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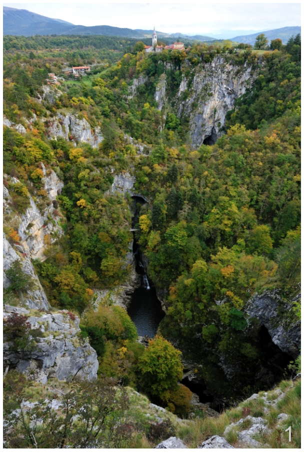
SUSTAINABLE MANAGEMENT OF SHOW CAVES

ABSTRACTS & GUIDE BOOK



Škocjan/Postojna, 2019

SUSTAINABLE MANAGEMENT OF SHOW CAVES

Škocjan Caves, 7-9 October 2019

ABSTRACTS & GUIDE BOOK

Škocjan/Postojna
2019

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Cover photos:
1) Velika and Mala Dolina collapse dolines with village of Škocjan;
2) first sinking point of the Reka River in Škocjan Caves – Mahorčičeva jama (Mahorčič's Cave);
3) first passage used for tourism in Škocjan Caves – Tominčeva jama (Tominc's Cave);
4) underground gorge of the Reka River in Škocjan Caves – Šumeča jama (Water-murmuring Cave);
5) relict passage of Škocjan Caves – Tiha jama (Silent Cave);
6) the Reka River in Martelova dvorana (Martel's Chamber) (all photos: Borut Lozej, PŠJ)

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Mario Parise: Management and scientific research in show caves: some considerations, based upon experience in southern Italy (invited lecture)

Martina Stupar, Mina Dobravc, Ljudmila Strahovnik: Tourist caves in Slovenia in terms of their nature conservation

Franci Malečkar: Forms of sustainable management of the Dimnice Cave

Coffee Break

Stipe Tutiš, Petra Kovač Konrad, Dalibor Jirkal: Project "Center of excellence - Cerovac caves; sustainable management of natural heritage and karst underground"

Neven Bočić, Nenad Buzjak: Geospeleological inventory and evaluation of caves characteristics in purpose of their protection and touristic valorization - example of Cerovačke caves (Croatia)

Nenad Buzjak, Neven Bočić: Preparation of Cerovačke caves (Croatia) for sustainable tourism – microclimate and carrying capacity aspects

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Janez Mulec, Samo Šturm: Remediation activities in response to microbial indicators of tourist impact in caves

Rosana Cerkvenik: Impacts of Visitors on Cave's Physical Environment

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Dalibor Jirkal, Petra Kovač Konrad, Stipe Tutiš: Activities and techniques for future sustainable management of Cerovac caves

Silvio Legović: Baredine Caves

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	Workshop on cave restoration
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14.00-18.30	**Field trip A (Škocjan Caves-Tiha & Šumeča jama)**
19.00-	**Dinner**

Wednesday, 9 October 2019

9.30-12.30	**Field trip B (Vilenica Cave)**
12.30-14.00	**Lunch**
14.00-18.00	**Field trip C (Škocjan Caves-Hankejev kanal)**

GENERAL INFORMATION

Oral presentations

- Presentations should be prepared either as **Power Point** (.ppt or .pptx) or **Adobe Acrobat** (.pdf) presentations and given to the organizers **during the break before the Session starts**. Duration of ordinary lecture with discussion is limited to **25 min**; invited lecturers are limited to **45 min**.

Posters

- Poster size: suggested max. format is 70 cm x 100 cm (portrait layout).
- Each author(s) can prepare a **5 minute presentation (1–3 slides)** in Power Point or Adobe Acrobat where the essence of their poster is presented or use printed version for oral presentation. Short presentations will be followed by discussion.
- **Leave the posters and short poster presentations (.ppt, .pdf) at the registration desk during registration**.

Field trips

- **Register for each the field trips** at the registration desk.
- Transport from congress venue to the Vilenica Cave (field trip B, Tuesday) will be organized (by car).
- For field trips A (Škocjan Caves-Šumeča jama & Tiha jama) and B (Vilenica Cave), **walking shoes and warm layered field clothes** are obligatory. **Headlamps** are recommended.
- For field trip C (Škocjan Caves-Hankejev kanal), **special equipment** is needed that can be provided for several people by organizers. However, use of your personal equipment is suggested since you are the most familiar with. Special equipment includes:
    - **boots, field cloth (cave suit is suggested), helmet with head lamp;**
    - **caving or climbing harness, double cowstail with carabiners.**
- **Participation on the field trips is voluntary and at your own risk.** The organisers do not accept any liability for any loss, damage, injury or death arising from or connected with the excursions. Participants are advised to arrange an appropriate insurance policy. The participants are obliged to to comply with the instructions of the organisers.

Workshop on cave restoration

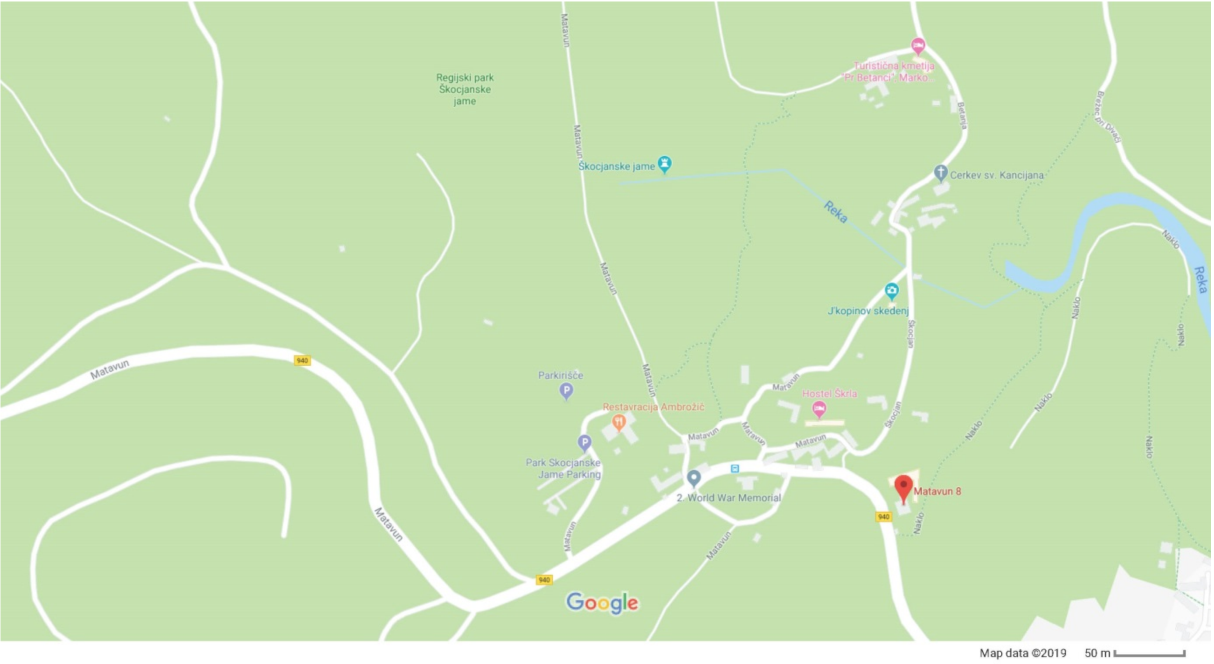
- In Wednesday, cave restoration section will start with **invited lecture**, followed by **workshop** and finished by **field trip** in touristic part of the Škocjan Caves (Tiha jama and Šumeča jama). For the workshop, you are kindly asked to prepare **2 min presentation** (Power Point, Adobe Acrobat or sequence of digital photos) presenting at least one of the following issues:
    - **physical/visual damage** that is observed in a cave(s) you are familiar with (speleothems, cave wall/roof, floor structures) and can be resolved by restoration;
    - **examples of (un)successful cave restoration** in a cave(s) you are familiar with;
    - **personal opinions of cave restoration** (needs, legislation, expenses);
    - **constraints of cave restoration**.
- Presentation given by invited lecturers and your presentation will be a basis for cca. **1 h discussion** afterwards. Ideas might also be used for possible project application.

Lunch & Dinner

- Lunches are organized during all days of the conference. Dinners are organized on Monday and Tuesday.

VENUE

Oral and poster presentations as well as the workshop on cave restoration will take place at the Promotion-congress centre “Pr Nanetovh” (Matavun 8, SI-6215 Divača). This place is also a starting point for all the excursions. Lunches and diners will be organized at the info centre (Restavracija Ambrožič).



Map of the venue with marked position of the Promotion-congress centre “Pr Nanetovh” (Matavun 8).

The Promotion-congress centre “Pr Nanetovh” (photo: Borut Lozej, Škocjan Caves Public Service Agency).

FIELD TRIPS

Afternoon field trip (A)

ŠKOCJAN CAVES (ŠUMEČA JAMA & TIHA JAMA)

Tuesday, 8 October 2019, 14:00–18:30

Highlights:

- *Cave restoration;*
- *Sustainability of show cave management & cave conservation;*
- *Bad and good practices of cave tourism;*
- *Monitoring of cave climate (temperature, relative humidity, ventilation, CO_2) and lampenflora.*

Škocjan Caves are system of several passages separated by up to 163-meters-deep Velika (Big) and Mala (Small) dolina collapse dolines. Important parts of the cave system are named as individual caves, like Mahorčičeva jama, Czoernigova jama, Mariničeva jama, Tominčeva jama, Šumeča jama, and Tiha jama (Fig. 1). Total length of the system is 5,981 m. The main stream passage with open flow between Ponor (Sink) and Jezero mrtvih (Lake of the dead) along Reka River drops from 317 m a.s.l. to 214 m a.s.l. The caves have been developed mostly in Upper Cretaceous massive limestones dipping generally for 20-30° to SW; only southernmost part of Tiha jama is located in thin-bedded Paleocene limestones. Speleogenesis is highly controlled by Reka River discharge (between 0.2 to 453 m^3/s; recurrence interval of 100 years; Mihevc, 2001) and fluvial sediment transport (30,000 m^3/a; annual average; Kranjc 1986). The typical discharge of the River Reka is 8.12 m^3/s (Slovenian Environment Agency). Extensive backflooding of up to a documented 132 m (Mihevc, 2001) is possible when the discharge exceeds 105-120 m^3/s. The Reka River that sinks into the Škocjan Caves reappears in Timavo Springs about 35 km NW of Škocjan Caves. Terrestrial laser scanning of the whole cave and collapse dolines in 2018 showed that the Martelova dvorana (Martel's Chamber) has volume of 2.55 Mm^3, which is the 2nd biggest natural underground chamber in Europe and 11th in the world.

The Škocjan Caves, especially Tominčeva jama (Tominc's Cave; Fig. 1), have been visited from Paleolithic times onwards and due to the impressive sink of the Reka River they were well-known in Antiquity. However, intensive and documented cave exploration following underground Reka River started in the first part of the 19th century. In 1819, Mahorčičeva jama and Tominčeva jama were opened for tourism (Puc, 1998). In the second part of the 19th century, exploration of the Škocjans Caves and path construction were done mostly by cavers of DÖAV (Deutscher und Österreichischer Alpenverein; Littoral section of Austrian Alpine Club) and locals. After discovery of Tiha jama in 1904, construction of an artificial tunnel from the collapse doline Globočak followed in 1933 and the nearly present-day tourist route was established. The cave was electrified in 1959 (Puc, 1998). According to Mihevc (2004), 7,650 m of cave pathways have been built for touristic purposes in Škocjan Caves;

with renovation of the old pathways over the last decade, especially between the first Reka River sink and the Velika dolina, about 3,500 m of pathways is used nowadays. In the last decade, number of visitors is increasing; in 2017, the Škocjan Caves were visited by 178,000, in 2018 nearly 190.000.

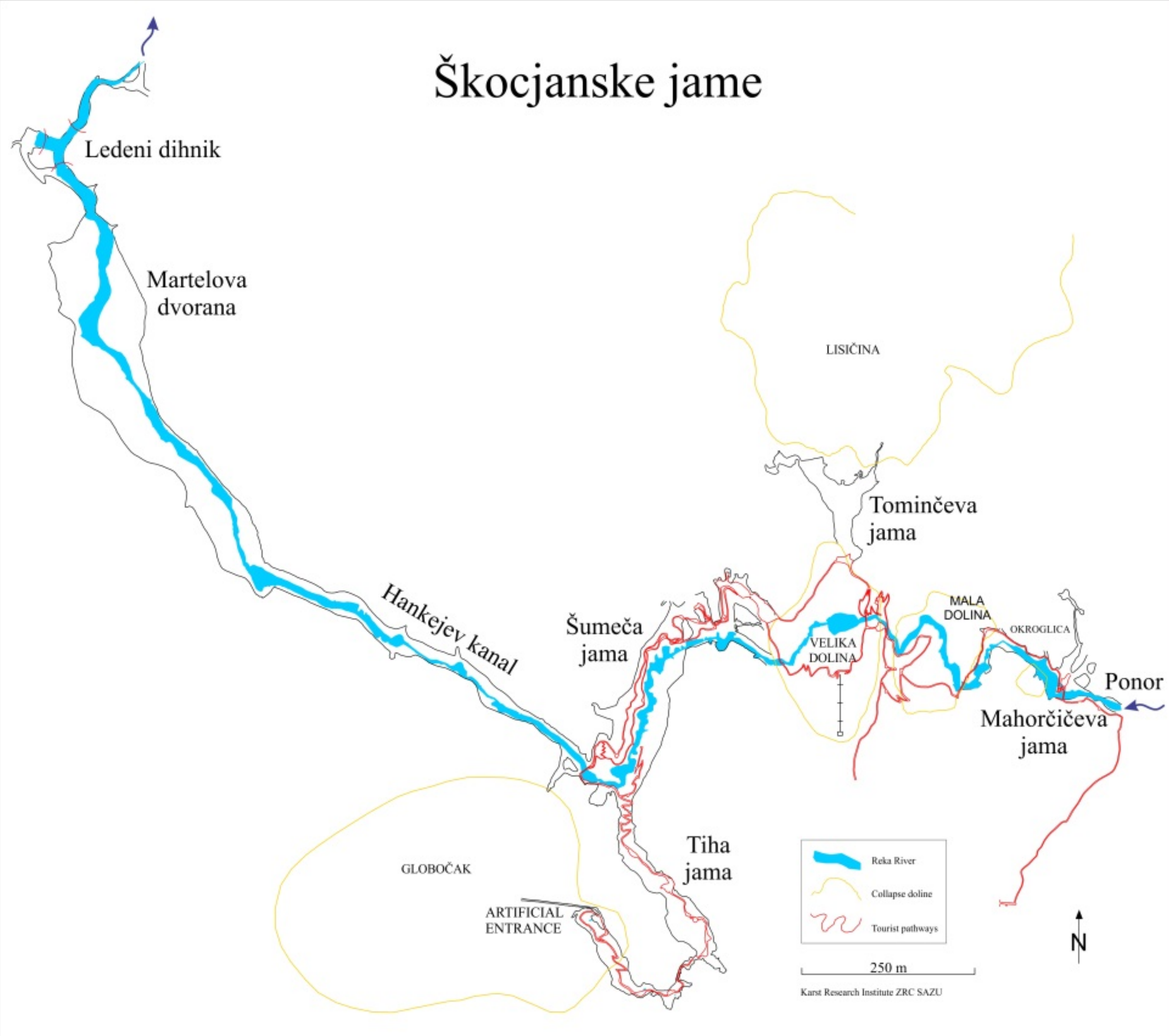


Fig. 1: Plan of Škocjan Caves.

The caves were inscribed to UNESCO Word Heritage list in 1986. To preserve and manage natural as well as important cultural heritage, Škocjan Caves Regional Park and public institution (Škocjan Caves Public Service Agency) were established by special law from 1996 (The Škocjan Caves Regional Park Act). Regional park comprises area of 413 ha and extends over the natural and cultivated area or Reka River sinking points (caves, collapse dolines, gorge, levelled karst surface, villages, traditional land use patterns) with much bigger buffer zone covering catchment area of the Reka River). Škocjan Caves Regional Park Buffer zone comprises 450 km^2 of the surface – mostly Reka River catchment area.

Science-oriented research has been focused on archaeology (Mesolithic, Bronze Age, Iron Age), hydrology (Reka River flooding and water quality, chemistry of percolation water), geology (tectonics, sedimentology), geomorphology (speleogenesis, active processes), cave climate (ventilation, temperature, relative humidity, CO_2, radon), biology (dolines as ecological refugiums, bats, troglobionts), and microbiology (air quality, transfer of microbial contamination, microbial activity in fluvial sediments) with evaluation of touristic impacts (lampenflora, cave climate, sustainability evaluation, monitoring plan). In the last years, a research is focused on hydrology of Reka River, cave climate, present-day speleogenesis, and evaluation of touristic use on cave environment (lampenflora, CO_2). General characteristics of cave climate, which we are going to present during field trip, were studied by Kranjc and Opara (2002) as well as V. Debevec (unpublished) focusing on humidity, CO_2, wind flow and radon concentration and daughter products, continued in the 2000s and 2010s and have been recently upgraded within the research project *Karst research for sustainable use of Škocjan Caves as world heritage site* performed by the Karst Research Institute ZRC SAZU, MEIS Environmental Consulting d.o.o. and Škocjan Caves Public Service Agency.

References:

- Kranjc A., 1986. Transport rečnih sedimentov skozi kraško podzemlje [Underground fluvial sediments transport as an example from Škocjanske jame (Kras, Slovenia)]. Acta Carsologica, 14-15: 109-116.
- Kranjc A., Opara B., 2002. Temperature monitoring in Škocjanske jame caves. Acta Carsologica, 31/1: 85-96.
- Mihevc A., 2001. Speleogeneza Divaškega krasa [The Speleogenesis of the Divača Karst]. Založba ZRC, Ljubljana: 180 pp.
- Mihevc A., 2004. Development of the tourist pathways in Škocjanske jame. In: Zupan Hajna, N. (ed.), Use of modern technologies in the development of caves for tourism. Postojna: Postojnska jama, turizem: 117-120.
- Puc M., 1998. Pomembnejši datumi v raziskovanju in turistični ureditvi Škocjanskih jam [Significant dates in the exploration and tourist arrangement of Škocjanske jame]. Naše jame, 40: 75-80.

Morning field trip (B)

VILENICA CAVE

Wednesday, 9 October 2019, 9:30–12:30

Highlights:

- *Long-term show cave management in changing social, political, and economic situation;*
- *Sustainability of show cave management & cave conservation;*
- *Bad and good practices of cave tourism.*

Vilenica Cave is 841 m long (Fig. 2) and 190 m deep cave (Fig. 3) located at Classical Karst between the settlements of Sežana and Lokev. Entrance to the cave is at an altitude of 418 m a.s.l. The cave has been formed in the upper Cretaceous limestone of Lipica formation (bedded and massive limestone with biostromes and bioherms; Jurkovšek et al., 1996) and is nowadays hydrologically relict passage above usual fluctuation of regional water table. Due to great age and high difference between pCO_2 concentration in soils above and in the cave, the cave is very extraordinary rich in speleothem formations; the most frequent ones are stalactites, palm-tree and stick shaped stalagmites, rimstone/calcite gours, and helictites. Share of cave floor covered by loamy sediment increases downwards and fills continuation of the passage at the bottom (Fabrisov rov discovered in 1963). About 250 m western of Vilenica Cave, 557-meters-long and highly decorated and vulnerable cave Gustinčičeva jama (Gustinčič's Cave) was discovered in 1999/2000 and soon after discovery strictly closed for visiting – as for other six caves strictly closed for visiting in Slovenia, entering the cave is possible mainly for research purposes only with permission given by Slovene Ministry of the Environment and Spatial Planning. The Vilenica Cave was scientifically studied mostly from aspects of geomorphology and geology (genesis, tectonics, cave sediment datation).

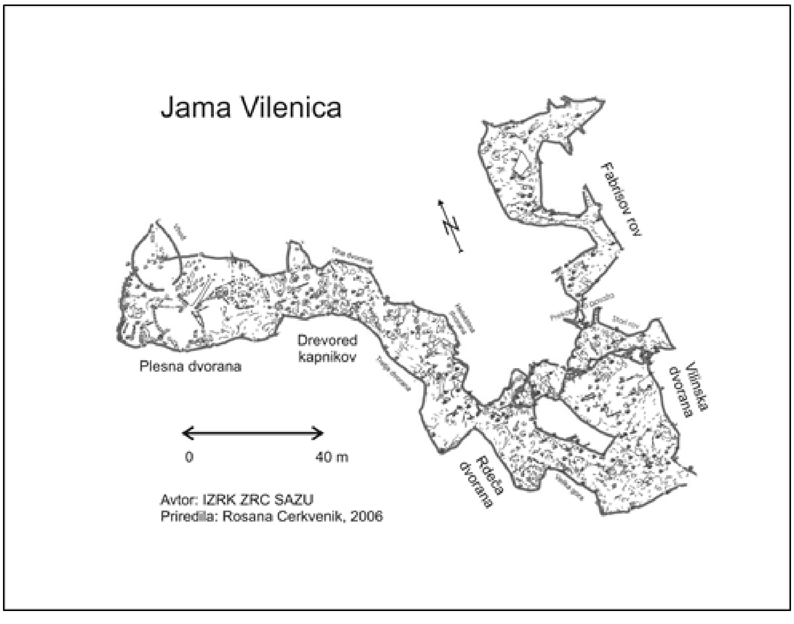


Fig. 2: Plan of the Vilenica Cave as a result of theodolite survey in 1985-86.

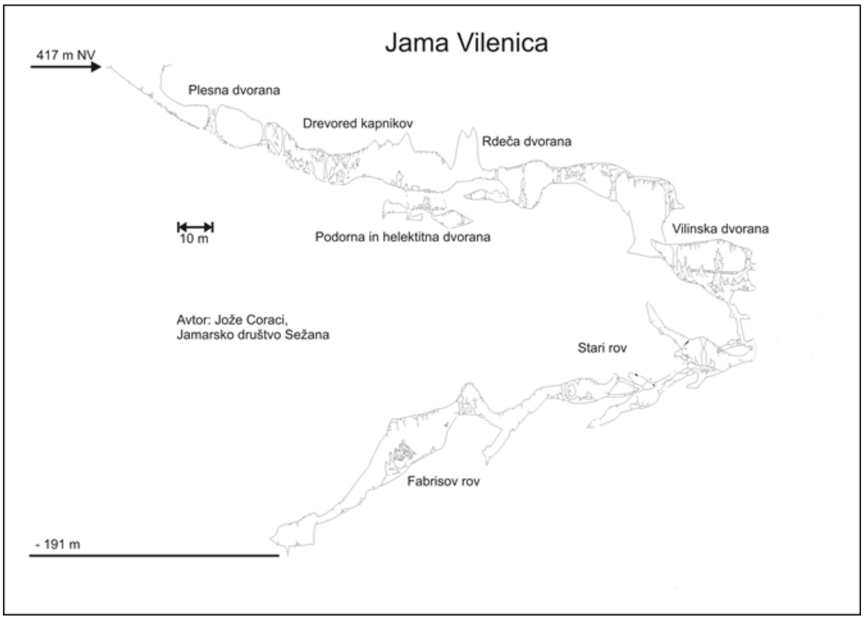


Fig. 3: Extended profile of the Vilenica Cave from 2000.

Vilenica Cave is considered to be the oldest show cave in the world and as such interesting from the historical aspect of show cave management. It was visited already in the Neolithic (pottery, charcoal, ash; Cerkvenik *et al.*, 2008) and used as a shelter for locals during incursions of the Ottoman Army in the late 15th to middle 16th century and later during Venetian wars. There is a pool of percolating water in the cave, 200 m from the entrance into the cave that served as a water source. In 1633, first paid entrance fee was recorded; income from visiting was shared between the Church of the nearby village Lokev and the land owner, count Petač/Pettazi. The Vilenica Cave was very famous at that time since it was only 2 km to the main road between Trieste and Vienna, close to the port of Trieste/Trst and in a vicinity of the Lipica stud farm. At the beginning of the 19th century, when the Vilenica Cave came under the Municipality of Lokev, an organized guiding service began. In 1836, the Municipality of Lokev did not manage the Vilenica Cave any more but visits were possible by contacting the inn Muha in Lokev. In that time (the period between 1821 and 1889), the Vilenica Cave was visited by more than 2,000 visitors (Grom, 1963). In the middle of the 19th century, when a railway Vienna-Trieste bypassed the Vilenica Cave and other caves in the vicinity were discovered (Postojna Cave, Škocjan Caves, and Divača Cave), an interest to visit Vilenica Cave decreased (Puc, 2000). The management of the Vilenica Cave became a burden for the owner, parish from Lokev, and so in 1886 they rented the cave to SAG for a "modest" rental fee. They did not allow large number of visitors into the cave, but they cared for the cave and the footpaths. The society was managing with the cave until 1943 (Puc, 2000). After World War II, the cave was most probably managed in the same way as Škocjan Caves; it means that it was nationalised and managed by the institution *Kraške jame* from Postojna. In 1951, the manager of the cave became the Municipality of Sežana with its institution *Zavod Škocjanske jame*. In 1963, this institution was attached to *Zavod Postojnska jama*. After World War II, the cave had a formal management, but in reality there it was not the case. In 1965, the institution *Zavod Postojnska jama* passed the management of the cave to the Sežana Caving Society (JDS). Sežana Caving Society gated the cave in 1962 to prevent additional stealing of dripstones, repaired the stairs that were destroyed, cleaned the whole path through the cave, and put the hand rails on the most dangerous parts. The re-opening of the cave was in 1963 (Grom, 1963). In following decades, there was a lot of work done on renovation (stairs, path, illumination, hand rails). Electric illumination was established in 1970s and later improved and separated into sectors; before, the Vilenica Cave was illuminated by torches and other lights that blacken speleothems. There have been more than 170,000 visitors in the period 1991-2010.

Since 1986, the chamber Plesna dvorana has been used once a year at the occasion of International Vilenica Literature Prize.

References:

- Cerkvenik R., Kariž N., Jakofčič J., Rijavec J., Terčon J., 2008. Jamarsko društvo Sežana 1955 – 2007. Sežana, Jamarsko društvo Sežana: 130 pp.
- Grom S., 1963. Vilenica pri Lokvi. Ob njeni ponovni otvoritvi 19. maja 1963 [Die Höhle Vilenica bei Lokev]. Naše jame, 5: 49-52.
- Puc M., 2000. Vilenica – zgodovina in opis kraške jame. Kulturni center Srečka Kosovela, Sežana: 119 pp

Afternoon field trip (C)

ŠKOCJAN CAVES (HANKEJEV KANAL)

Wednesday, 9 October 2019, 14:00–18:00

Highlights:

- *History of Škocjan Caves exploration & establishment of exploration/visiting infrastructure;*
- *Renovation and adaptation of cultural heritage for touristic purposes;*
- *MEM measurements of active speleothem growth (calcite prepicitation).*

Hankejev kanal (Hanke's Channel; Fig. 1) is about 800 m long part of Škocjan Caves between Müllerjeva dvorana (Müller's Chamber) located upstream in Šumeča jama and Martelova dvorana (Martel's Chamber) located downstream. It is a typical keyhole passage; upper part of the passage is formed as a phreatic tube elongated along tectonized bedding plane that was later incised downwards in vadose conditions into gorge (Mihevc, 2001). Regarding to present-day rate of processes (Prelovšek, in press), about 75-meters-high passage was mostly carved by Reka River fluvial sediments. Lower part of the Hankejev kanal can be as narrow as 10 m. Walls with absent lateral extension (e.g. notches) are nearly vertical. Age of the Hankejev kanal is unknown; regarding to present-day abrasion and attrition rates, several millions of years of incision is expected. At some places, extensive calcite precipitation (3 mm/a; Mihevc, 1996) can be observed as a result of hard water and intensive ventilation; such speleothemes are up to about 50 ka old (Mihevc, 2001).

First exploration it the Hankejev kanal (1886-1890) followed underground water course and was challenged by several up to 4-meters-high waterfalls. Exploration equipment was poor as well as illumination. Explorations were possible only during low discharge (few weeks per year) and constantly threatened by floods; therefore an access/security path with narrow wooden traverses was gradually built already during exploration and more or less finished in slightly more than two years (Müller, 1998; Mihevc, 1989). Such path was used for safety during water rise, for transport of research equipment during low-middle discharge, and was as such crucial for continuation of exploration. It was used by experienced visitors already in 1891 (Shaw, 2010). Between World War I and II, path maintenance stopped and walking became dangerous and life-threatening. Path recognized as an important part of Škocjan Caves' cultural heritage was threatened too.

Interest for exploration in Hankejev kanal highly increased in 1980s, when trial of resurveying with some renovation works started (Mihevc, 1995). In 1991/92, security cable was installed along the caved path to enable safer transport of diving equipment to a terminal sump (Sancin, 1992). With following episodes of renovation, when employees from Berchtesgaden National Park (Germany) were participating too from 2003 and 2007, renovation of about 400-600 m of the path (Fig. 4 and 5) from the beginning of Hankejev kanal to Swidovo razgledišče (Swida's Viewpoint) was finished in 2019 and the old path prepared to be included into tourist offer of the Škocjan Caves. The path downstream of Swidovo razgledišče has not been renovated; access to the terminal sump (Jezero mrtvih) requires Reka River discharge below 2 m^3/s and use of a boat. During the renovation, special attention was given to preserve cultural heritage; fences were restored in old-fashion appearance and at Swidovo razgledišče, where the fence was adequately preserved, left in its original state. The path is periodically flooded by Reka River; last time on 3rd February 2019 when discharge of Reka River was slightly more than 300 m^3/s, but damage caused mainly by floating debris can be repaired easily. Several memorial plaques can be seen along the path in Hankejev kanal and further downstream indicating names of the chambers or dedicated to the most meritorious 19th-century explorers of Škocjan Caves.

Fig. 4 and 5. Renovation of the old path in Hankejev kanal (photo: PŠJ).

References:

- Mihevc A., 1995. Nove meritve Martelove dvorane v Škocjanskih jamah [New Surveys in the Martel Hall, Škocjanske Jame]. Naše jame, 37: 39-44.
- Mihevc A., 1996. Some preliminary results of of micrometric measurements in Škocjanske caves, Slovenia. Kras I speleologia, 8/7: 66-71.
- Mihevc A., 1989. Ostanki orodij prvih raziskovalcev Škocjanskih jam in Kačne jame [The remains of gears of the first explorers of Skocjanske jame and Kačna jama]. Naše jame, 31: 27-33.
- Müller F., 1998. Raziskovanja v Škocjanskih jamah leta 1890 med 18. in 25. podzemnim slapom [Explorations in Škocjanske jame in 1890 between the 18th and 25th underground waterfalls]. Naše jame, 40: 38-57.
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- Shaw T., 2010. Aspects of the History of Slovene Karst 1545-2008. Založba ZRC, Ljubljana: 306 pp.

ABSTRACTS[2]

[2] *Arranged by first author's family name. - abstract of oral presentation; - abstract of poster*

Geospeleological inventory and evaluation of caves characteristics in purpose of their protection and touristic valorization - example of Cerovačke caves (Croatia)

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Cerovačke caves are situated on the northern slope of the southeastern part of the Velebit Mountain (the part called Crnopac) in Croatia. There are three caves: Lower (4058 m long), Middle (360 m long) and Upper Cerovačka Cave (3835 m long). Lower and Upper caves has a long tradition of cave tourism. They became show caves in 1951 with 700 m footpath in each cave. From then, few (good or worse) phases of management and renovation occurs. Today, both caves have old infrastructure, but also obsolete interpretations. A new start project aims to renovation of entire tourism infrastructure and modernization of site visiting program with an emphasis on high-quality interpretation, sustainable management and nature protection. To achieve these three requirement we provided research devoted to geospeleological inventory and evaluation of caves characteristics. Inventory was provided during extensive field work including geospeleological mapping on cave map 1:500. We mapped and evaluated following elements: rocks (good visible examples), structural elements, speleomorphology (mezo-scale), speleothems, speleogens, cave sediments, water bodies and anthropogenic elements. With this data, we also have included data on biospeleological, paleontological and archeological evaluation and based on it, we made zoning of both caves. We detected 10 zones of interest in Lower and 9 zones of interest in Upper Cave. For each zone we made evaluating chart with following elements: name of zone, location in the cave, main characteristics, special values, advantages and disadvantages and recommendations and suggestions. Finally, we conclude that during tourism valorisation in the Lower Cave emphasis should be placed on education, and in the Upper Cave on the ambience and aesthetic experience.

Keywords: geospeleology, caves, geotourism, cave protection, Croatia

Preparation of Cerovačke caves (Croatia) for sustainable tourism – microclimate and carrying capacity aspects

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During the implementation of the project for the tourist arrangement of Cerovačke caves in 2016, microclimatic research and assessment of the carrying capacity were carried out. During the microclimate study, long-term air temperature and relative humidity measurements were performed at the locations in the caves and at one location on the surface. The Onset HoboPro V2 data loggers were used for the measurements. In addition, short-term measurements of airflow and CO_2 concentrations by anemometer PCE-007 and Kestrel and the CO_2 meter Telaire T7000 were performed. The carrying capacity is determined based on the measured data, the data about the length and area of the pathways in the caves and based on the number of visitors. For the purpose of quality visits and interpretation, protection of the cave environment and meeting the safety requirements, guidelines and recommendations for determing of carrying capacity have been developed.

Keywords: microclimate, carrying capacity, visitors, cave

Impacts of Visitors on Cave's Physical Environment

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Studies of impacts on caves usually cover the topics of water pollution, microclimate, lampenflora and cave biota. On the other hand, there is a much more important influence on the morphology of the cave directly from visitors, such as footprints, soiled and broken formations, graffiti. They accumulate in caves and reduce their scientific and aesthetic values.

The caves of the Classical Karst have been in use since Prehistoric times and the use of the caves varied. They were used as shelters, hiding places or in cult manner; as places for deposition (weapons, explosive, as refuse dumps and waste water) and for exploitation of natural sources (karst springs, ice). The most known use since the 17th century has been for tourism and speleology. Due to speleological explorations, development of karstology as a science and the development of tourism, the region and its phenomena have become world known. But long and intense use of caves, particularly in the last two centuries, have caused significant impacts also on caves' physical environment.

The impacts of visitors were studied in 22 caves of the Classical Karst in Slovenia and in two caves of the Classical Karst in Italy (Carso Triestino). The caves were divided into show caves, well-known caves, less-known caves and easily accessible caves.

The most significant impacts are off-trail footprints – trodden fine sediments, destroyed gours and cave pearls; graffiti and broken formations. In show caves, infrastructure causes the most significant and visible impacts, followed by the impacts of cave maintenance (off-trail footprints, broken formations, etc.). Infrastructure for mass visits of caves must comply with regulations on the safety of visitors, but these regulations often require interventions in caves that cause harm on their inventory.

Keywords: Classical Karst, impacts on caves, cave use, cave physical environment

Cave Administration of the Czech Republic

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The Cave Administration cares for the show caves in the Czech Republic; it arranges steps according to the nature protection demands and ensures the technical protection after the state Mining Authority rules. It also cares for exploration, monitoring, documentation and guide services for the public. The Cave Administration also participates in given activities in other caves and underground spaces and geological localities of the Czech Republic. It provides the statewide evidence and documentation of caves and other speleological objects. Currently the Cave Administration cares for 14 show caves and one mining locality containing cave spaces. It guarantees their protection according to the maintenance plan. In terms of the revitalization program the Cave Administration eliminates negative impacts of previous activities and exploitation of caves as well as renovates their real estate and technical furnishing. External tourist premises are being restored and educational exhibitions are being prepared at them, informative and scientific publications are published.

Keywords: show caves, management, protection, Czech Republic

Cave climate of show caves: examples from Postojna Cave and Škocjan Caves

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Cave climate is influenced by natural factors, such as the state and changes in the outside atmosphere, the water fluxes in a cave, the shape of a cave and the spatial distribution of entrances. These combined may result in a very complex and diverse cave meteorology. Show caves are subjected to additional disturbances, caused by construction and use of tourist infrastructure, such as opening new or widening existing passages, closing passages, use of trains, power lines, and by the presence of the tourists alone. The question arises if we can distinguish these causes from the natural, to what level are they acceptable, and are they (i)reversible. In the presentation some of these questions will be discussed based on the long-term observations in Postojna Cave and Škocjan Caves.

Keywords: cave climate, show caves, long-term monitoring, Postojna Cave, Škocjan Cave

Cave Conservation and Restoration: Current Best Practices

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During this overview of science-based, current best practices in cave conservation and restoration, participants will explore the philosophies and methods of mitigating anthro-pogenic impacts in caves. Starting from techniques described in the peer-reviewed chapters of our 600-page book titled *Cave Conservation and Restoration*, we will con-duct classroom discussions and in-cave activities to identify, analyze, and mitigate neg-ative cave impacts. In the cave, participants will remove fill, rubble, mud, lint, and debris remaining from infrastructure development and tourism. Teams will restore natural cave surfaces, sediments, and speleothems. We will discuss methods for assessing and re-moving contemporary graffiti while identifying and protecting cultural and historic mark-ings; introduce techniques and tools for repairing broken speleothems using archival, cave-safe materials and epoxies (including stalactites, draperies, rimstone dams, and large formations); emphasize practices to prevent cross-contamination; and encourage minimum-impact caving ethics. The foremost concern should be the perpetuation of healthy spelean ecosystems. Through opportunities for in-depth analysis, application of decisions, and fine-tuning of skills, participants will focus on decisions regarding cave conservation, always guided by the principle: *First do no harm — Primum non nocere.*

Keywords: cave restoration, cave conservation, cave management, speleothem repair, formation repair, impacts, cave-safe

Activities and techniques for future sustainable management of Cerovac caves

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Cerovac caves have been since 1998 given to private concessions. This resulted in poor management which devastated the infrastructure and cave inventory. For future sustainable management of Cerovac caves with help of EU funds new and high-quality infrastructure is being build and comprehensive monitoring of cave environment will be provided. Signalization will be build in the paths, also the drainage system as well as electricity and communication system. In this way construction inside the cave is minimized. Based on the monitoring results the optimum capacity of touristic visits in the cave will be determinated.

Keywords: infrastructure, monitoring, optimum capacity, paths

Baredine Cave

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First part of the poster shows the Baredine Cave as a tourist offer, presenting (i) short history of exploration and protection, (ii) short history and development of cave as a tourist attraction, (iii) description and highlights of the visit, (iv) basic info on about management mode, number of employees, and number of visitors, and (v) presentation of additional offer surrounding the cave. Second part of the poster includes information, examples and photos about already implemented and future implementations of sustainable management of Baredine Cave:

- Environmental component: Construction of independent solar power plant to provide total demand of electricity power needs during working hours, implementation of new energy saving lighting system, system of ventilation and tracking of CO_2 emission in the cave;
- Social component: employment of local population, partnership with local community in regards of organization of local and tourist manifestation, regular staff education, regular exhibitions about importance of caves and water of the underground;

- Economic component: importance of regular investment in maintenance of existing infrastructure, importance of development of an additional offer beside the cave visit and providing a complete tourist product.

Keywords: Baredine Cave, offer presentation, sustainable management, implementation

Forms of sustainable management of the Dimnice Cave

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Next year, the Cave Society from Koper marks the 55th anniversary of the care for the Dimnice cave. It is located along the road Trieste - Rijeka in the SW part of Slovenia. On the upper floor of the galleries, a kilometer long tourist route has been arranged since 1914. In the spiral reaches the bottom of a 40-meter deep pit with a ballroom. It descends to the remains of the only water catchment of the underground river in Europe. It is an exceptional open air museum presenting the contact of the karst surface with underground, speleobotanics, cave climate, spelogenetic phenomena, human coexistence with nature, technical heritage and phenomena for the book of record.

All this enables the implementation of various forms of approaching and getting to know the underground, which go beyond the centuries-old practice of passive listening to visitors to guides. Interactive learning and experiencing the environment with all the senses with final reflection are adapted to all age groups The Center for the curricular and extracurricular Activities, Ljubljana has been carrying out two decades of activities for school groups in several programs. With the help of the work sheets, they follow and record the plants, they learn about the cave as a living environment, measure temperatures, recognize speleogenetic phenomena. In the program "Water through the karst" they descend from the ponor in the blind valley to the source of the Rižana River in order to get to know the problem of karst aquifers. Gifted children are allowed to list the condition of the bats colony. The results indicate that the cave management is appropriate.

The cavers are involved in the implementation of programs for teams building, which also aim to get to participate in the discovery of the galleries. As the only one in Slovenia is organised a caving run for five years now. Concerts, literary meetings and regardings of Saint Nicholas are prepared in the dance hall.

Despite the fact that in Dimnice the first implementation of caving run was among the Slovenian caves, all types of visits are carried out with manual or headlamp flashlights along the paths. Enable the independence of the participants. On steep sections, carpets are installed that prevent slips.

Keywords: Dimnice Cave, Center for the curricular and extracurricular Activities, Ljubljana, interactive learning, teams building, caving run, caving run

Remediation activities in response to microbial indicators of tourist impact in caves

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Caves that are equipped for and accessed by large groups of tourists are potentially subject to significant changes of their pristine environmental and biological parameters. Suitable monitoring systems based upon the simultaneous use of physico-chemical and microbiological parameters can provide data to help identify issues and to advise the implementation of protective measures. The combination of artificial lighting and its widespread accompaniment of lampenflora is one of the key issues to be addressed by cave management. Simultaneous use of three approaches is the only viable way to restrict lampenflora growth: avoidance of the use of lamps with emission spectra that support photosynthesis, restrictions on how many hours the lighting system is used, and regular removal of biomass, e.g. by use of buffered hydrogen peroxide solution. Regular spectrophotometric monitoring of the affected surfaces and of the associated microbial load assists in defining sensitive sectors within caves, and helps to prevent excessive biomass blooms in the future. Tourists disperse organic material and microorganisms on the soles of their feet. Deployment of a disinfectant barrier at the cave entrance, used in combination with regular and thorough cleaning of tourist footpaths, can help to keep the human-derived microbiota at a relatively low level. This has particular importance in minimizing its contact with the cave microbiota in order to prevent horizontal gene transfer, e.g. antibiotic-resistance genes. Changes in airborne microbiota also provide a quantitative measure of human impact. To a degree cave conditions do support initial preservation and subsequent culturability of components of the human-derived microbiome, e.g. staphylococci in settled aerosol particles. The impact of tourists on cave ecosystems is not negligible, and in some particularly sensitive locations restriction of visitor numbers, whether temporary, seasonal or permanent, should be considered. Based upon the individual peculiarities and perceived vulnerabilities of specific tourist caves, cave zonation should be considered and implemented as an integral part of a sustainable cave management plan.

Keywords: cave management, conservation, monitoring, lampenflora, aerobiology

Importance of the speleological digital inventory of karst features at Škocjan Caves

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The Škocjan Caves are exceptional in terms of dimensions, both for Slovenia and Europe. Already when applying to be listed as the UNESCO World Heritage, and later in the adoption of the Škocjan Caves Act and the establishment of the Škocjan Caves Park, the knowledge of the entire cave system has proven to be relatively modest. The cave map that was made at the time of the first surveys was later only extended by new explorations. The latter cave map significantly improved in time with new survey techniques, but carried on also some errors and inaccuracies from the first measurements. Until 2018, the survey of the cave system counted a surface of 11.6 ha and a volume of 5.2 million m^3. New 3D scanning surveys performed between 2018 and 2019 will precisely adjust the previous surveys.

The scientific and cultural importance of the Škocjan Caves and their karst features needs to be reflected in an authentic approach both for touristic promotion, for research and conservation studies. Here we present an attempt for a speleological digital inventory of the karst features at the Škocjan Caves intended to map and describe all those phenomena the cave system that have a certain visual, scientific or historical value or significance. The digital inventory will also help to evaluate the changes occurred on individual karst phenomena since their first inventories until now, by summarizing the natural and anthropogenic impact on the caves. Inventory can therefore be understood as a live collection document in which can be added, modified, as well as taken away from individual items, and presented in a shape of e-tool with interactive map and rich information on the current status of karst features and their changes over time.

Keywords: inventory, karst, GIS mapping, dynamic map, e-tool

Management and scientific research in show caves: some considerations, based upon experience in southern Italy

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Show caves are all over the world the main way to introduce high number of people to the karst world. Since opening the very first show caves, cavers, managers and scientists had to face the problems in finding a compromise between touristic development and local economy and environment conservation. It is now accepted that each show cave is, for some reasons, not natural anymore, being changed the main physical parameters that characterized it before opening to the public. Nevertheless, co-existence of a proper management with cave science and research is possible. This goal should be reached through joint efforts from both the parts (managers vs. scientists), and could potentially result in sites more interesting to visit, based upon scientifically sound but easy-to-comprehend explanations by trained cave guides. Based upon Italian experience, and with a particular regard to southern Italian show caves, this contribution will try to highlight the main difficulties in managing show caves and developing scientific research actions, aimed at both preserving the natural environment as much as possible, and obtaining useful information and data to tell nice stories about karst and caves to the general public, with a peculiar focus on young generations.

Keywords: show caves, visitor capacity, scientific research, management, sampling, ethic

The challenges of sustainable management of a show cave Petnička Pećina (Petnica Cave)

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Petnica cave (Western Serbia) was a couple of times arranged for tourist visits but it has never had official tourist traffic. It was arranged for the second time in the late 1980s, but was devastated immediately afterwards. Because of this, some authors distinguish it as a inactive tourist cave. However, this speleological site has visitors on a daily basis.

A recent attempt to develop a methodology for evaluating Serbia's speleological geoheritage has resulted in guidelines for the future sustainable development of the Petnica Cave. The results of the research indicate that Petnica Cave has an educational, scientific, sports and tourism function. Therefore, the originally planned tourism function should not be at the forefront of its future use. The future sustainable development of the Petnica Cave is influenced by the facts that it is the only cave in the Valjevo Karst arranged for tourism purposes and that it is located near the Petnica Science Center and PIO Gradac.

The restoration of this devastated speleological site should follow the positive practices applied in the sustainable managed show caves. The planning of new activities must respect the results of the research and emphasize the functions of the cave that most important for it - educational and scientific.

Keywords: Petnica Cave, show cave restoration, sustainable management, Speleological geoheritage of Serbia

Impact of visiting on cave air CO_2 concentraction in Škocjan Caves

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Carbon dioxide (CO_2) is considered as a gas highly influencing during speleogenesis. It's relatively high solubility in water influences intensive CO_2 flux between air and water, as well as rock, especially in atmosphere, soil, vadose, and epiphreatic zone. Different concentrations in karst underground (400-42,000 ppm in case of karst of Škocjan Caves) are guiding two main karst processes; downstream increase of cave air CO_2 results in

carbonate dissolution while downstream decrease leads to calcite precipitation resulting in (massive) speleothem formations. Cave air CO_2 concentration primary depends on natural sources and sinks; especially in show caves, CO_2 concentration might be severely influenced by breathing and ventilation-enhanced modifications of passages or entrances. While calcite speleothems plays one of the most important roles in show cave's attraction, substantial cave air CO_2 increase due to breathing and resulting reduced growth of calcite speleothems might act as a long-term negative feedback loop for cave tourism. Enhanced ventilation has positive effect on CO_2 decrease but introduces other problems (freezing in winter and condensation in summer).

In Škocjan Caves, CO_2 concentrations were extensively measured and evaluated spatially in cave air, in percolation water as well as in Reka River. To observe temporal behavior and impact of visiting, CO_2 monitoring site was established in Tiha jama passage. CO_2 fluxes from percolation water into the cave atmosphere were measured at two important and accessible places (Tiha jama-Goba and Ponvice) and compared with human release of CO_2 during exhalation. Short monitoring at two separated locations within weakly ventilated passage (Tiha jama) was done to observe CO_2 increase due to natural and anthropogenic sources. Research is funded by *Karst Research* (P6-0119) programme and *Karst Research for Sustainable Use of Škocjan Caves as World Heritage* (L7-8268) research project.

Keywords: cave climate, carbon dioxide, CO_2, Škocjanske jame

Tourist caves in Slovenia in terms of their nature conservation

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Slovenia is a homeland of pioneering karstological research and also the first initiatives for the protection of caves that date back to 1908. It is also one of the few countries that regulates the protection of caves with a special law. The Cave Conservation Act, adopted in 2004 on the basis of the Nature Conservation Act 1999, constitutes a systematic basis for their protection. Thus, all registered caves in Slovenia longer than 10 m have the status of a natural value of national importance, defined protection regimes and nature protection guidelines. Many caves in Slovenia also have the status of a natural monument. The current number of caves with the status is 12,338 of which only 22 are tourist caves. In addition to exploring, visiting is the most common use of caves, so the managing of tourist caves is also regulated by the law. Tourist cave management is mostly carried out by local caving or tourist associations. Exceptions are the Postojna and Predjama cave systems and the Škocjan Caves located in the Regional Park. In the last decade, visitor trends show a rapid increase in the number of visitors, which consequently influences the caves inventory. In the largest tourist caves, monitoring of cave climate, cave fauna, monitoring of the lampenflora, the quality of running waters and some other influences are carried out. The results of the monitoring are the basis for the preparation of measures and guidelines in order to reduce the negative consequences of tourism use. The Institute of the Republic of Slovenia for Nature Conservation carries out many tasks in the field of cave protection, such as preparation of nature conservation guidelines and consulting to managers. Based on some concrete examples, the activities of the nature conservation service will be presented, and the experience and the problems of managing Slovenian tourist caves will be highlighted.

Keywords: caves, nature conservation, tourism

Karst research as basis for sustainable management of Škocjan Caves

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Škocjan Caves visitor numbers are increasing every year. The Caves that have been listed as UNESCO's World Heritage Site since 1986 need a balance between protection of natural worth and increasing tourism. This can only be provided by good knowledge of the natural characteristics of the cave provided by karst research studies and by specifying the permissible level of anthropogenic impact. In 2017 Slovenian Research Agency and Park Škocjanske Jame financially supported a project *Karst research for sustainable use of Škocjan Caves as world heritage* (L7-8268) performed by ZRC SAZU and MEIS d.o.o. The project includes studies of karst geology, geomorphology, lampenflora, microbiota, cave fauna, cave meteorology, hydrology of Reka River and percolating water. Guidelines for the sustainable use of the Škocjan Caves will be proposed as summary of the project. Among many project achievements we need to mention at least two. First is a new geological map 1:5,000 of the surface above the Škocjan Caves where cross-sections showed an interesting geology, regarding Velika and Mala Dolina, where older limestone is visible in the geological map as two karst erosional windows. The second achievement is continuative monitoring of air temperature and CO_2 at Goba site in Tiha Jama since 19 December 2017 and maintenance of additional temperature sites (Tunel, Šumeča Jama, Tominčeva Jama). Meteorological monitoring at hourly intervals showed that Goba expresses the lowest temperature in Tiha Jama and variable conduct of CO_2 that depends on opening/closing of the entrance doors. Possible causes are also water percolation and unknown passages in the vicinity. Goba indicates a specific meteorology within Tiha Jama. Pearson correlation coefficient (PCC) shows that daily air temperatures at Tunel and Goba sites have strong covariance (0.81 and 0.74) with number of visitors. Strong covariance between Šumeča Jama and outside temperatures (PCC = 0.81) and between Šumeča and Tominčeva Jama (PCC = 0.94) supports the idea that Šumeča and Tominčeva Jama do not demonstrate anthropogenic impact on air temperature.

Keywords: karst research, geology, cave meteorology, sustainable management, Škocjan Caves

Project "Center of excellence - Cerovac caves; sustainable management of natural heritage and karst underground"

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In April 2018 the EU project "Center of excellence - Cerovac caves; sustainable management of natural heritage and karst underground" (Competitiveness and Cohesion operational programme 2014-2020) started. The main goal of the project is to improve sustainable use of natural heritage, primarily in Nature park Velebit with focus on Cerovac caves (Upper and Lower Cerovac caves). Cerovac caves are situated in Lika region, County of Gračac, one of the most undeveloped parts of Croatia. It is the first project in Croatia where a such funds are available for restoration of a show-caves and multidisciplinary cave research. Cerovac caves were open for public in 1951, but since 1998 were poorly managed what resulted in devastation of caves inventor, infrastructure and surrounding landcape. Now with new techniques in construction and monitoring the project tries to provide the best solutions for sustainable tourism. In this activities one of the most important tasks is to gather experience from other show caves and create a strong network with them.

Keywords: Cerovac caves, Lika region, EU project