed in limestone below the flysch formation, and are not passable because of siphons (dimensions too small for diving). Another peculiarity of Žuti Krš are three lukewarm karst springs situated at a small distance - in the river bed, on the left bank and on the right bank. Discharge of water with temperatures from 16,5 to 19 °C and with gasses of atmospheric origin (N_2, O_2) indicates deep circulation along the Dževrin fault (Dragišić & Ćalić-Ljubojević 2000).

Fig. 5: Geomorphological map of the area of Drenjar hills and the System cave Drenjarski.

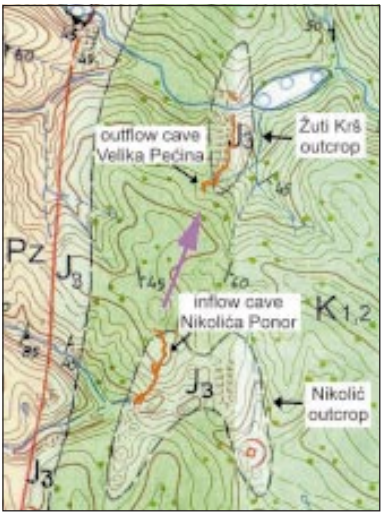


Fig. 4: Limestone outcrops along the main ridge.

Hills Veliki Drenjar and Mali Drenjar

The area of Drenjar hills is the widest part of the ridge Dževrinska Greda and therefore it abounds in features characteristic for contact karst - blind valleys and ponors (Fig. 5). It can be said that, thanks to its width, karst was "strong enough" to resist the fluvial pattern and to use its own conduits for wa-

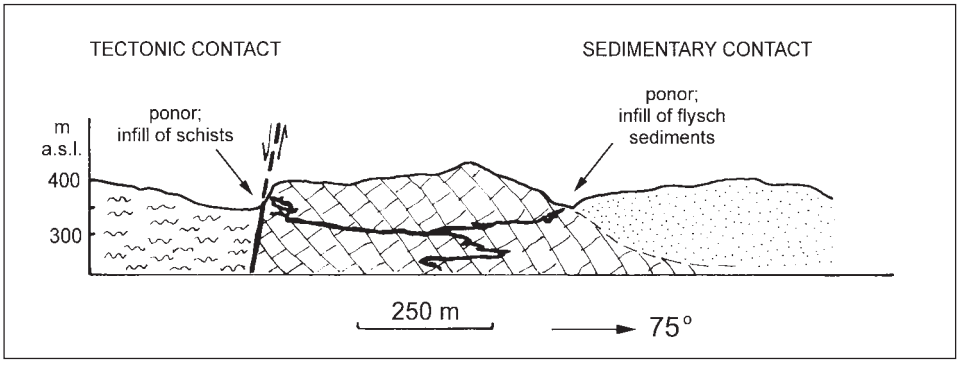


Fig. 6: Cross-section through Drenjar hills.

ter drainage. Underground connections between eight ponors and two spring zones are obvious thanks to passable cave passages. Dry valleys on the surface also indicate possible (or former) connections, but that is not necessarily the present direction of groundwater. The longest cave system, the Drenjarski System, is 3230 m long, but the explorations are still in progress, with promising chances to reach the spring Bigar. The cave went through several phases of sediment filling and washing away. In parts of the main passage which are more than 20 m high, cemented pebbles (of diametres up to 20 cm) are present even 1-2 m below the ceiling. Huge collapsed boulders (of even more than a thousand cubic metres of volume) indicate intensive tectonic activity of the area. The fact that they are covered with several tens of centimetres of fine sand is a sign of relatively recent phase of intensive sedimentation.

DISCUSSION

Karst features of narrow limestone belts - and that of the Dževrinska Greda, as a typical example - show characteristics of contact karst and fluviokarst. Lateral input of water by allogenic rivers cause either transporting of high quantities of bedload into the karst underground, or entrenchment of through-gorges in the narrow belt or limestone outcrops. Which of these possibilities will take place, depends on the size of upstream catchment area (and, consequently, input discharge), as well as on the width of the limestone belt. If an area is characterized with considerable tectonic movements, that brings about even more peculiarities. On Dževrinska Greda, thanks to its location along the regional fault, deep groundwater circulation enabled the existence of lukewarm springs, as well as springs with stable discharge regardless of the season.

Being formed in the areas of fluvial - karstic interface, contact karst and fluviokarst do not exert typically karstic development and they could not fit into the concept of the Pure Karst Model (Šušteršič 1986). Instead of being *centrical* in shape, the basic morphologic elements of the karst surface are in this case *linear*; and the underground drainage pattern is not oriented *vertically*, but *horizontally*. Of course, this should not be taken *sensu stricto*, since there are certain occurrences of vertical circulation: in the phreatic zone, the above mentioned deep groundwater circulation along the fault, and also in the vadose zone - percolation of atmospheric

waters towards the epiphreatic zone. However, it must be noted that the quantity of these waters is much smaller than the quantity of waters from the surface streams that enter the karst. Average yearly precipitation in Eastern Serbia is only about 600 mm, and we must take into account the extremely small surface of limestones (in this case, the whole limestone belt, together with adjoining outcrops, has only about 5 km^2). Among the eight necessary conditions for realization of pure karst (Šušteršič 1986), the third one, requiring the lack of lateral changes, is not fulfilled on Dževrinska Greda. Furthermore, the dimensions (surface and volume) of the rock mass of adequate characteristics are unusually small. On the other hand, the same rock mass is, in proportion to its dimensions, very rich in solutional cavities. These facts require careful determination of factors affecting the development of this type of karst.

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Povzetek

Kraške oblike v ozkih pasovih apnenca - in Dževrinska greda je tipični primer - so značilne za kontaktni kras in fluviokarst. Alogene reke bodisi vnašajo velike količine vlečenega tovora v kraško podzemlje, bodisi vrezujejo prebojne soteske skozi ozke pasove ali izdanke apnencev. Do česa bo prišlo, je odvisno od velikosti gorvodnega porečja (in skladno s tem pretoka) in od širine apnenčevega pasu. Če so za ozemlje značilni še znatni tektonski premiki, so posledice lahko še bolj nenavadne. Zaradi lege ob regionalnem prelomu, so na Dževrinski gredi zaradi globokega kroženja talne vode tako topli izviri kot tudi izviri s stabilno izdatnostjo, ne glede na letni čas.

Ker sta nastala na fluvialno-kraškem stiku, kontaktni kras in fluviokarst ne kažeta tipičnega kraškega razvoja in se ne skladata z zasnovo “modela čistega krasa” (Šušteršič 1986). Namesto krožnih oblik, so v tem primeru osnovne morfološke enote kraškega površja linearne; in mreža podzemeljskega odtoka ni usmerjena navpično, ampak vodoravno. Med osmimi temeljnimi zahtevami, ki morajo biti izpolnjene za nastanek čistega krasa, v Dževrinski gredi tretja, to je odsotnost lateralnih sprememb, ni izpolnjena. Dalje je velikost (površina in volumen) kamninske gmote ustreznih značilnosti nenavadno majhna. Po drugi strani pa je ta kamninska gmota, glede na svojo velikost, zelo bogata s korozijskimi votlinami. Ta dejstva zahtevajo zelo pazljivo določevanje tistih dejavnikov, ki vplivajo na razvoj tega tipa krasa.