

Brestovská Cave as a new locality for speleotourism in Slovakia

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Abstract

On August 31, 2019, three years have passed since the Brestovská Cave was opened to the public. This cave is the youngest cave open to the public in Slovakia and the only one opened in the Orava Region. Brestovská Cave lies in the cadastral area of the Zuberec village, near the Museum of the Orava village in the West Tatra Mountains. The cave administrator and operator is the Slovak Caves Administration based in Liptovský Mikuláš, which is an organizational unit of the State Nature Conservancy of the Slovak Republic. There is no artificial lighting in the cave. Visitors are equipped with helmets and headlamps. This form of access is called a speleological guide service. Our article deals with complex characteristics of the cave (physico-geographical conditions, history of discovery, research, cave access and protection, cave attendance analysis).

Key words: Brestovská Cave, cave attendance, speleotourism, West Tatra Mountains, visitors

Introduction

Karst areas in the Slovak Republic occupy an area of 2700 km². In terms of geotourism, they represent a highly attractive area with a wide range of surface and underground karst forms. Caves are the most important underground karst forms. According to Nature and Landscape Protection Act no. 543/2002 Coll., the cave is a man-accessible and naturally created hollow underground space in the Earth's crust whose length or depth exceeds 2 m and the dimensions of the surface opening are smaller than its length or depth. 7242 caves are officially registered in the Slovak Republic as of 31.12.2017.

In terms of speleotourism, 18 caves are open to the public in Slovakia. 13 of them are operated by the Slovak Caves Administration: Belianska Cave, Brestovská Cave, Bystrianska Cave, Demänovská Cave of Liberty, Demänovská Ice Cave, Dobšinská Ice Cave, Dómica Cave, Driny Cave, Gombasecká Cave, Harmanecká Cave, Jasovská Cave, Ochtinská Aragonite Cave, Važecká Cave. 5 caves are operated by other entities: Krásnohorská Cave, Dead Bats Cave, Bad Hole Cave, Bojnice Castle Cave, Small Stanišovská Cave. So far, the last cave opened to the public in Slovakia was Brestovská Cave on August 31, 2016. It became the only cave open to the public in Orava Region and West Tatra Mountains and the second (after the Belianska Cave) in the Tatra National Park. Brestovská Cave was opened to the public in a special form of access - speleological guide service. There is no artificial light in the cave, helmets, and headlamps are available for visitors. Krásnohorská Cave, Dead Bats Cave, Bad Hole Cave, and Small Stanišovská Cave have a similar form of access.

Speleotourism is a special form of geotourism. It is defined (Zelenka and Pásková, 2012) as a form of tourism associated with the exploration and discovery of cave spaces and abysses. Climbing activities, cave diving, etc. are part of this. Their definition is an example of an understanding of speleotourism in the narrower sense of the term. Also, Panoš (2001) defines speleotourism, more narrowly, as an organized speleological activity focused on cultural-cognitive activities in unavailable (to the public) underground karst forms (caves and abysses). These forms are available for people with basic equipment (helmet, own lighting) and under the guidance of an experienced professional guide (speleologist). Speleotourism, in the broader sense, is understood as an individual or group tourism, organized in commercial interest in the caves opened to the public or other attractive karst forms equipped with safety equipment. Such areas are illuminated, have signposted trails, stairs, locked entrance, some have electric lifts. They are technically secured, and the tour is carried out with the help of a trained guide.

The problem of speleotourism, or of the use of caves and karst phenomena in geotourism has been addressed by several authors. General characteristic of speleotourism was discussed by Cardozo Moreira and Neto de Carvalho (2013), Cigna and Burri (2000), Cigna and Forti (2013), Doorne (2000), Kranjc (2008), etc. Regional aspects of geotourism have been addressed, for example in the work of Anderson (2010), Antić (2018), Cigna (1993), Emeka et al. (2017), Figueiredo (1998), Forti and Cigna (1989), Knežević and Grbac-Žiković (2011), Lobo (2007), Lobo and Moretti (2009), Pavlovich (2003), Tičar et al. (2018), Tomić et al. (2018).

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This paper aims to brief description of the physico-geographical conditions of the cave, the history of discovering, research, opening and protection of this locality. In the second part of the paper, we analyze cave attendance, especially on the basis of statistical data obtained during the first year of the cave operation.

Materials and methods

In the first step, we performed an excerpt of all available literary and map works about the cave. We also used materials in the archives of the Slovak Caves Administration, the Slovak Museum of Nature Protection and Speleology and cave groups operating in the area. In these places, we also consulted the necessary issues with individual workers, active and inactive speleologists. The second step was the field research in the underground spaces of the cave as well as on the surface around it. We went through the accessible route as well as the spaces outside it, we also moved in the aquatic environment. We made photo documentation and made partial measurements - especially climatic. In the third step, we gathered statistics about cave attendance, worked out the relevant map outputs in the GIS environment and analyzed and processed all the data for publication.

Location and delimitation of the cave

Brestovská Cave is located in northern Slovakia in the Žilina Region and Tvrdošín District. It belongs to the cadastral area of Zuberec Village and the local area of Zuberec-Brestová (Fig. 1). Near the cave, there is the Museum of the Orava Village. The entrance to the cave is oriented to the north in the wooded slope of the Studený Potok Valley, at an altitude of 867 meters above sea level. The total length of the cave is currently 2026 m. In terms of the geomorphological division of Slovakia (Mazúr et al., 1986), the cave belongs to the sub-province of the Inner Western Carpathians, the Fatra-Tatra Region, the geomorphological unit of the Tatras, the sub-unit of the Western Tatras and the geomorphological part of Roháče. The cave lies in the territory of the Tatra National Park.

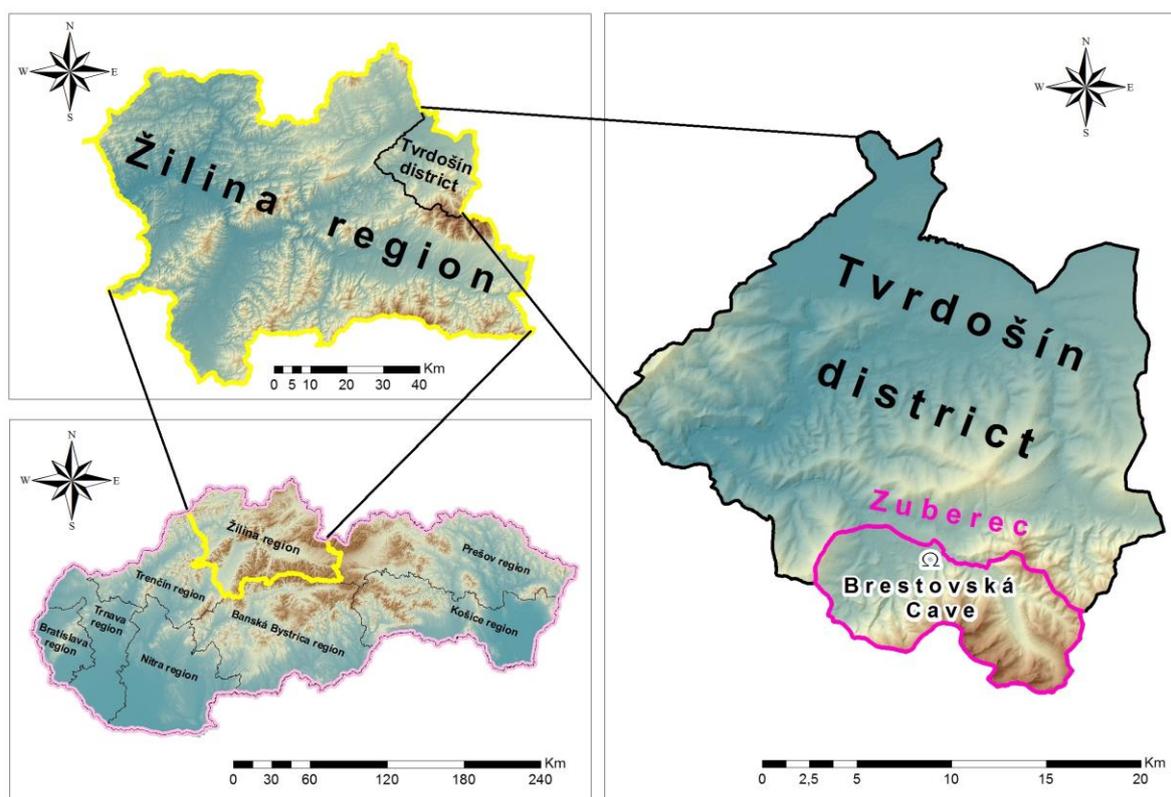


Fig. 1 Location of the Brestovská Cave in Slovakia

Results and Discussion

History of discovering, research, opening and protection

The first written mention of the cave, more precisely of today's Brestovská spring, comes from the pen of Tytus Chalubinski, a famous Polish lover of the Tatras and the founder of the Tatra Association in Zakopane. In 1886, he writes about it as "a cave by the springs of Cold Water" (Chalubinski, 1886). A year later, the cave

Stetkóvka (Brestovská Cave) is also mentioned by J.G. Pawlikowski, another member of the association and pioneer of nature protection and speleology in the Tatras (Pawlikowski, 1887). Already at that time, he considered the possibilities of opening the cave and regretted its location, aside from the interest of tourists. A military garrison from Dolný Kubín in 1923-1925 also participated in the cave survey. They managed to get about 250 m from the entrance where they were stopped by a water siphon. In 1929 the cave is mentioned by Polish geographer M. Gotkiewicz under the name Zuberecká Cave (Lalkovič, 2008). The Stetkóvka Water Cave is mentioned in 1936 in T. Zwolinski's guide about the Tatras and Zakopane (Zwolinski, 1936). In the same year, the military circles began to consider the use of known cave space in terms of civil protection of the population against air raids, or as a place to store military material. In 1950 P. Čaplovič also mentions the cave under the name "Cave in Roháče" (Čaplovič, 1950). After the foundation of the Slovak Speleological Society in 1949, J. Brodňanský, the founder of an organized speleology in Orava, joined the cave exploration. He aimed it to the length of 445 meters and named it Brestovská Cave for the first time (Bella et al., 2016). Further research of the cave was possible only by a diving survey, which was first carried out in 1968 under the leadership of the Slovak Karst Museum in Liptovský Mikuláš with the participation of diving club members from Žilina. In 1969 the cave was geomorphologically examined by Anton Droppa, an employee of the Institute of Geography of the Slovak Academy of Sciences (Droppa, 1972). In 1979 the 120 meters long siphon in the cave was overcome, in 1981 about 600 meters of new space were surveyed. At present, the cave speleological survey is mainly attended by speleologists from the Orava Region group.

The first intention to open the Brestovská Cave was developed by the Slovak Caves Administration in Liptovský Mikuláš at the end of the 1970s. This idea was not finally realized. Cave, more precisely its entrance lock was often damaged in the 80s and 90s by vandals or covered in waste. Negative anthropogenic interventions in the Brestovská Cave were manifested mainly by damage to the sinter filling. In accordance with Nature and Landscape Protection Act Nr. 543/2002 Coll., the cave became a National Natural Monument and in 2008 a cave protection zone with an area of about 60 hectares was declared. Additional cave research, based on which the project of the cave accessibility was processed, was carried out by the Slovak Caves Administration in 2006-2007 and published in 2008. Before the cave was opened, certain limits and conditions of attendance were set to minimize disruption of the fragile cave environment. It was necessary to limit tourist access during the winter months due to the hibernation of bats. During the hibernation period (November-March), it was suggested to limit access to a maximum of 3 to 4 admissions per day, with a maximum of 10 to 15 persons per admission, and there should not be two groups of visitors at the same time. It was proposed to determine the number of visitors during the day, because the cave, due to its morphology (cramped and small spaces), does not allow more visitors. Opening works in the cave began in IV. quarter of 2015, they were paid from the Environmental Fund within the Ministry of Environment of the Slovak Republic. The walkway was led over the riverbed to avoid treading on habitats and fluvial sediments. Several staircases, bridges and steps are installed on the tour route. In the accessible section of the cave, artificial belay devices and staircases take up a length of 97.3 m, of which staircases are 47 m. Above the entrance door to the cave is a fly-in opening for bats. Surface path to the cave entrance with instruction panels was modified and completed in August 2016. The length of the accessible part of the cave is 217 m, however, since the entire route is passed two times, back and forth, the length of the sightseeing route is 434 m and has 240 steps. The duration of the tour is about 50 minutes and the number of visitors per entrance is limited to a maximum of 15 persons, the price of an adult ticket is 8 euros. The route leads from Vstupná chodba (Entrance Hall) through Zuberecká chodba (Zuberecka Passage), Brodňanského riečisko (Brodňanského River Basin), Jazierková sieň (Lake Hall), Bivaková sieň (Bivouac Hall) and Kopečného chodba (Kopečného Passage) to Sieň potápačov (Divers' Hall), from where visitors return (Fig. 2). The cave was solemnly opened on August 31, 2016, with the participation of the Minister of the Environment. Since the cave is not electrically illuminated, every visitor must wear a helmet and headlamp provided by the operator - State Nature Conservancy of the Slovak Republic, Slovak Caves Administration

Physico-geographical conditions

The space of the cave itself, through which ponor allochthonous waters flow, is created in light gray Ramsau dolomites with irregularly spaced inserts of darker Gutenstein type of limestones. There are also dark gray Reifling limestones with irregular chert positions. Paleogenic rocks consisting of dolomite and limestone-dolomite breccias and conglomerates rise in the highest part of the cave on the ceiling (Vlček and Psočka, 2008). Cave passages are developed on significant tectonic disturbances; therefore they have mostly straight course. Their breaks originated at the crossing of structural defects. The largest cave spaces were formed along the east-west faults direction. The Brestovská Cave is a flow fluviokarst cave, which is part of the underground hydrological system between the Brestovská vyvieračka (Brestovská Spring) and the ponors of the allochthonous waters of Studený Brook and its tributaries from the side valleys. The underground spaces of the Brestovská Cave are known mainly in the spring and middle flow part of the hydrological system. The length of the Old cave (as we called it), which from the entrance includes freely accessible underground spaces to the tributary siphon overflowed with speleodivers, is about 445 m. This siphon is followed by extensive, non-flooded parts of the cave divided by three shorter sumps but bypassing the non-flooded corridors. The cave ends by the 5th

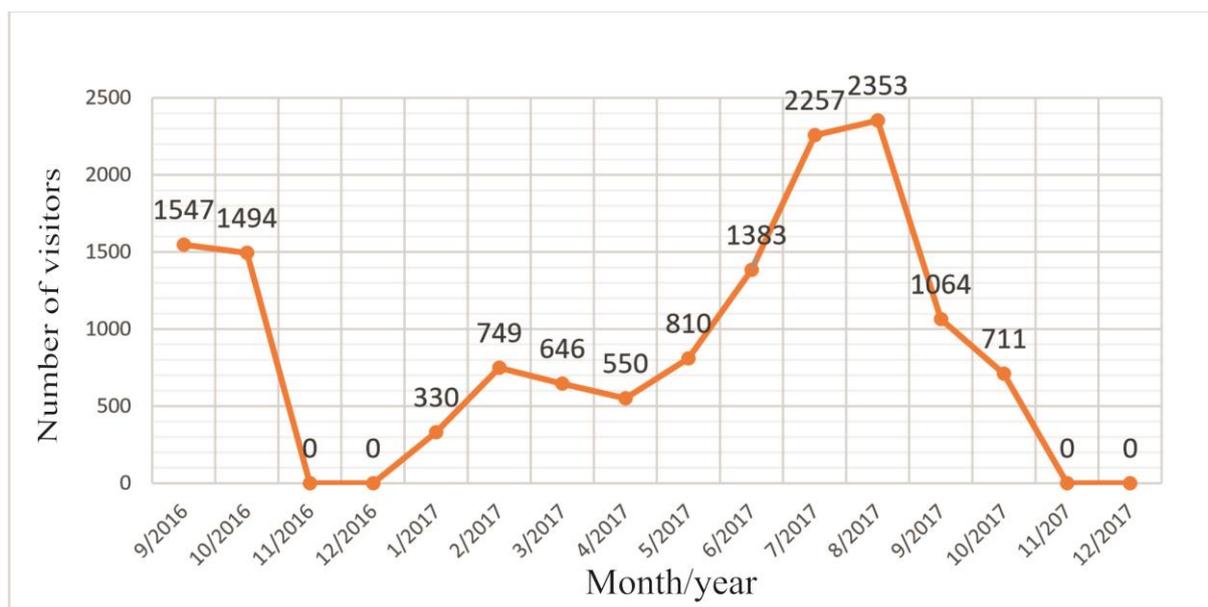
tributary siphon, which was not overflowed yet. In terms of vertical division in the cave are distinguished two floors. The lower floor is a corridor with an active underground watercourse (Brodňanského River Basin, Lake Hall, lower part of the Zuberecká Passage), upper floor is a section of higher-lying inactive corridors with a more or less uneven longitudinal profile (Kopečného Passage, Zuberecká Passage), which formed about 5 to 10 m above the current river bed on the lower floor (Bella, 2008). There are relatively few classical sinter decorations in the cave. The formation of richer dripstone decoration is limited by a thin rock overburden with a small proportion of chemically pure limestones. Therefore, the water leaking into the cave from the precipitation contains a relatively small amount of dissolved calcium carbonate. Part of the sinter decoration was damaged or broken by vandals in the past. Brestovská Cave is considered from a hydrological point of view as a very important site. It is dominated by a continuous underground stream running through the lower floor. The complete course of the underground river is not yet known. Nevertheless, its length in the focused part of the cave along with water siphon reaches almost 600 m. According to current knowledge, the stream is supplied by several sources. The main ones are surface waters flowing in the cave basin. In the karst-nonkarst contact zone, they disappear into the underground in ponors. Groundwater allochthonous waters of shallow circulation of own hydrogeological structure are also involved in the creation of the underground hydrological system in the cave. The largest surface stream in the vicinity of the cave is Studený Brook, which originates in the crystalline rocks of the northern slopes of Roháče. Tracing tests at the site proved the communication of the surface water of the Studený Brook with the groundwater stream in the cave (Haviarová and Pristaš, 2013). The cave's underground stream regime is strongly influenced by external climatic and hydrological conditions. According to its monitoring, the lowest flow rates are related to winter months (January, February, March). The highest flow rates are associated with the snow melting period (April, May), although the short-term increase also occurs during the year after intensive or possibly longer rainfall. The average flow rate in the cave ranges from 100 to 150 l/s, it can increase relatively quickly to several times its original volume. The accompanying phenomenon of the increase in the flow rate is the rise of the water level on the main river, which in some places of the cave can reach 2 meters at the time of extremes. Such situations were recorded in the cave, for example in July 2008, July 2010, September 2010 and May 2014. One of the reasons for the rise in the level of the underground stream is the existence of several siphons along its route. The cave is known for the presence of 7 speleological diving explored and documented siphons in a total length of 220 m (Haviarová, 2008). Brestovská Cave lies in a cold climate area with a July temperature of 12 to 16°C. The average annual rainfall ranges from 1000 to 1200 mm. The average annual air temperature in the Entrance Hall is 6°C. The only aperture to exchange air between the surface and the cave climate are the vents for bats at the cave entrance. The influence of the external climate is manifested only in this part of the cave. The coldest part of the cave is the space along the active underground watercourse. The average air temperature in the Divers' Hall, with an underground river, is 5.8°C. The water temperature in the riverbed was around 5.1°C. The course of air temperature in the monitored parts of the cave has an uneven character. The minimum readings are in the Entrance Hall and Lake Hall in May, and in the Divers' Hall in April. The highest temperatures are measured at all three sites in September. Maximum surface temperatures are in July, the shift of maximum values in the monitored parts of the cave by two months is probably caused by a delayed response of underground spaces to surface temperature changes. Based on the analysis of the terrestrial biocoenosis of the Brestovská Cave, it is possible to find the presence of representatives of terrestrial arthropods - trogliphilic isopods *Mesoniscus graniger* and *Ischyropsalis manicata*, which are Carpathian endemites. They are characteristic indicators of wet and cooler habitat types. This is one of the northernmost habitats of this species in Europe, and probably the terrestrial cavernicolian isopods (*Isopoda*) at all. Both species are limited by their occurrence to the entrance part of the cave (Entrance Hall). This area near the surface with the presence of water and organic material is characterized by a relatively varied representation of surface fauna. These are mostly: *Tetrodontophora bielensis*, *Acrogalumna longipluma*, *Nebria rufescens* and a lot of millipedes, gastropods, spiders, earthworms. The brown frog (*Rana temporaria*), was observed several times in the watercourse. Higher dry areas of the cave (Lake Hall, Bivouac Hall and Kopečného Passage with adjoining corridors) are inhabited by little diversified communities of fauna composed almost entirely of *Diptera*, *Collembola* and *Acarina*. The most famous and numerous representatives of the cave fauna are bats. Brestovská Cave is one of the most varied underground shelters of bats in the Tatras. So far, 9 species of bats have been identified in the cave and in the immediate vicinity of its entrance. However, only *Myotis myotis* hibernates regularly and in larger numbers. *Myotis mystacinus* and *Myotis brandtii* hibernate irregularly, occasionally also *Rhinolophus hipposideros*, *Eptesicus nilssonii*, *Eptesicus serotinus*, *Barbastella barbastellus* or thermophilic Mediterranean species - *Rhinolophus ferrumequinum*. Brestovská Cave is in general one of the northernmost known hibernation areas of *Rhinolophus ferrumequinum* in Slovakia and Europe *Myotis nattereri* was detected in the autumn. The period of winter sleep (hibernation) in case of bats usually lasts from late October to mid-April (Kováč et al., 2008).

Cave attendance

Brestovská Cave was opened for speleotourism from 1.9.2016. In 2017 it was visited by 10853 visitors. The total number of visitors in 2018 was 10726 and in 2019 it was 10 269. It has a slight decreasing tendency. For comparison, the total attendance of all caves operated by the Slovak Caves Administration was 633,158 persons in 2017, so the share of Brestovská Cave in the total amount is only 1,67 % and is the last in the ranking. In 2017, Belianska Cave takes the first place (128 437), the second is Demänovská Cave of Liberty (119 908). On weekdays and outside the summer months, 4 entrances to the Brestovská Cave take place daily. The maximum capacity of visitors per entry is 15 persons, entries are made at a 90-minute interval starting at 9:30 and last entry at 14:00. During the top season, from the beginning of May, there are 6 entries per day. Intervals: 09:00, 10:15, 11:30, 13:00, 14:15 and 15:30. There are even 10 entries per day during the Easter holidays. However, the maximum number of people per entry does not change, so the maximum is still 15 persons. Children under 6 years of age cannot enter the cave. It is also interesting that the cave is closed every Monday. The main onslaught of visitors was apparent from September 2016 to December 2017 in the summer season in July and August 2017. The minimum number of tourists visited the cave in January 2017. In November and December 2016 and 2017 the cave was closed to the public. The increased number of visitors in February 2017 compared to January 2017 was probably due to the more favorable snow conditions at the nearby ski resort in February, and thus to a higher concentration of visitors in nearby accommodation facilities and their interest in the cave (Table 1, Graph 1). The most numerous nationalities among the visitors of the cave are the Slovaks, who make up 86.76%. Behind them are Czechs (6.78%) and Poles (5.51%). Visitors from other countries such as England, Germany, Russia or other countries do not reach 1% together and their share in the total cave attendance is minimal, even negligible (Table 2).

Month/Year	9/2016	10/2016	11/2016	12/2016	1/2017	2/2017	3/2017	4/2017
Number of visitors	1547	1494	0	0	330	749	646	550
Month/Year	5/2017	6/2017	7/2017	8/2017	9/2017	10/2017	11/2017	12/2017
Number of visitors	810	1383	2257	2353	1064	711	0	0

Table 1 Cave attendance from 9/2016 to 12/2017



Graph 1 Cave attendance from 9/2016 to 12/2017

Country	Total number	in %
Slovakia	9416	86,76
Czechia	736	6,78
Poland	598	5,51
Great Britain	42	0,39
Germany	26	0,24
Russia	18	0,17
Other	17	0,16
Total sum	10853	100

Table 2 Cave attendance by the nationality in 2017

Northwest part of the cave with a guided tour

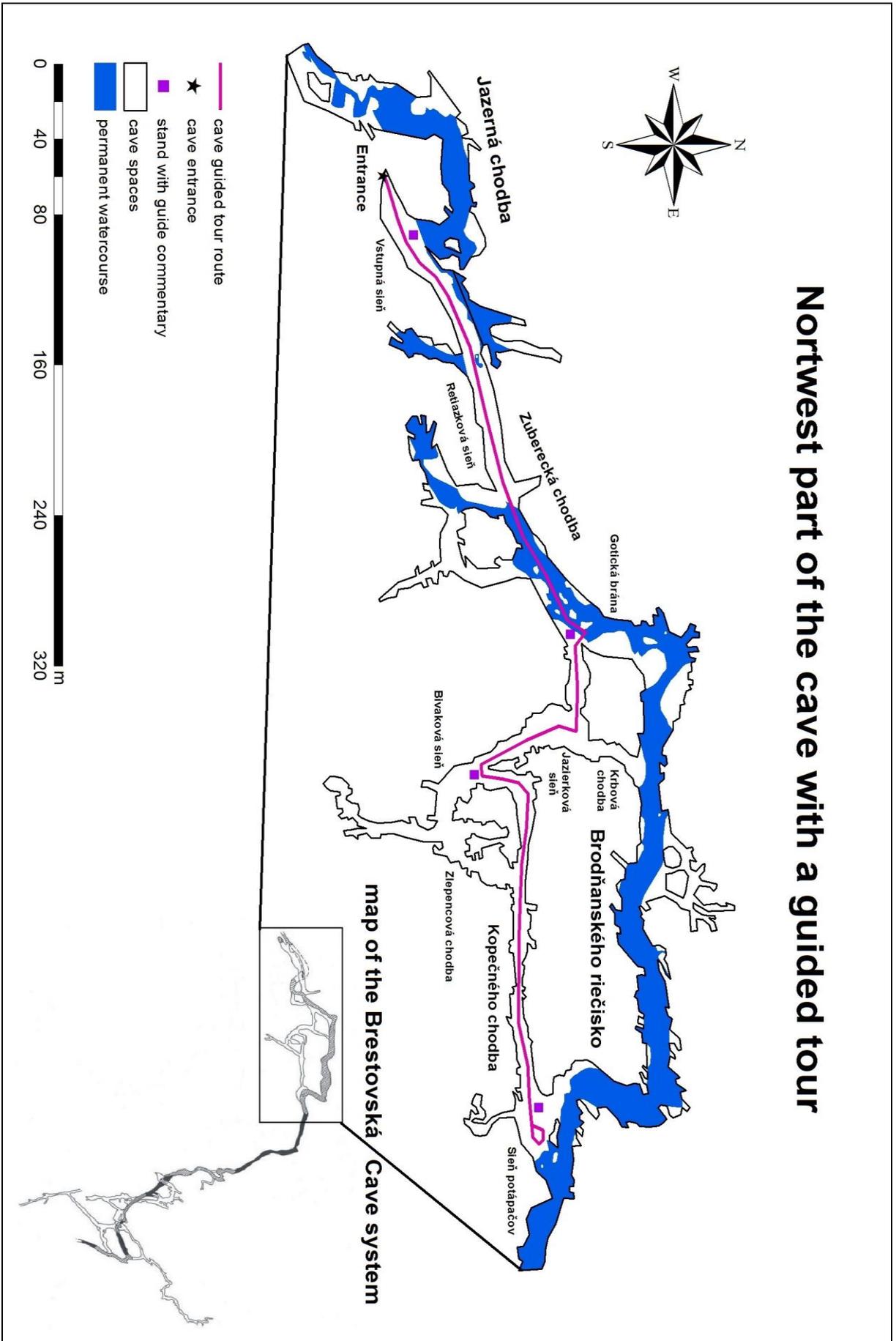


Fig. 2 Map of the Brestovská Cave



Fig. 3 Entrance to the Brestovská Cave



Fig. 4 Steel footpath over the underground river

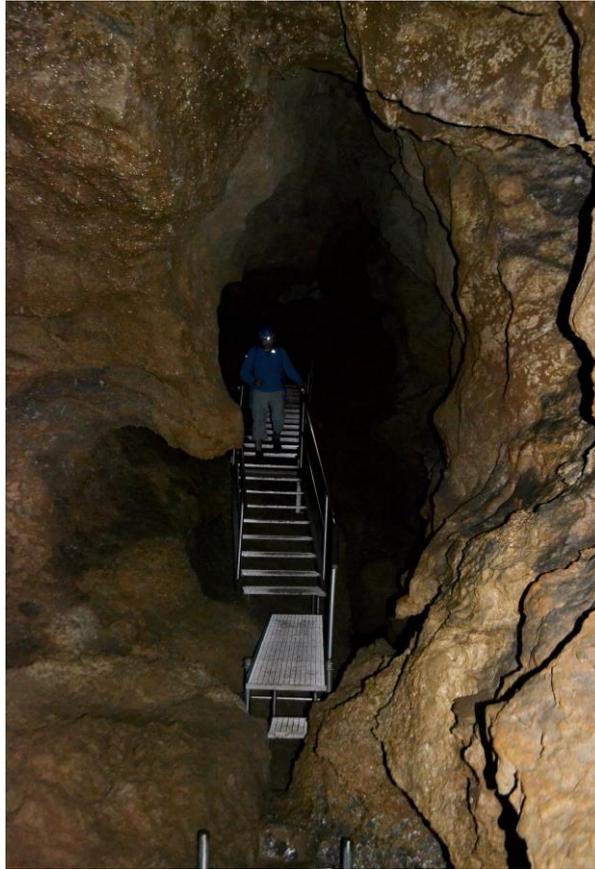


Fig. 5 Ladders and staicases in the cave



Fig. 6 Visitors in the cave



Fig. 7 Explanation in the cave

Conclusion

Brestovská Cave represents the most famous cave phenomenon of Orava Region and West Tatra Mountains, which is from 1.9.2016 open to the public as another geotourism object in the region. Alongside the neighboring Museum of Orava Village, the frequently visited Roháčska Valley and the nearby ski area, expands the offer of tourism in this area. The first reflections on making the cave accessible to the public date back to the 19th century, and the idea was realized after 129 years. Although the cave is not majestically decorated, it is nevertheless an invaluable jewel of the nature of Orava Region. Alongside the Belianska Cave and the freely accessible caves, Brestovská Cave allows visitors to see the diverse underground world of the Tatras in a legal way. The route with a minimum of artificial belay devices reduces the anthropogenic impact on the fragile cave geosystem and allows visitors to experience an adrenaline experience underground, different from the classical accessible caves. The journey along the underground watercourse allows receptive visitors to listen to the murmur of raging water and in 'dry' corridors, concentrate on the sound of the impact of leaking drops. Cave air, in turn, has a beneficial effect on people with upper respiratory diseases. We only hope that the cave will become a stable and frequently visited place for speleotourism in this part of the Tatra Mountains and will become known not only to the people in Slovakia but also to foreign tourists.

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