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REVIEW OF THE MOST SIGNIFICANT CAVES IN MONTENEGRO

PREGLED NAJPOMEMBNEJŠIH JAM ČRNE GORE

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Abstract UDC 551.44(497.16)
Mirela Djurović & Predrag Djurović: Review of the most significant caves in Montenegro
The most significant caves in Montenegro were distinguished in response to their physical-geographic, biological, archeological and morphometric characteristics (length and depth). Caves distribute in four distinctive regions: coastal karst, karst plateau (relict valley system), fluvial karst (recent hydrologic systems) and the high mountainous karst area. The most outstanding within the last, due to abundances of the major caves with depths from a few hundred meters to 1,162 m, are four mountain regions: Mt. Durmitor, Mt. Lovćen-Orjen, Mt. Maganik and Mt. Bjelič.
Key words: caves, karst, Dinarides, Mt. Prokletije, Montenegro.

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Mirela Djurović in Predrag Djurović: Pregled najpomembnejših jam v Črni gori.
Najpomembnejše jame v Črni gori so bile proučevane glede na njihove fizikalno-geografske, biološke, arheološke in morfometrične lastnosti (dolžina in globina). Jame so porazdeljene v štirih različnih regijah, in sicer v obalnem krasu, na kraških planotah, fluvialnem krasu (recentni hidrološki sistemi) in na območjih visokogorskega krasa. Med zadnjimi z najpomembnejšimi jamami, globokimi od nekaj sto metrov do 1162 metrov, najbolj izstopajo štiri gorovja: Durmitor, Lovćen-Orjen, Maganik in Bjelič.
Ključne besede: jame, kras, Dinaridi, Prokletije, Črna gora.

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INTRODUCTION

Speleological investigations in Montenegro have been done for more than a hundred years. During this period over a thousand caves were explored. At the beginning of twentieth century the Cave Duboki do (Sarkotič-Höle) worthies the deepest explored cave in a world (Lahner 1917, 1919). In the second half of 20th century the exploration of caves was focused at different aspects: physical speleology, biospeleology, speleoarcheology, applied speleology (solutions of water-supply problems), geoheritage (Djurović & Djurović 2010), as well as in attempt to identify the deepest and the longest caves. Speleological exploration within the last twenty years underwent dynamic evolution. This period characterizes the increasing interest and hunt for the deepest caves.

There are several available reviews on the subject of speleological researches and their achievements in Montenegro (Pretner 1961; Lješević 1980; Lješević & Barović 1981; Maksimović 1997; Djurović 2017). A need for new review on the most significant speleological objects arose from the fact that passed many decades, since the very last review has been published, from that period a number of noteworthy caves were discovered. Therefore, the collection of data obtained throughout a range of studies carried out, their analyses, division and classification of the most significant caves were evaluated. The last two were employed by physical-geographic, biological, archeological and morphometric characteristics (length and depth) of caves.

FACTORS AFFECTING SPELEOGENESIS

The most important factors in speleogenesis in Montenegro (Fig. 1) are geological background, size and thickness of limestone, altitude and denivelation of karst relief, recent climate and relic and contemporary geomorphological processes.

Rocks of different composition and age (from Paleozoic to Quaternary) are exposed in Montenegro (Bešić 1975, 1980, 1983). The most abundant are diverse carbonate rocks of Mesozoic age that occur from the Adriatic coastal area till the highest mountain peaks (>2,500 m a.s.l.). The thickness of limestones ranges from a few hundreds to about 1,500 m. In the central part of the state limestones are over 2,000 m thick. Carbonate rocks cover approximately 85 % of the territory of Montenegro.

Fig. 1: Geographic position of Montenegro (Map by: Mirela Djurović).

Mountainous relief is dominating in Montenegro. From its total spatial area of 13,812 km^2 only 10 % are plains (0-200 m a.s.l.) and approximately 56.7 % of its territory exceeds 1,000 m a.s.l. (Mladenović 1984). Such distribution of vertical elevation had significant role in speleogenesis governing the direction of water circulation in karst.

Broad mountain plateaus are noteworthy in relief in Montenegro. They derived under fluvial- denudation processes from the Miocene through to Pliocene, i.e. during past geomorphological periods lack of tectonic events (Cvijić 1926; Milojević 1937). Most of plateaus occur at high mountain relief environments, between 700 and 1,450 m a.s.l. All are intensively karstified and some are cut by canyons whose depth commonly exceeds 1,000 m (Djurović & Petrović 2007), supporting a vertical migration of water in karst.

Diversity of recent climate in karst regions is the consequence of their different elevation and distance from the sea. The average annual temperature ranges from 15.7 °C (in coastal karst - Herceg Novi) (Burić *et al.* 2012) to 4.7 °C (high mountainous karst - Žabljak) (Djurović 2012). The average air temperature in the highest karst terrains, about 2,050 m a.s.l., is approximately 1.6 °C. In regions of 2,500 m a.s.l. is only about 0.1 °C (Djurović 2011).

Montenegro receives the average annual precipitation of 1,798 mm. During winter (October-March) precipitation reaches 1,223 mm (68 %), while in summer

(April-September) is only 575 mm (32 %) (Radojičić 1996). The annual precipitation in karst regions depends on their distance from the sea, their altitude and orography. The highest precipitation, of approximately 4,604 mm annually, receives karst terrains on west of Montenegro, behind the Boka Kotorska Bay (Mt. Orijen). There has been recorded the absolute maximum of 7,067 mm in 1979 (Djurović & Djurović 2016). Karst terrains on north of Montenegro (Mt. Durmitor – Žabljak) receive annually 1,453 mm (Djurović 2011), whereas in the highest karst terrains (> 2,500 m a. s. l.) this value approaches to 2,600 mm (Djurović 2012).

Relief of the karst terrains above 1,800 m a.s.l. is affected by cryo-nivation processes beside the recent karst ones (Milivojević & Djurović 2010). Melting of snow, which retains during summer in a form of snowpack at high-mountainous karst terrain, produces meltwater that enable water to percolate for a pretty long period.

Glacial processes that took part at all high-mountainous karst terrains in Montenegro (Cvijić 1889, 1903, 1913; Milivojević 2007; Milivojević *et al.* 2008; Djurović 2009; Stepišnik & Žebre 2011; Hughes *et al.* 2010, 2011; Petrović 2014) had significant influence on speleogenesis of deep caves. Numerous morphological traces of glacial process (cirque, glacial valley, glacial sholders, nunataks, lateral and terminal moraines) reflect on the intensity of glaciation. Glacial process took part during three stages (Djurović 2009). The oldest phase considers MIS 12 (470-420 ka), the younger MIS 6 (190 - 130 ka) and the last, cirque one MIS 5d - 2 (110 - 11.7 ka) (Hughes *et al.* 2011). Glaciers that were formed during the mentioned glacial phases accumulated huge amounts of water in the highest karst terrains. During interglacial phases, the melting of snow produced notable amounts of meltwater that is responsible for very intensive speleogenesis and deep karstification. Consequently very deep caves formed. Such deep karstification is confirmed by karst springs with considerable discharge. Such springs emerge at the bottom of deep canyons, karst poles or in the coastal area of Skadar lake and Adriatic Sea: Vukovo vrelo, Vidrovan, Gornjepoljski vir (Nikšićko polje), Ljutica (Canyon of the Tara river), Pivsko oko - 20 m^3/s (Canyon of the Piva river) (Prohaska *et al.* 2004), spring Ljuta, Gurdić, Sopot, Spila (Boka Kotorska Bay), Karuč, Bolje sestre (Skadar Lake).

METHODOLOGY

Results of speleological researches in Montenegro could be found in different publications ranging from scientific and professional popular journals over different elaborates to advanced digital media services (sites of different speleological clubs, organizations, institutions and various informative services, etc.). Such a wide array of sources inevitably opens the question of whether the presented data are credible. Results presented in scientific journals were employed in their original forms as have been already scientifically approved. The data from other sources were subjected to critical analysis that included analyzing of graphical displays (quality and accuracy of detail ground plan, longitudinal and transverse section of caves) (*Jeannin et al. 2007;* Sirotek & Weigel 2006), geographic location description, morphological and hydrological characteristics, as well as all other relevant data. The comparative analyses of obtained results with previous research results or those acquired by different researchers have been also applied (Yamaç 2018). Hence, all relevant parameters required for a cave to be included in a group of the most significant caves were critically analyzed.

The Map of the most significant caves in Montenegro has been created in a few stages. The first one included the delineating of karst areas using primarily the Basic geological map 1:100,000 SFR Yugoslavia (15 sheets) (Group of authors 1958-1968; Group of authors 1962-1966; Group of authors 1962-1967; Group of authors 1962-1967; Group of authors 1962-1969; Group of authors 1962-1969; Mirković *et al.* 1962-1968; Živaljević *et al.* 1964-1978; Mirković *et al.* 1965-1972; Mirković *et al.* 1967-1974; Mojsilović *et al.* 1973-1981; Mirković & Vujisić 1980-1986). As geological formations on these maps were not distinguished regarding petrology but rather by principles of stratigraphy, the additional analyses including analysis of detail topographic maps 1:25,000 and aerial photographs and satellite images were obligatory for ambiguous parts (Benson & Yuhr 2016). According to morphological, hydrological, climate and evolutionary data (Djurović 1998) the four distinctive karst regions, which are representative for karst specificities in Montenegro and caves within, were recognized during the second stage (Djurović 2017). The next, third stage, involved the classification of caves into five categories regarding their length, depth, hydrological, speleobiological and archeological characteristics. Afterwards, the geographic location of the each of the selected caves in Montenegro was designated on the map along with related graphical symbols.

REVIEW OF THE MOST SIGNIFICANT SPELEOLOGICAL OBJECTS

According to present knowledge of speleological objects, the most significant caves in Montenegro are located in four regions, which were distinguished by morphological, hydrological, climate and evolutionary characteristics: coastal karst, karst plateau (relict river systems), fluvial karst (recent river systems) and high mountainous karst (Fig. 2).

Coastal karst is exposed along the coastal line of Adriatic Sea and Skadar Lake. Accelerated, glacial-eustatic rise of sea-level (Matthews 1990; Peltier 1999; Lambeck & Purcell 2005; Surić *et al.* 2005; Surić 2009; Slavec 2011), which correlates with the period after LGM (started before about 19 ka and lasted till 7 ka before), led to flooding of coastal caves (Lambeck & Chappell 2001; Lambeck *et al.* 2002). Change in sea-level (recent rise of ~1.8 ± 0.3 mm/yr is determined instrumentally) determined hydrological function of these caves that occur today either as permanent or intermittent karst springs (Church *et al.* 2004). During fluvial maximum their discharge is moderate (e.g., Ljuta >180 m^3) (Stevanović 2010). Springs are distributed at low altitudes and many of them are at least partly beneath the sea level, i.e. Skadar lake level. Majority of caves is in the Boka Kotorska Bay: Spila (N° 8 in Tab. 1), Sopot (N° 9 in Tab. 1), Ljuta (N° 10 in Tab. 1), Gurdić (N° 11 in Tab. 1) (Renaud 1999; Guis 1999a, 1999b, 1999c; Milanović 2004; Eusebio *et al.* 2005a, 2005b; Mihajlovski 2006; Eusebio *et al.* 2007a, 2007b; Milanović 2007), along the coast of Skadar lake: Voločka Jama (N° 25 in Tab. 1) (Otava & Zajiček 1988, 1989, 1990; Szerszeń 2008; Graczyk 2011;) and Krevenica (N° 31 in Tab.1). One of the most significant caves in mountainous karst is the cave Savino oko (N° 57 in Tab 1.). Regardless of similar morphologic-hydrologic characteristics with the caves listed in the coastal karst region, it displays differences concerning its position (base of Prokletije), located at high altitude, type of speleogenesis, hydrogeological characteristics and so forth (Szerszeń 2008a, 2008b).

Karst plateau region in Montenegro (Cvijić 1926; Petrović 1997) displays similar characteristic to other karst plateau areas in Dinaric karst (Gams 2004; Bognar *et al.* 2012; Bočić *et al.* 2015). More than a few tenths of square kilometers of Montenegrin karst plateau is lack of surface water and the overall precipitation tends to disappear into limestones lying below. Karst plateaus are intensively karstified areas, and dotted by numerous dolines and karrens that form a peculiar topography, commonly inaccessible. Morphological records of relict valleys (Cotton 1968) significantly changed under karst processes meanwhile are also recognized in the relief of the karst plateau region beside a karst forms. According to the results of their reconstruction a few larger relict valleys systems have been distinguished. A number of caves of different morphological and hydrological characteristics, time and type of genesis, etc., within were explored.

Within the relict valley system Mt. Lovćen - Cetinjsko Polje - Skadar Lake are identified several long caves: Cetinjska Pećina (N° 22 in Tab. 1), Lipska Pećina (N° 23 in Tab. 1), Začirska Pećina (N° 26 in Tab. 1), Caves Spila-Babatuša (N° 27 in Tab. 1), and Grbočica (N° 28 in Tab. 1), (Petrović & Božović 1980; Lješević & Barović 1981; Mihevc 1983; Petrović 1997; Djurović *et al.* 2002; Lajovic 2010; Kovačević & Kovačević 2014).

Caves in the other two relict valley systems are significantly deeper than the previous ones:

- the Mt. Lovćen - Njeguško Polje - Boka Kotorska Bay are: Nyúl Lika (N° 17 in Tab. 1), Duboki Do (N° 18 in Tab. 1), Njegoš Pećina (N° 19 in Tab. 1), Bogoš Barlang Cave (N° 20 in Tab. 1), Cave Dögös (N° 21 in Tab. 1), (Radulović 1974; Habič 1980; Lješević & Barović 1981; Kiss & Takácsné - Bolner 2006; Takácsné - Bolner 2006; Hegedűs *et al.* 2010; Hegedűs & Takácsné – Bolner 2012, 2013),
- the Mt. Orjen - Grahovsko polje - Dragaljsko polje - Boka Kotorska Bay: Gouffre du Brouillard (Maglena jama) (N° 4 in Tab. 1), Cave Pištet PT4 (N° 5 in Tab. 1), Cave Propast Pema (N° 7 in Tab. 1), (Dvořák & Večerek 2001; Večerek & Dvořák 2002; Groupe Spéléologique Minos 2003; Večerek *et al.* 2003; Dvořák 2004, 2009, 2010, 2011; Dvořák & Dvořák 2008; Binding 2010; Duxbury 2010; Binding 2011; Duxbury & Božović 2013).

Fluvial karst in its broadest sense represents karst region having both, the fluvial and the karst relief forms (Gams 2004; Bognar *et al.* 2012; Furlani *et al.* 2016; Phillips 2017; Donnaloia *et al.* 2019). It is found in the northern and northeastern parts of Montenegro. Canyons and gorges in karst plateau were incised by large allogenic rivers (Tara, Piva, Morača, Lim etc.) (Djurović & Lješević 1994; Djurović & Petrović 2007) that carried water in amounts large enough to incise limestone masses but to remain as surface flows due to impermeable basement. The main direction of flows and groundwater pathways in this part of Montenegro has been driven by the deeply incised canyons. Underground karst flows emerge at surface in a form of abundant karst springs either at the bottom of gorges and canyons: Djalovića gorge - Pećina nad Vražjim firovima (N° 53 in Tab. 1) (Sirotek 2005, 2006, 2015) and, Juriško vrelo (N° 52 in Tab. 1), Mrtvica canyon - Jama (N° 67 in Tab. 1) (Šimiček & Kahle 2015) or on the margins of karst plateau: (Gornjepoljski Vir estavelle and intermittent spring – near the city of Nikšić), Ljutica (canyon Tara), Pivsko Oko (canyon Piva), Oraška jama and Oboštičko Oko (in the vicinity of Danilovgrad city). The pronounced discharge of springs reflects on complex but recent hydrologic systems, in which the direct speleological researches are extremely hard, even at the edge of possibility in regards to technical difficulties. In spite of a numerous karst springs, due to mentioned reasons, just a small number of caves have been explored in this region (Kličković 1997; Mirović 1997; Vučković & Kličković 1997). A number of abris, which formed during different stages of evolution of river valleys, are also characteristic. In many of them were discovered Paleolithic settlements (Benac & Brodar 1958; Brodar 1962; Basler 1975), as well as remains of Quaternary fauna (Bogićević & Dimitrijević 2004; Argant & Dimitrijević 2007).

High mountain karst is developed in a mountain highlands, which have been subjected to Pleistocene glacial processes allowing glacial karst to be formed (Stepišnik & Žebre 2011; Djurović & Djurović 2015). Currently is this area exposed to cryo-nivation processes along with the karst one (Lješević 2004; Milivojević & Đurović 2010; Djurović 2011). Caves in high mountain karst were carved by melt water, not by erosion force of surface flows that sink into limestone bedrocks (Adamson *et al.* 2014; Žebre & Stepišnik 2015). Meltwater, derived by widespread glaciers melting at the end of the oldest glacial phase (MIS 12) in high mountain regions in Montenegro, was the main agent in cave development primarily (Milivojević *et al.* 2008; Djurović 2009; Hughes *et al.* 2010, 2011). The second intensive developing phase took part during and at its end the Last glacial maximum. The influence of glaciers to speleogenesis terminated by melting of glaciers from the cirque glacial phase (MIS 5d-2), regardless the existence of current glacier Debeli namet at the Mt. Durmitor (Djurović 1999; Hughes 2007, 2008; Djurović 2012; Djurović & Djurović 2016). Very important factors in speleogenesis in the current phase of the cave development are meltwater derived by melting of snow and snowpack at the surface, as well as accumulated snow and ice at the cave entrance. In a number of cave entrances were noted thick deposits of snow and ice (Gavrilović 1963) occasionally exceeding 100 m in thickness. Their melting enables the persistence of the erosion process in caves even in periods of lack of water supply from the surface. The deepest speleological objects occur in the highest levels of the high mountainous karst. Their abundance brought them the dominance within the most significant caves in Montenegro. Their entrances are in Pleistocene glacial forms (cirques and glacial valley) (e.g., Opasna Jama (N° 32 in Tab. 1) (Pavićević *et al.* 2015). Daily and annual water regime is very specific due to snow, particularly due to snowpack. Maximal recharge in caves is related to the intensity of melting of snow and snowpack, instead to the amount of precipitation. Mountainous regions at Durmitor, Maganik and Bjelič, including Lovćen with its slopes, are distinguishing in number of deep caves. Examples at the Mt. Durmitor mountain are Bunda Jama (N° 34 in Tab. 1), Jaskinia X 1108 (N° 36 in Tab. 1), Jama na Vjetrenim Brdima (N° 37 in Tab. 1), Jama Samo Lepo (N° 38 in Tab. 1), Jamski Sitem u Obručinama (N° 39 in Tab. 1), Jama Fliš (N° 40 in Tab. 1) and Jama u Malom Lomnom Dolu (N° 41 in Tab. 1) (Lješević *et al.* 1980; Lješević & Barović 1981; Mottram 1986; Garašić 1986a, 1986b, 1986c, 1986-1987; Courbon & Chabert 1986; Jackson 1987; Milinčić *et al.* 1996; Ćalić - Ljubojević & Mandić 2004; Vrviščar 2006; Podržaj 2009; Chojnacki 2010; Szczygieł 2010; Moody *et al.* 2013; Peters 2013). At the Mt. Maganik are beside the cave Iron deep (N° 47 in Tab. 1), which exceeds 1,000 m in depth, also known: Jama u Pribatovom Dolu (N° 43 in Tab. 1), Jaskina Nyx (Jama u Treštenom vrhu) (N° 44 in Tab. 1), Aither (N° 45 in Tab. 1), Jaskinia M13 (N° 46 in Tab. 1), Zoran Jama (N° 68 in Tab. 1) and Jaskinia M73 (N° 48 in Tab. 1) (Vujić 1994, 1999; Maślanka 2008; Dvořák 2011a; Furtak 2012; Adamec *et al.* 2013; Dvořák & Baldík 2013; Królewicz 2013-2017; Otava & Baldík 2013; Dvořák 2014; Šimiček & Kahle 2015). There are in the south part of the Mt. Prokletije (Bjelič) (Kardaś 1978): Jaskinia Do Savino Oko (N° 58 in Tab. 1), Jama frižider (N° 59 in Tab. 1), Abisso degli Uomini Liberi (N° 60 in Tab. 1), Jaskinia Łezka – Jaskinia Kolektor (N° 61 in Tab. 1) Cave Jaskinia Gornicza (N° 62 in Tab. 1), Jaskinia Lodova (N° 63 in Tab. 1), Jaskinia Gigant (N° 64 in Tab. 1), Abisso dell'Ombra (N° 65 in Tab. 1) and Jaskinia Niby Czarna (N° 66 in Tab. 1) (Kicińska & Najdek 2007; Najdek 2007, 2008; Najdek & Kasza 2008; Kasza *et al.* 2010a, 2010b; Kicińska *et al.* 2011; Santolin 2012; Kicińska & Najdek 2009 - 2013; 2013; Najdek & Kicińska 2013-2017; Vučetić & Andjelić 2013). There are on Mt. Lovćen: Jama u Majstorima (N° 16 in Tab. 1) (Skarep & Trnavac 2004), System Jages barlang (N° 13 in Tab. 1) - Kétlyukú barlang (N° 14 in Tab. 1) (Takácsné - Bolner *et al.* 2015) and Sistem Pala Skala (N° 15 in Tab. 1) (Mihalič *et al.* 2017; Tičar 2016; Tičar *et al.* 2017; Tičar & Kozamernik 2018, 2018a). There are on the Mt. Orjen Jeskyně Kozí Díra (N° 3 in Tab. 1) (Dvořák & Večerek 2001) and on Mt. Pivska planina Todorova Jama (N° 33 in Tab. 1) (Lješević 1976).

The early first description of cave animals in Montenegro (*Neotrechus suturalis*) dated back in 1864 to L.W. Schaufuss (Pretner 1961). Recognition of the most significant caves in regards to diversity of fauna (Pretner 1977; Nonveiller & Pavićević 1999; Pavićević 1990;

Pavićević *et al*. 1999; Karaman 2000) is difficult due to imprecise determination or referring of caves in which fossil fauna were found. In many caves presented in this paper, which were distinguished according some another criterions, were discovered habitats of diversified cave fauna: Lipska Pećina (N° 23 in Tab. 1), Grbočica (N° 28 in Tab. 1), Jama na Vjetrenim Brdima (N° 37 in Tab. 1). Particular importance deserve depicting of cave fauna in: Megara (N° 29 in Tab. 1) (*Niphargus zorae, G. Karaman, 1967; Speonesiotes pretneri,* Müller *1934; Speonesiotes montenegrinus Z. Karaman 1967); Speonesiotes laticollis,* Müller *1934* (Müller 1934; Karaman 1967a, 1967b; Barović 1995)*, Lipska Pećina* (N° *23 in Tab. 1*) *(Anthroherpon absoloni*, Gueorguiev 1990; *Folkia mrazeki*, Nosek 1904; *Bogidiella montenigrina*, Karaman 1997; *Neobisium umbratile*, Beier 1938; *Typhlogammarus mrazeki*, Schäferna 1906) (Nosek 1904; Schäferna 1906; Beier 1938; Guéorguiev 1990; Karaman 1997), Grbočica (N° 28 in Tab. 1) (*Adriaphaenops staudacheri*, Scheibel 1939; *Elaphoidella montenegrina*, Karanović 1997; *Lithobius sketi*, Matić & Darabantu 1968; Niphargus brevicuspis sketi, Karaman 1966) (Scheibel 1939; Karaman 1966; Matić & Darabantu 1968; Karanović 1997), Obodska Pećina (N° 24 in Tab. 1) (*Plagigeyeria montenigrina* Bole 1961; *Saxurinator hadzii*, Bole 1961; *Spelaeodiscus obodensis*, Bole 1964; *Spelaeodiscus unidentatus*, Bole 1961; *Sphaeromides virei montenigrina*, Sket 1957) (Sket 1957; Bole 1961, 1965), Jama na Vjetrenim Brdima (N° 37 in Tab. 1) (*Adriaphaenops zupcense tartariensis*, Pavićević 2001; *Tartariella durmitoriensis durmitoriensis*, Nonveiller & Pavićević 1999) Ledena Pećina (N° 35 in Tab. 1) (*Neotrechus hilfi grossi*, Jeannel 1928; *Leonhardella antennaria antennaria*, Apfelbeck 1907), (Nonveiller & Pavićević 1999; Pavićević 2001). Of particular importance are also three caves where five troglobiotic beetle species were identified: Vilina Pećina (N° 6 in Tab. 1) – Crkvice, Boljanovića Jama (N° 12 in Tab. 1) – Kotor and Pećina u Kučericama (N° 2 in Tab. 1) – Mt. Orjen (Groupe Spéléologique Minos 2003; Zagmajster 2007), Pećina nad Vražjim firovima (N° 53 in Tab. 1) (*Remyella propiformis,* Winkler 1933) (Moravec 2017).

Archeological and paleontological caves represent morphologically simple and short objects. Many of them are attributed to long-lasting accumulation of sediments that contributed to paleontological and archeological findings to remain preserved. They occur all over karst regions excluding high mountain area. The Lower Paleolithic findings were discovered in the cave Trlica (N° 49 in Tab. 1) (Dimitrijević 1990; Codrea & Dimitrijević 1997; Crégut-Bonnoure & Dimitrijević 2006; Argant & Dimitrijević 2007; Derevjanko *et al*. 2012; Made & Dimitrijević 2015; Vislobokova & Agadjanian 2015). Traces of the Middle Paleolithic habitats were identified in Mališina Stijena (N° 51 in Tab. 1), Bioče (N° 30 in Tab. 1) and Crvena Stijena (N° 1 in Tab. 1) (Brodar 1962; Vogel & Waterbolk 1972; Basler 1975; Brunnacker 1975; Malez 1975; Radovanović 1986; Bogićević & Dimitrijević 2004; Đuričić 2006; Morley 2007). Remains of the Upper Paleolithic habitats are preserved in Crvena Stijena (N° 1 in Tab. 1), Mališina Stijena (N° 51 in Tab. 1), Medena Stijena (N° 50 in Tab. 1) and Trebački Krš (N° 55 in Tab. 1) (Benac & Brodar 1958; Rakovec 1958; Malez 1975; Radovanović 1986; Nikolić 1992; Đuričić 1996; Dimitrijević 1999; Mihailović 2014).

Tab. 1: The most significant caves in Montenegro.

No	Name of cave	Location	Entrance	Deep	Long
1	Crvena stijena	Bilećko jezero	725*	20	-
2	Pećina u Kučericama	Mt. Orjen	*		
3	Jeskyně Kozí díra	Mt. Orjen	1011	662	1714
4	Gouffre du Brouillard (Maglena jama)	Mt. Orjen	1120	>282	-
5	Pištet (PT4)	Mt. Orjen – Kotor	725	455	-
6	Vilina pećina	Mt. Orjen – Crkvice	*		
7	Propast Pema	Mt. Orjen	680	318	>1500
8	Spila	Risan	20	72	410
9	Sopot	Risan	29	70	400
10	Ljuta	Kotor	20	133	170
11	Gurdić	Kotor	0	52	460
12	Boljanovića jama	Kotor	*		
13	Jages barlang	Mt. Lovćen	1320	216	944
14	Kétlyukú barlang	Mt. Lovćen	1360	715	3600
15	Sistem Pala skala	Mt. Lovćen	1328	667	984
16	Jama u Majstorima	Mt. Lovćen	1195	388	-
17	Nyúl lika/Zečija rupa	Njeguško polje	1112	400	1700

18	Duboki do	Njeguško polje	997	505	>2247
19	Pećina Njegoš	Njeguško polje	874	308	5300
20	Bogoš	Njeguško polje	1074	279	>1617
21	Dögös barlang (Žestoka pećina)	Njeguško polje	853	101	1100
22	Cetinjska pećina	Cetinje	668	57	1067
23	Lipska pećina	Cetinje	480	+155	1810
24	Obodska pećina	Rijeka Crnojevića – Cetinje	*		
25	Voločka pećina	Skadar Lake	6	47	250
26	Začirska pećina	Cetinje	445	201	1173
27	Spila-Babatuša	Virpazar - Trnovo	345/350	55	290+
28	Grbočica	Virpazar - Trnovo	390	87	798
29	Megara	Podgorica	283	-	260
30	Bioče	Canyon Morača	*		
31	Krevenica	Tuzi	37	50	>200
32	Opasna jama	Mt. Žijovo	1355	>500	>2000
33	Todorova jama	Mt. Pivska planina	1660	297	-
34	Bunda jama	Mt. Durmitor	2028	286	612
35	Ledena pećina	Mt. Durmitor	2150	68	38
36	Jaskinia X 1108	Mt. Durmitor	2193	272	1799
37	Jama na Vjerenim brdima	Mt. Durmitor	2175	775	1951
38	Jama Samo lepo	Mt. Durmitor	2160	321	-
39	Jamski sitem u Obručinama	Mt. Durmitor	2135	464	>2680
40	Jama Fliš	Mt. Durmitor	2080	582	1672
41	Jama u Malom lomnom dolu	Mt. Durmitor	2098	605	>1870
42	Jama u Crkvenom dolu	Mt. Maganik	-	463	-
43	Dvogrla jama u Pribatovom dolu	Mt. Maganik	1720	395	-
44	Jaskinia Nyx (Jama u Treštenom vrhu)	Mt. Maganik	1950	622	>1000
45	Jeskyně Aither	Mt. Maganik	1920	380	-
46	M13	Mt. Maganik	-	333	765
47	Iron deep (Železna jama)	Mt. Maganik	1767	1162	3360
48	Jaskinia M73	Mt. Maganik	-	473	646
49	Trlica	Pljevlja	*		
50	Medena stijena	Canyon Ćehotina	*		
51	Mališina stijena	Canyon Ćehotina	*		
52	Juriško vrelo	River Bistrica – Bijelo Polje	747	35	> 1000
53	Pećina nad Vražjim firovima	River Bistrica – Bijelo Polje	835	-	17 500
54	Župan pećina	Lubnica selo, Berane	1205	22	1160
55	Trebački krš	Berane	*		
56	Čardak	Mt. Greben – Gusinje	1969	175	1054
57	Savino oko	Ropojana – Gusinje	1000	90	
58	Jaskinia Do Savino Oko	Mt. Bjelič	1998	256	588
59	Jama frižider	Mt. Bjelič	2020	225	462
60	Abisso degli Uomini Liberi	Mt. Bjelič	1910	402	849
61	Jaskinia Łezka-Jaskinia Kolektor	Mt. Bjelič	-	263	1011
62	Jaskinia Gornicza	Mt. Bjelič	2019	585	2083
63	Jaskinia Lodova (Ledena jama)	Mt. Bjelič	1945	451	1956
64	Jaskinia Gigant	Mt. Bjelič	2116	296	1635
65	Abisso dell'Ombra	Mt. Bjelič	1969	250	-
66	Jaskinia Niby Czarna-Babina sisa	Mt. Bjelič	1885	236	1611
67	Jama	Mt. Maganik (River Mrtvica)	350	56	1244
68	Zoran Jama	Mt. Maganik	1780	>630	-

** Arheological, paleontological or biospeleologically sites*

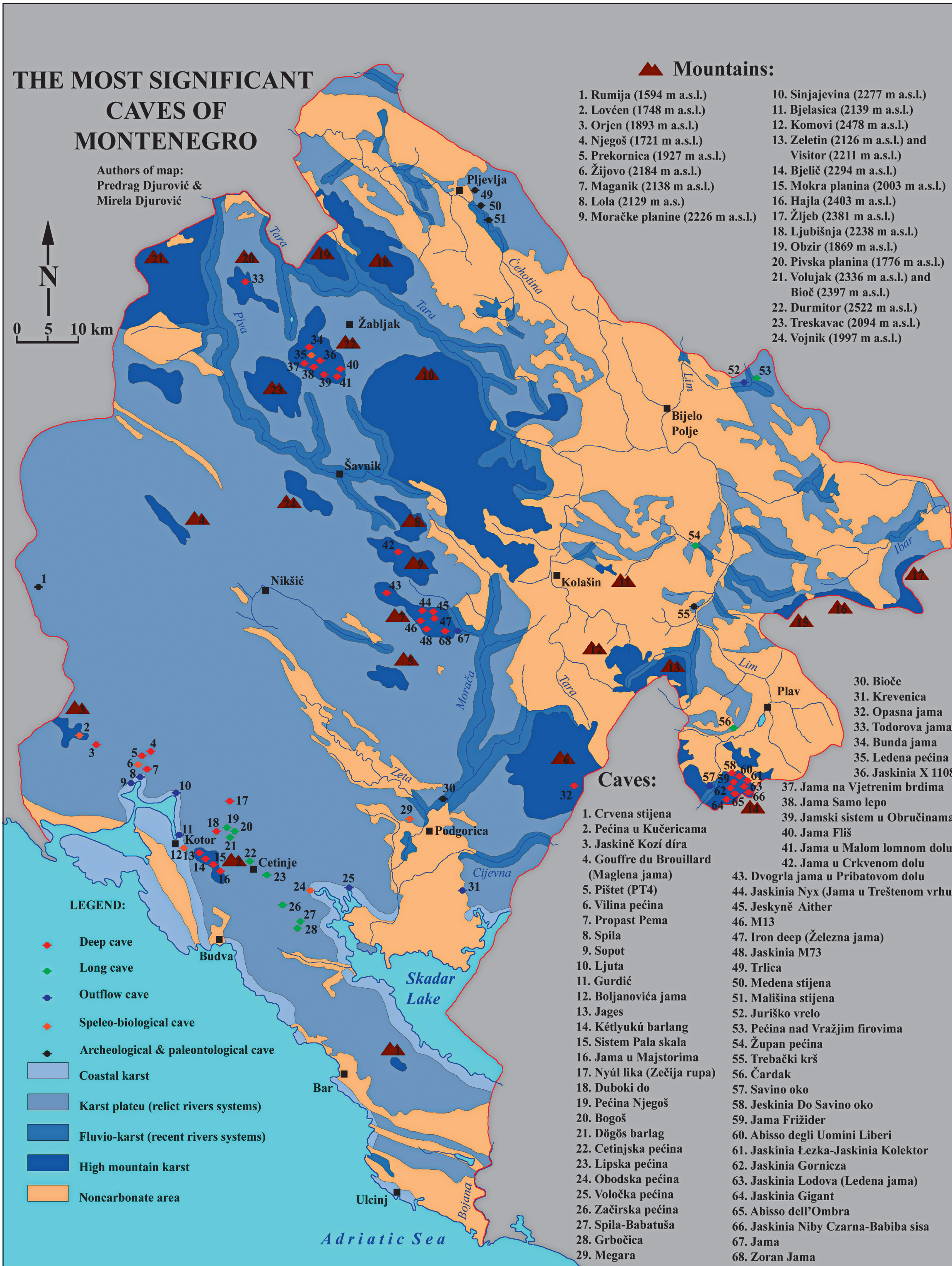

Fig. 2: Map of the most significant caves in Montenegro.

CONCLUSION

The most significant caves in Montenegro expose from the coastal Adriatic Sea and the Skadar lake to the highest mountain peaks (regions exceeding 2,000 m a.s.l.). Caves formed in carbonate masses occasionally over 2,000 m thick. Their development is ascribed to a range of paleoclimate (glacial/interglacial) and recent climate conditions (mean annual temperature from 0 to 15 °C and mean annual precipitation of 1,500 to over 4,000 mm). Their genesis is attributed to various forces: water melted from glacier, snowpatch and snow, erosion by rivers, glacial-eustatic rise of global sea level, etc. Many caves preserved traces of Paleolithic inhabitants and also represent habitats of diverse cave fauna. Four regions in the high mountainous karst are particularly outstanding in abundances of the most significant caves in Montenegro: Mt. Durmitor, Mt. Lovćen-Orjen, Mt. Maganik and Mt. Bjelič. Numerous caves vary in depth from a few hundred meters to 1,162 m.

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