

CHARACTERISTICS OF KARST RELIEF OF WEST HERZEGOVINA CANTON

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Karst phenomenon and typical forms of relief in it has always represented a real attraction and aroused the interest of many researchers. Many researchers have dealt with the theme of Dinaric Karst, however, we can not say that all parts of the region are equally well and sufficiently investigated. Some segments of the relief mountain range Dinarides sparked more interest with its attractiveness, while others are ignored or very superficially studied, especially regarding the karst relief of Bosnia and Herzegovina. From all of the above follows the primary purpose of this study, and it is reflected in deepening knowledge of insufficient or less investigated karstic regions of Bosnia and Herzegovina, and one of these spatial units is West Herzegovina canton, which is a truly representative of karst.

Key words: Karst, relief, West Herzegovina canton, karst form, karst poljes

INTRODUCTION

The role of the Dinaric karst in the study and explanation of the world's karst phenomena is very important because the first detailed scientific studies of karst in the world, as well as the first theories of the circulation of water in karst, developed just on the Dinaric karst in the late 19th and early 20th century (Bonacci et al, 2008).

This paper will highlight the main features of karst topography of West Herzegovina canton as part of the classical Dinaric Karst. How present knowledge on this issue are not rich, this work will establish the basic conditions and processes of design and development of the karst in a given area, analyze the current status of karst topography, and karst formations that have developed in this area.

Apart from some general scientific methods that were used during the development work, also worth pointing out application specific geographical methods, such as physical-geographical method, and method of spatial visualization, which implies the necessity of creating thematic maps in the geographic information system (GIS).

In this paper, it is first necessary to define the geographic position and explain the physical-geographical characteristics of the study area, to be based on that could specifically analyze the karst relief and karst features in a given area. Based on the above, the paper is methodologically conceived on the principle of the abstract to the concrete, and through the work methodology it is possible to point out the fact that West Herzegovina canton is a truly representative of the karst phenomena, and that the local natural values are undeservedly neglected in the field of scientific research in relation to some other areas of the Dinaric karst.

Geomorphological forms, both on the surface and in the underground karst, not only represent a real phenomenon, but these natural values can be very usable resource from an economic point of view, and it is, therefore, necessary to know their genesis, incidence, and prevalence in a certain area. In this regard, relief of West Herzegovina canton is an ideal subject to demonstrate the importance and true value of karst, with which should be proud, not only the residents of this area, but all over Bosnia and Herzegovina.

CASE STUDY

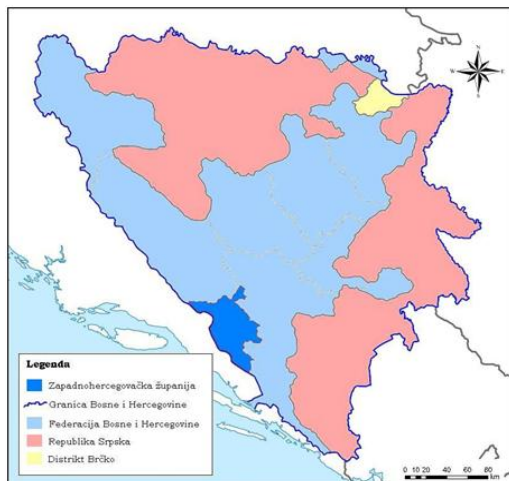


Fig. 1. Regional geographical position of West Herzegovina canton

Izvor: GIS data; obradio autor, 2015.

altitude value of the study terrain is 625 meters. The lowest point of relief is in the southeast of the canton, at the exit of the river Trebižat to Čapljina municipality, and is 22.2 meters, while the highest point, peak Pločno, reaches to 2,228 meters above sea level and is located in the northeast part of the massif Čvrsnica (Šimunovic, 2007).

NATURAL GEOGRAPHICAL FEATURES OF WEST HERZEGOVINA CANTON

The geological structure of the territory of West Herzegovina canton is a result of a long geological history. In this area dominated primarily deposits from the Mesozoic era, especially from the Jurassic and Cretaceous ages, which are lithology represented by limestones and dolomites. Older lithostratigraphic units of the Paleozoic are represented only in the canyons of Čabulja and Cvrstica, in the north of the canton. The youngest lithostratigraphic units of the Neogene period are presented by glacial, slope and river sediments from the Pleistocene epoch, and by river debris, wetland and lake sediments from the Holocene epoch (Šimunovic, 2011).

The Canton belongs to the Outer Dinarides of Bosnia and Herzegovina who are part of a single Dinaric mountain range, which is the main geotectonic unit of the southeast Europe. Horizontal faults in this area are marked the tectonic structure and have played a key role in shaping the recent appearance of the relief from West Herzegovina canton.

Geotectonic and geological structure caused the formation of karst and karst-corrosion relief and landforms with large plains in carbonate rocks, which has a dominant distribution in this canton. In addition to the karst, on the treated area were created other types of relief, especially fluvial along rivers, and to a lesser extent, the highest regions of Čvrsnica represented fossil glacio-nivacioni type (Marijanović, 2012). The relatively small area that includes the West Herzegovina canton is characterized by a very diverse climate, as a result

of geographical location, and the fact that this area is located at the transition between the Adriatic coast and the high mountains of Bosnia. The southernmost parts have an average maximum annual air temperature, while going to the north the average air temperature is gradually declining. Schedule of average annual precipitation is inversely proportional in relation to the distribution of average annual air temperature (Zupčević and Spahić, 1998).

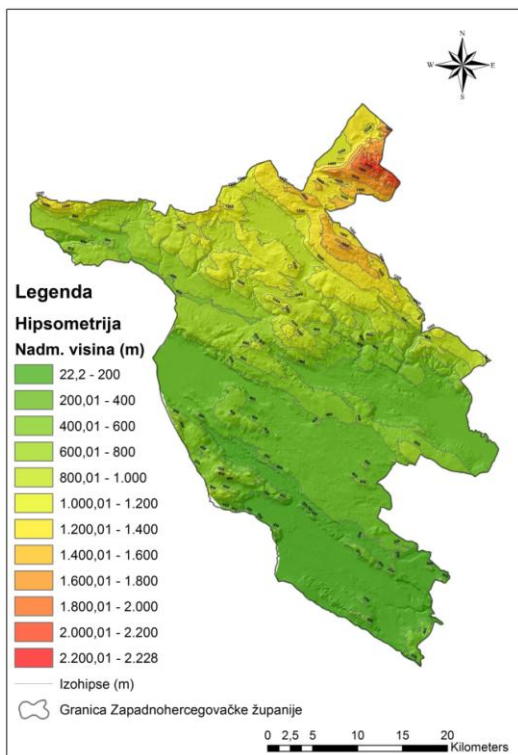


Fig. 2. Hypsometric map of the study area

Izvor: GIS data; obradio autor, 2015.

elements eurosiberian and Alpine-highdinaric subarea. It should be added that some landscapes look like a real desert karst in the winter or during the summer drought when the vegetation completely dies (Dizdarević and Redžić, 1998).

DISCUSSION

In geomorphological terms investigated area belongs to two relief macro-regions of Bosnia and Herzegovina. The north and spacious smaller part of the area is part of the macroregion Bosnia-Herzegovina Dinaric karst, while the southern and spacious larger part belongs to the macro region low Herzegovina.

Karst relief is certainly the most dominant genetic type of relief in the researched area, and he is almost on the whole territory of the canton, except in the north on the higher hypsometric levels, and in the valleys of major watercourses, where they are developed by other varieties of relief.

The entire territory of the Canton belongs to the catchment area of the river Neretva and it is important to point out that due to the dominant distribution of karst in the area other than the "normal" surface, developed and underground karst hydrography. Water courses of West Herzegovina canton that the Neretva is not due to the Adriatic Sea end up as sinks in karst fields. Although rainfall is sufficient for the whole area, many rivers are periodic flows that occur during heavy rains and melting snow (Slišković, 1994). Although periodic, the rivers are using deep erosion cut deep valleys in the limestone.

In this area has developed several types of soils, of which the most underdeveloped automorphic soils - bare karst, rockeries (lithosols), and sierozem (regosols). In addition, to a lesser extent are represented developed automorphic soils like brown soil on limestone and dolomite (calcocambisols) and red soil (terra rossa) (Resulović, 1998).

In terms of vegetation, the Canton is part of the Mediterranean subarea, although to a lesser extent represented

The relatively high average annual rainfall, which is secreted on the micro tectonic cracked limestones of the treated area resulted in a pronounced polymorphism in karst topography and in the development of different types of karst (pockmarked karst, naked karst, crack karst, covered karst etc.).

Exogenous karst landforms

The carbonate lining of the study area represents a good basis for developing of exogenous karst landforms, which are primarily the result of corrosion, biocorrosion, and thermomechanical processes. The intensity of the individual exogenous karst landforms, as well as their sizes, are the result of the interdependence of tectonic movements, lithological, structural, relief, climate and soil characteristics (Petrović i Manojlović, 1997). Cracks are a special type of mikrokarst landforms, which because of their prevalence and diversity especially stand out in the relief of West Herzegovina canton. Larger limestone surfaces furrowed by cracks called škrapari, and they are very characteristic of the karst relief of this canton. The fissures tectonic of the terrain and the relatively high rainfall favored the development of cracks, which is related to various gaps, which direct the corrosion process (Perica, 2009). In particular, they are present on inclines with a gradient less than 12 °. Because of the relief configuration, which is a key indicator of schedule amount of precipitation in the treated area, corrosion effects on cracks are most intense in the north of West Herzegovina canton (Štitar mountains, lower parts of Čvrstica, Zavelim, Trtla etc.), the same is going to reduce according to its central parts, and in the south of the canton cracks are least exposed to the influence of corrosion. The dominance of cracks is also evident in the complex slope facades of mountain morpho- structures dissected by hanging valleys and notches, which marks the shift of steeper slopes with pediments, which is especially true in the foreland steps of Čabulja and pediments on the southern slopes of the massif Čvrstica.



Fig. 3. Cracks on Čabulja

Izvor: www.picasaweb.google.com



Fig. 4. cracks on Čvrstica

Izvor: www.blogger.ba

Sinkholes are various sizes and shapes, polygenic designed on karst carbonates of West Herzegovina canton. Their appearance is linked to flatter karst terrains intersected by fault gaps (Božičević, 1991). The schedule of the sinkholes points to the fact that their direction congruent with the direction of the main fault and fracture system, or that the

series of sinkholes follow the main route and the accompanying fault and fracture systems between the right horizontal faults. The total number of detected sinkholes in the Canton is 17,284, and their biggest distribution is observed within Herzegovinian mountain setting on a relatively leveled ground, respectively in the field of Tribistovo, Cerov Dolac and Crne Lokve. From these areas the largest areal is the Crne Lokve, with a sinkhole density of 188/km² (Šimunovic, 2007).

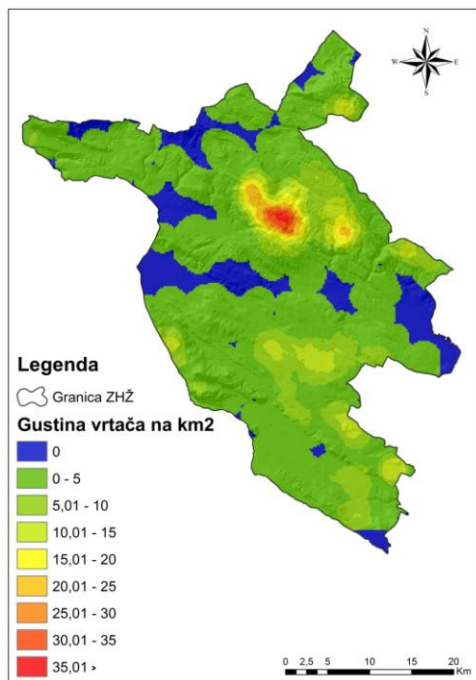


Fig. 5. Density distribution of sinkhole
Izvor: GIS data; obradio autor, 2015.



Fig. 6. Poljes in karst of West Herzegovina canton
Izvor: GIS data; obradio autor, 2015.

Endogeni krški reljefni oblici

Unlike the sinkholes, coves in the karst are created primarily influenced by tectonic, and only partly by karst erosion. A good example of tectonic predisposition in the treated area represents cove - polje Trn, then the cove - polje Mokro, cove Ruževo polje, and Vučipolje in the mountain setting Herzegovina (Šimunovic, 2007). Also, in the study area two coves especially stand out, namely: Grabova Draga-Polog i Dugo polje.

The territory of West Herzegovina karst geomorphological is known for neotectonic lowered basins of fields in the karst. On the morphogenetic development from the fields in karst in this area influenced kvartar succession of lacustrine and fluvial-inundation process of Trebižat, Vrljika, Lištica, Ugrovača and surrounding karst springs and estavelas. In particular, this applies to larger fields in karst, such as Bekijsko polje, Ljubuško polje, Posuško polje, Rakitsko polje and Mostarsko mud (Mikulić, 2013). In the treated area fields

in karst are provide dinar direction, parallel to the surrounding mountain hills, whose bottoms further neogen clastics are filled with paleogene flysch.

Newer Plio-Quaternary uplift and rotational movements of the surrounding mountain morpho- structures of the outer Dinarides influenced the narrowing and closing off vast old-miocene pull-apart structures, what resulted with the formation of recent basins of fields in the karst, but as a good example can serve many smaller fields in the Canton, such as Trnsko, Mokro and Kočerinsko polje (Šimunović, 2011).

Endogenous karst landforms

In accordance with the predominantly carbonate composition of the treated area, the emergence of underground karst formations isn't rare. However, most of this area is not partially or completely speleological researched, so it cannot give any precise answer about the development of the endogenous relief. What is definitely known is that the shape, size, and direction of the speleological objects result of tectonic activities, as well as lithological and hydrogeological characteristics of the rocks.

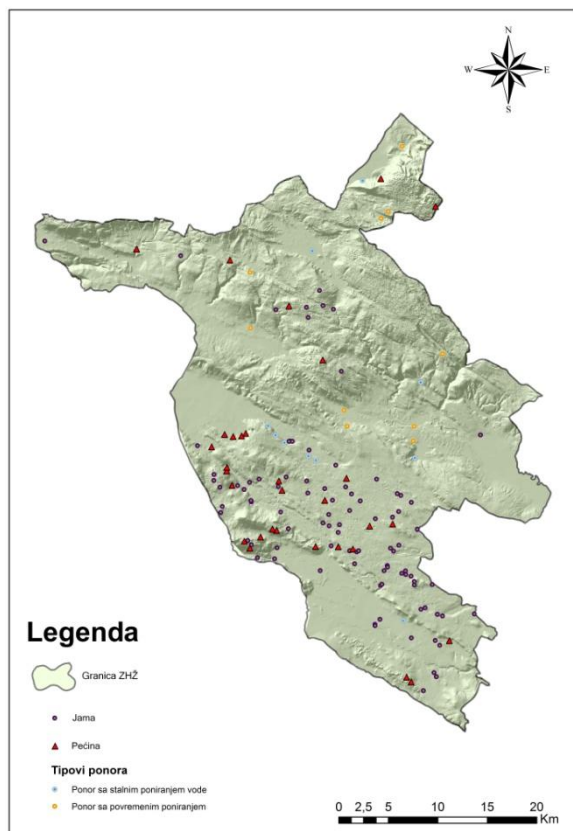


Fig. 7. Endogenous karst landforms of the study area
 Izvor: GIS data; obradio autor, 2015.

Delving deep into the interior along numerous gaps rain water has a strong corrosion and mechanical work, which results in the creation of various underground karst formations. These forms are very diverse, but can be distinguished in two main groups, namely: destructive and accumulation of origin (Temimović, 2007).

In the study area were created numerous caves, and the fact that none of them is not significant in size does not diminish their importance and value. Genesis of caves on the treated area is related to corrosion and mechanical action of underground streams. Among the most famous caves of the West Herzegovina canton can be included: cave Vrbine by Kongora, Ravlića cave in Peć-Mlini (Grude), Hajdučka cave in Batin, Mijatova cave in Natural park Blidinje, Ciganska cave by Zagorje, cave in Česića Dragi, cave by the waterfall Žukovice, cave on Miljacka, cave in Crna Osoja, Šimićeva pećina (Posušje), Bubalova cave in the near of Hardomilje, Rajina cave, Šabića cave (Ljubuški), Pravčeva cave by

the spring of Lištice, Pratarska cave in the hill Rujan, cave in the hill Matijevića gradina, cave Golubinka in Rasno (Široki Brijeg) etc. The most famous is Ravlića cave located high above the river spring of Tihaljina (260 MASL.), on the outskirts of the village Peć (today is the use of the name Peć Mlini) in Tihaljina. Archaeological excavations at this object discovered the remains of the settlement, which dates from the neolithic era, respectively the younger stone age (Oreč, 1984).

The karst of the Canton is rich with numerous pits, a large concentration of these speleological objects is characterized, above all, for its southern part, respectively the valley of Trebižat. Genesis of them in the study area, as well as caves, is primarily related to the effects of corrosion, but also for the mechanical destruction of groundwater (Temimović, 2008). Of the numerous pits in this area can be subdivided into the following: pit Vilinka by Sutina (Posušje), pit in Knešpolje, pit Tribošić (Široki Brijeg), Bubalova pit on Hardomilje, pit by Kašće, Antunovića pit, pit by Jagodnjik (Ljubuški) etc. Bubalova pit is the most famous pit of all the above, located on Hardomilje, at the top of the hill Veliki Humac, part of the mountain chain Humci. This pit is a harmony of pits and caves and is on the list of the legally protected geomorphological natural monument.



Fig. 8. Waterfall Kravice

Izvor: www.nasbiro.com

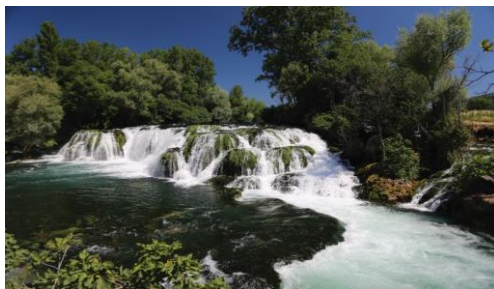


Fig. 9. Waterfall Koćuša

Izvor: www.guida-viaggio-bosnia.com

Sinks are a common form of limestone terrain in the area of West Herzegovina canton, according to the form they can be in the form of caves and pits or form of cracks and small caverns through which rainwater go or infiltrated in karst underground (Spahić, 2013). Almost all the underground rivers of the study area are lost in them, and they are especially expressed on the fringes of fields and coves in the karst, and in dry river valleys. The river system Tihaljina - Mlade – Trebižat is characterized by a lot of sinks, as the river in its course many times plunges and again rises. Also, a lot of sinks can be seen in the area of Mostar mud. Sinks and their zones have been identified, primarily, in the northeastern part of the field, from the hill Humac, along the river Lištica to Kamenjak, and in the zone of the limestone promontory Kamenjak to the locality Stupi. The larger sinks are Biline, Bonjevir, Krenica, Košina, Kolovrat, Renkovača, Rabanica and the sink Velika jama or Kruševo sink. Besides these, known sinks in the study area are sink Šainovac, Džambin sink, Perkića sink, Vidrinka sink, Mikulića sink etc.

When one looks at the spatial distribution of underground karst formations in the West Herzegovina canton, it can be concluded certain regularity of their appearance in the relief. Their presence is mostly typical of big river valleys, respectively underground streams, especially in the southern part of the Canton (in the catchment area of Trebižat), where is observed the largest concentration of endogenous forms.

The treated area is also characterized by the accumulation karst relief forms, which are formed by deposition of limestone from aqueous solutions (calcium bicarbonate). Besides travertine, the most beautiful forms of this type occur in caves and pits (Temimović, 2008). First of all, travertine is represented in the river bed of Trebižat as travertine barriers and thresholds, as well as on river banks outside of the bed. This accumulation karst form is most responsible for the existence of numerous waterfalls in the said watercourse, of which the largest are the far famous waterfalls Kravice and Koćuša

CONCLUSION

Through the work methodology pointed out the general characteristics of the karst terrain and karst formations in the West Herzegovina canton, thereby meeting the primary purpose of the work of deepening the knowledge of insufficient or less investigated karstic regions of Bosnia and Herzegovina. One such spatial unit is, certainly, the research territory, which can be characterized as a true representative of the karst phenomena.

West Herzegovina canton is located in the south-western part of Bosnia and Herzegovina. According to geographical regionalization of Bosnia and Herzegovina treated area is part of the Mediterranean Bosnian-Herzegovinian macroregion, more precisely, the administrative borders of this canton are identical to the boundaries of West Herzegovina mesoregion.

In terms of geomorphology, karst relief, which is designed on Mesozoic carbonate base, is the most dominant genetic type of relief in the researched field, and he is almost on the whole territory of the canton. The relatively high average annual rainfall, which decides on micro tectonic cracked Herzegovina limestone, resulted in a pronounced polymorphism karst topography and the development of different types of karst (pockmarked, naked, covered, etc.).

The area of West Herzegovina karst geomorphological is most recognizable by neotectonic lowered basins fields in the karst. The emergence of some of the existing basin fields in karst is a result of reverse faulting in terms of thrust-boron-scaly material. So, basins are caused by lowering the wing of reverse faults, which direction is the Dinaric direction (northwest-southeast).

From fields in karst in the area of West Herzegovina canton worth pointing out the following: Posuško polje, Ljubuško polje, Grudsko polje, Lištičko polje, Mostar mud, Bekijsko polje, Kočerinsko polje, Mokarsko polje, Drinovačko polje, Veljačko polje, Vitinsko polje, Studenačko polje, Jezerac, Rastok, Rašljansko polje, Rakitno polje, Rastovačko polje, Ruževno polje, Vučipolje, Čerinsko polje etc.

The researched area is rich with endogenous relief forms, whose presence is mostly typical of big river valleys, and underground streams, especially in the southern part of the Canton (in the catchment area of Trebižat). Among the distinguished destructive forms are stressed Ravlića cave, Šimićeva cave, and Bubalova pit, and of the accumulation forms far known are the travertine waterfalls Kravica and Kocusa.

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