

KARST RESEARCH INSTITUTE ZRC SAZU



## 23<sup>rd</sup> INTERNATIONAL KARSTOLOGICAL SCHOOL "CLASSICAL KARST"

### Caves – Exploration and Studies

combined with the

50<sup>th</sup> Anniversary of the International Union of Speleology – UIS

Celebration is under the honorary patronage of his  
Excellency Mr. Borut Pahor, the President of the Republic of Slovenia



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**PROGRAM & EXCURSIONS & UIS & ABSTRACTS**

Postojna, 2015

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Škocjanske jame.

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## PREFACE

The International Karstological School “Classical Karst” has been conducted annually since 1993. Different aspects of karst studies are presented each year. The basic objectives are to present the state-of-the-art in the selected topic, and encourage discussions related to the school’s topic through lectures, poster presentations and field trips in the Classical Karst of Slovenia.

23<sup>rd</sup> Karstological School will be devoted to the exploration and scientific study of caves. Caves play an important role in human history. They were used as shelters and dwellings by early people; they were places of anxiety, mystery, religion, fear, curiosity, adventure, and also knowledge. People have explored caves for thousands of years, but the first systematic exploration and realistic descriptions are from the 17<sup>th</sup> Century. In the 19<sup>th</sup> Century, when many of the natural sciences were forming, cave exploration by individuals and caving societies laid the foundations of speleology as we understand it today—where cave exploration, mapping and science work hand-in-hand for new, better, understanding of caves.

Last day of the School, Friday June 19, will be dedicated to the 50<sup>th</sup> Anniversary of International Union of Speleology – UIS. UIS was established during the 4<sup>th</sup> International Congress of Speleology, which was held in Ljubljana and Postojna in 1965. The UIS was officially founded during the Closing Ceremony of the Congress on September 16<sup>th</sup> in Ljubljana.

# PROGRAM

Conference place: Cultural Center of Postojna, Gregorčičev drevored 2, Postojna, 15.-19.6.2015

## MONDAY, 15. 6. 2015

7.30-13.00 **Registration of participants** (Cultural center of Postojna)

### OPENING SESSION (Cultural center of Postojna)

8.45-9.00 **Opening**

9.00-9.45 **Keynote lecture**

### SESSION 1: CAVE SCIENCE (Cultural center of Postojna)

9.45-10.45 **Invited lectures**

10.45-11.15 **Coffee break**

11.15-12.15 **Invited lectures**

12.15-13.00 **Lectures**

13.00-15.00 **Lunch break**

### SESSION 2: CAVE SCIENCE (Cultural center of Postojna)

15.00-16.30 **Lectures**

16.30-17.00 **Coffee break**

### POSTER SESSION (Cultural center of Postojna)

17.00-18.00 **Poster presentations** (2 minutes/poster)

Caves – exploration and studies; other topics on speleology and karstology

18.00-19.00 **Karst mysteries** (Cultural center of Postojna)

20.30 **Welcome Reception at the Karst Research Institute ZRC SAZU**

(Titov trg 2, Postojna)

## TUESDAY, 16. 6. 2015

7.30-13.00 **Registration of participants** (Cultural center of Postojna)

### SESSION 3: OPEN EXPLORATION FRONTIERS; BIG CAVE SYSTEMS

(Cultural center of Postojna)

9.00-9.40 **Keynote lecture**

9.40-10.40 **Invited lectures**

10.40-11.15 **Coffee break**

11.15-12.15 **Invited lectures**

12.15-13.00 **Lectures**

13.00-14.30 **Lunch break**

14.30-21.00 **Excursion 1: Part of underground river Ljubljanica: Planinska jama,**

**Rakov Škocjan, Cerkniško polje** (Bus station of Postojna)

(bus & walk; light and walking shoes are needed)

**WEDNESDAY, 17. 6. 2015**

8.30-13.00 **Registration of participants** (Cultural center of Postojna)

**SESSION 4: HISTORY OF CAVE EXPLORATION IN CENTRAL EUROPE – »ALCADI«**

(Cultural center of Postojna)

- 9.00-9.40 **Keynote lecture**
- 9.40-10.30 **Invited lectures**
- 10.30-11.00 *Coffee break*
- 11.00-11.20 **Invited lecture**
- 11.20-12.55 **Lectures**
- 13.00-14.30 *Lunch break*
- 14.30-21.00 **Excursion 2: Tourist cave Vilenica** (Bus station of Postojna)  
(bus & walk; walking shoes are recommended)

**THURSDAY, 18. 6. 2015**

- 8.30-21.00 **Excursion 3: "Classical Karst" caves: Škocjanske jame , Velika jama v Brščikih (Grotta Gigante) and Timavo springs** (Bus station of Postojna)  
(bus & walk; tourist caves, walking shoes are recommended; packed lunch is provided)
- 18.00-20.00 **Registration of participants** (Karst Research Institute, Titov trg 2, Postojna)

**FRIDAY, 19. 6. 2015**

- 8.00-10.00 **Registration of participants** (Cultural center of Postojna)
- 8.15-11.00 **Excursion 4: Cave Postojnska jama & Expo Postojnska jama**  
(show cave tourist visit and visit of new exhibition; start at the cave entrance; you will get tickets from the School organizers; train starts at 8.30h)
- 9.00-12.00 **Workshop on Dinaric Karst & UNESCO** leaded by Paul Williams  
(Cultural center of Postojna)
- 12.30-17.00 **Registration of participants** (Cultural center of Postojna)

**SESSION 5: INTERNATIONAL UNION OF SPELEOLOGY** (Cultural center of Postojna)

- 13.00-13.15 **UIS President Welcome Speech**
- 13.15-14.40 **Keynote lectures**
- 14.40-14.55 **UIS book presentation**
- 14.55-15.20 *Coffee break & book signature*
- 15.20-16.00 **Keynote lecture**
- 16.00-16.40 **Invited lectures**
- 16.40-17.40 **Lectures**
- 18.30-19.30 **Registration of participants** (at the entrance to Postojnska jama)
- 19.30 **Photo of participants** (on the stairs in front of the entrance to Postojnska jama)
- 19.45 **Train to the cave**
- 20.00-21.00 **50<sup>th</sup> UIS Anniversary:** celebration in the cave Postojnska jama
- 21.30-1.00 **UIS Banquet** in front of the cave Postojnska jama

**SATURDAY, 20. 6. 2015**

9.30        Optional: free visits to non-tourist caves with cavers of JZS (Speleological Association of Slovenia): information available at registration desk

9.00-13.00    **UIS Bureau meeting**

14.30-20.00    **UIS Bureau meeting**

**SUNDAY, 21. 6. 2015**

9.00-13.00    **UIS Bureau meeting**

**Invitation to a Special session: Unresolved mysteries in Karst**

(Scheduled Monday, 15.6.2015)

This year's school will be as always a great opportunity as a meeting point between experienced and new researchers from different parts of the globe.

The last years, a Special Session on Mysteries in Karst science was held, and it was quite successful, in that some answers could be found, and others are actively investigated at the moment.

Usually talks in schools and congresses deal with progress of ongoing research and with their results. This session, however, has the aim to present the still-unresolved problems and to promote and stimulate research! In opposition to many other scientific branches, karstologists most often try to collaborate in order to resolve problems. This session should therefore promote further the world-wide collaboration.

Because there are no results, talks usually are short, but because questions are formulated, discussion should be longer. Therefore, talks are limited to about 5 minutes, while discussions may last 10-15 minutes.

You are all invited to contribute to the session. Please send a brief problem outline and description to [praezis@speleo.ch](mailto:praezis@speleo.ch).

With best regards,  
Philipp Häuselmann

# INFORMATION

**NOTICE: No School materials and admission to excursions, reception, celebration, or banquet will be available without your official registration BADGE!**

## Excursions:

**Everyone must register at the registration desk.**

Only registered people will be allowed to attend the excursions!

**Participation at the excursions is at your own risk!**

Buses depart from Bus station Postojna (see Map of Postojna).

Light and walking shoes and field clothes are necessary if written.

Use of insect repellents is highly recommended because of ticks (possible infection with Lyme boreliosis and tick-borne encephalitis).

## Lunch:

Lunches are not organized (with exception on whole-day excursion – Excursion 3).

## Lectures:

PowerPoint presentations should be given to organizers at the break before Session starts.

## Posters:

**Leave the posters at the registration desk (necessarily before the Lunch break!).**

Max. format of poster: 70 cm x 100 cm (width x height) **PORTRET layout**.

Please be available during the poster session and stand by your poster during the session.

## MAP OF POSTOJNA



- 1 Karst Research Institute ZRC SAZU, Titov trg 2, Postojna – Reception at the Institute
- 2 Cultural Center of Postojna, Gregorčičev drevored 2, Postojna  
– Registration & Scientific program (Lectures & Posters)
- 3 Cave Postojnska jama – UIS 50th Anniversary celebration & Banquet & Tourist visit
- 4 Postojna bus station (excursions)

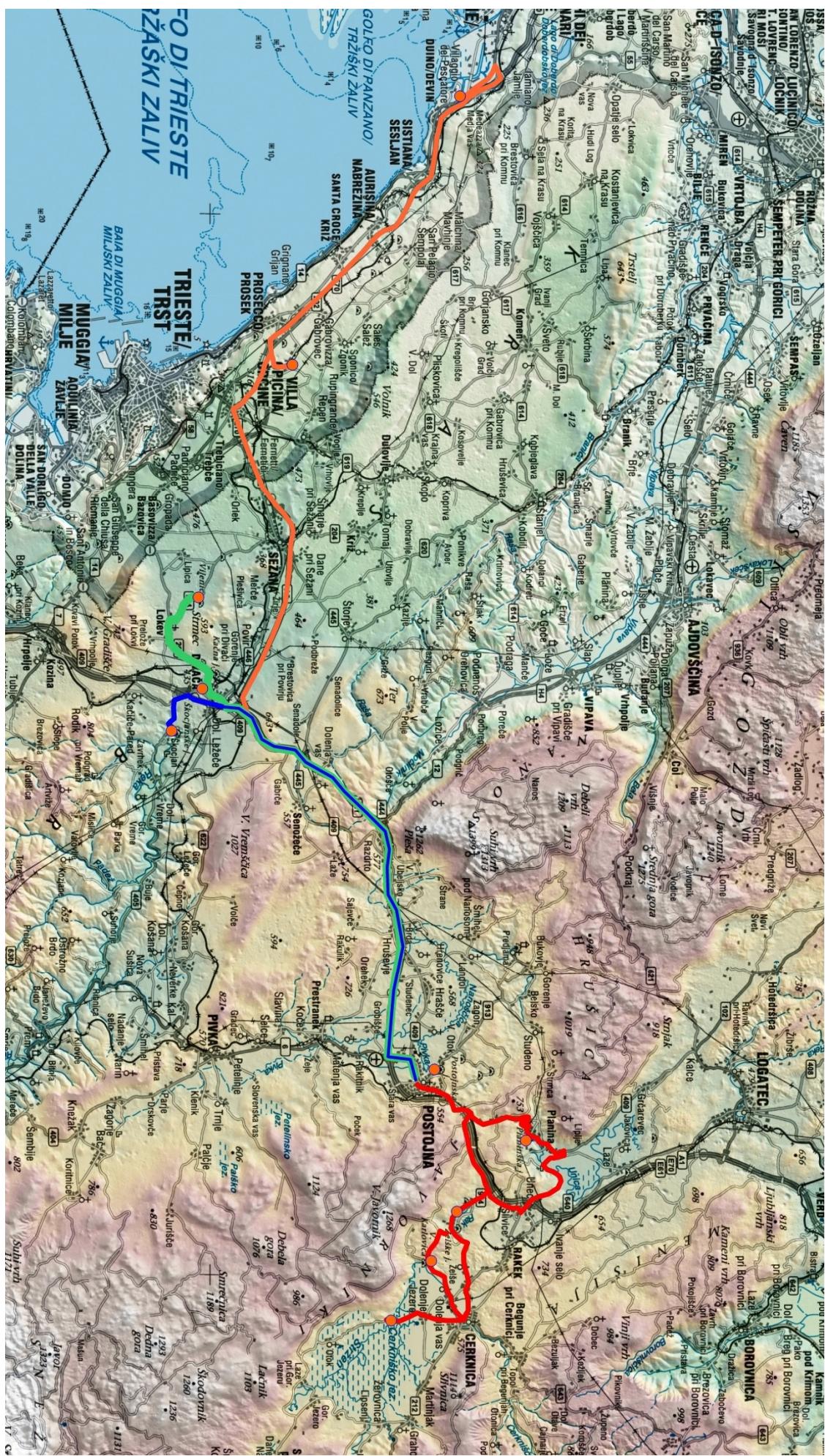
## Places to eat:

- 5 Minutka: pizzeria and restaurant, Balkan food
- 6 Proteus: restaurant with local and "global" food
- 7 Štorja pod stopnicami: bistro with local and "global" food
- 8 Bar Bor: restaurant, simple but good local food
- 9 Čuk: pizzeria and restaurant, local and "global" food

- ★ Fast Food
- ★ Bakery
- Market
- ▼ ATM
- ✉ Post Office

## **EXCURSIONS**

1. Part of underground river Ljubljanica: Planinska jama, Rakov Škocjan, Cerkniško polje
2. Tourist cave Vilenica
3. “Classical Karst” caves: Škocjanske jame, Velika jama v Briščikih (Grotta Gigante) and Timavo springs
4. Cave Postojnska jama & Expo Postojnska jama



## EXCURSION 1, TUESDAY, JUNE 16<sup>TH</sup> 2015

### Part of underground river Ljubljanica: Planinska jama, Rakov Škocjan, Cerkniško polje

Andrej Mihevc, Nadja Zupan Hajna

Karst Research Institute ZRC SAZU, Postojna, Slovenia

#### Planinsko polje

Planinsko polje developed in geologic structures of the Idria fault zone. Its wider surrounding is built of Jurassic and Cretaceous limestone and Upper Triassic dolomite, dolomite also form a part of the polje bottom. Polje is about 6 km long and 2 km wide. There are two narrow pocket valleys on SW part formed by springs of Unica and Malenčica rivers. Polje consists of 16 km<sup>2</sup> flat surface at height about 450 m and is about 50 m deeper than lowest surrounding levelled surface.

Planinsko polje presents the most important water confluence in the river basin of Ljubljanica. Tectonically crushed and almost impermeable dolomite barrier along the Idrija wrench fault zone, which crosses the polje, forces the karst waters to overflow from higher karstified limestone background to the surface and after crossing Planinsko polje toward NE sink into the underground again.

Planinsko polje is flooded several times in a year. The minimum inflow to the polje amounts to 1,5 m<sup>3</sup>/s; mean 23 m<sup>3</sup>/s, maximal was estimated to 100–120 m<sup>3</sup>/s, the total ponor capacity being about 60 m<sup>3</sup>/s. At floods, lasting 1–3 months, the water increases up to 10 m and up to 40 million m<sup>3</sup> of water inundate the polje.

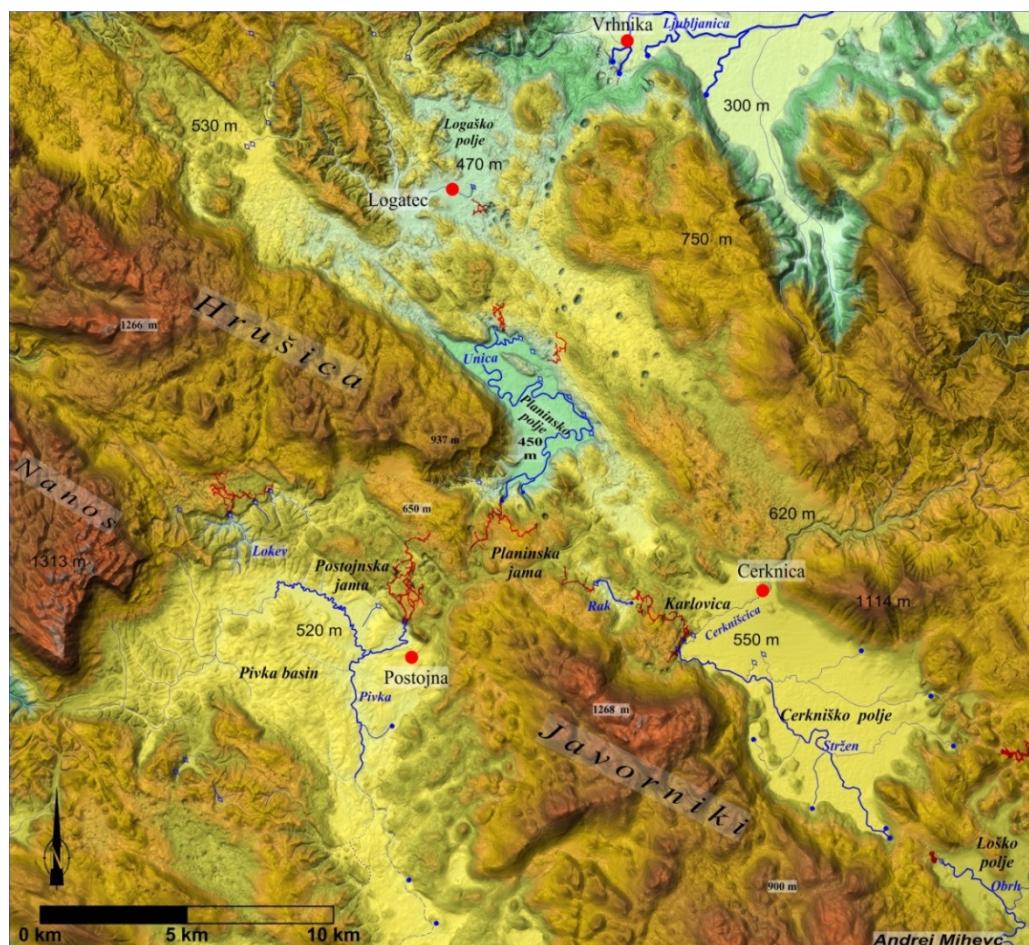


Figure 1: Planinsko polje and the karst around it.

The principal Unica swallow-holes are disposed at northern edge, where mostly medium and high waters are sinking. At low waters the whole Unica is disappearing in swallow-holes at eastern polje's border. The water is sinking directly from Unica bed through the polje's bottom across more than impassable 150 swallow-holes and fissures. Larger caves behind the ponors are Najdena jama cave (5,110 m), Logarček (4,334 m) and Vetrovna jama (700 m).

### Planinska jama

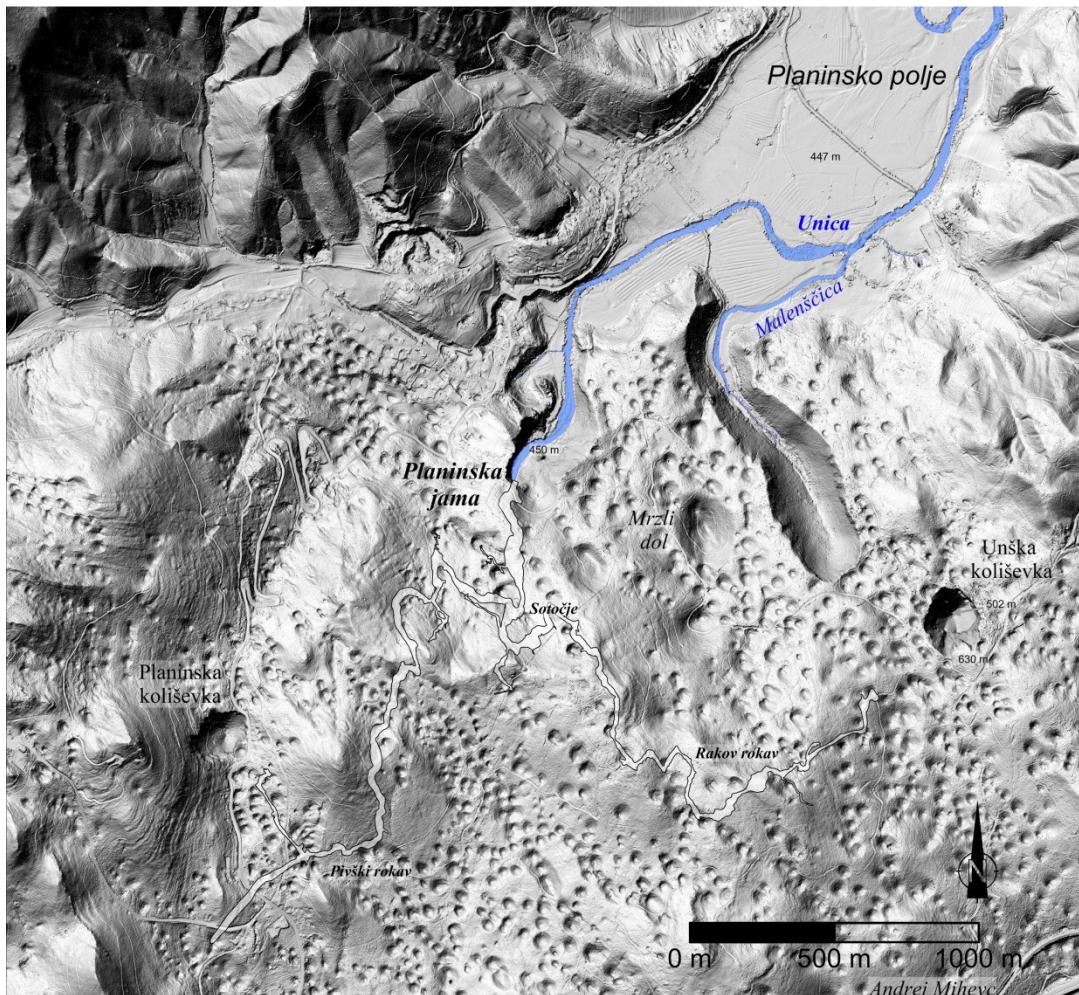


Figure 2: Surface of the southern edge of Planinsko polje with the outline of Planinska jama (LiDAR data, Geodetski oddelek ARSO).

Planinska jama (Reg. No. 748; 45°49'11.62"N; 14°14'44.39"E; 453 m a.s.l.) is situated on the southern edge of Planinsko polje, with its entrance at the end of a large pocket valley. The cave discharges the main spring of the Unica river, which flows through the polje (Fig. 2). The inner parts of the cave are at a slightly higher elevation than the entrance. A planed surface with many dolines occurs 50 m above the cave. The cave is one of the largest caves of the Postojnski kras (Fig. 1).

The cave entrance is situated in the Upper Cretaceous limestones and dolomites (Buser, Grad & Pleničar 1967). According to Gospodarič (1976), the entrance part and Rakov rokav are developed in Lower Cretaceous bedded limestones, limestones with chert and limestone breccia. Pivški rokav (Pivka Branch) and Rudolfov rov (Passage; to the south of the Rakov rokav – Rak Branch) are developed in Upper Cretaceous massive limestone and breccia with Caprinidae and Chondrodontae. Bedding dips north-eastwards at 20° in the Rudolfov rov.

Planinska jama is a 6,656 m long cave with active stream passages. Only some small side passages at higher elevations are not active, such as Rudolfov rov. The passages are large, about 15 m wide and high. There are some collapse chambers and one of the passages terminates in a large collapse.

The confluence of the Pivka river, which arrives from Postojnska jama and the Rak river from Rakov Škocjan is situated within the cave. The two main passages were named after the tributaries: Pivški rokav and Rakov rokav. Both rivers flow into the cave via deep sumps (Fig. 3).

Gospodarič (1976) described sediments, which he found in the following stratigraphic succession: the oldest coloured chert gravels; older laminated loam (Middle Quaternary); white chert gravel (Riss); flowstone (80 ka, Riss–Würm); younger laminated loam (lower Würm); flowstone (Middle Würm); flood loam (Upper Würm); flowstone (Postglacial) and the youngest flowstone (Holocene). Erosion of the sediments was contemporaneous with the last phase of flowstone formation.

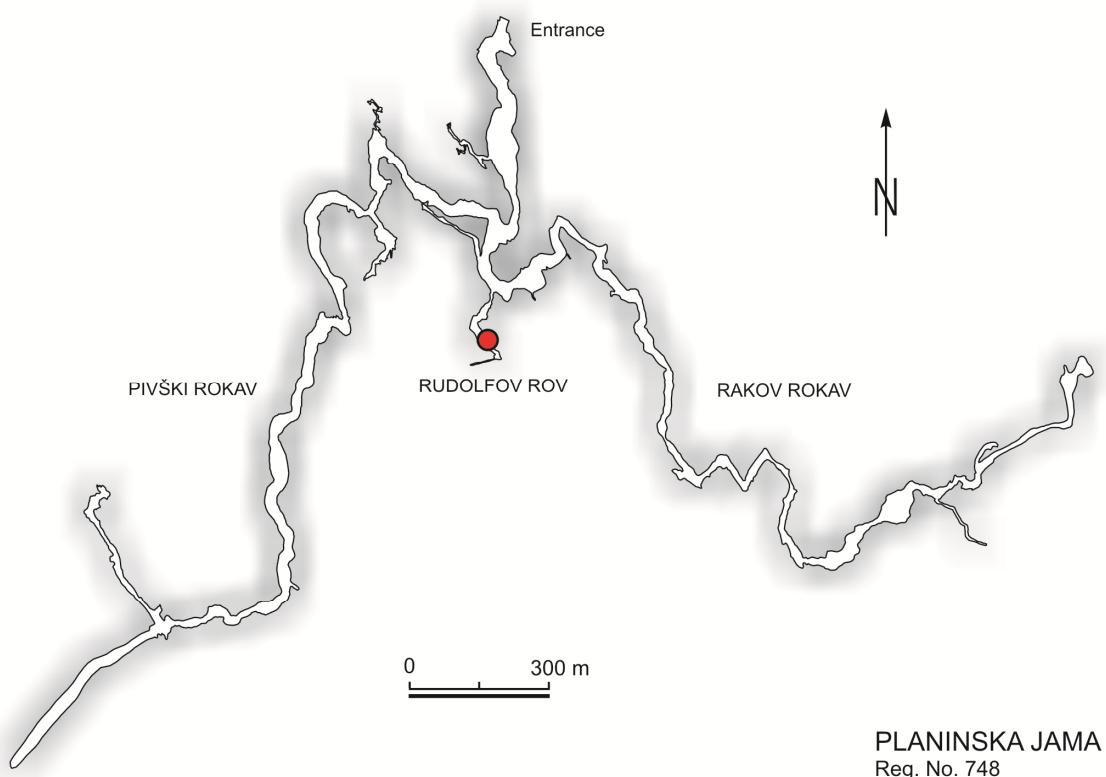


Figure 3: Map of Planinska jama with Rudolfov rov location.

Rudolfov rov is a side passage of Rakov rokav about 200 m long at ca 460–475 m a.s.l. The entrance to the passage is in the southern wall of Rakov rokav at 470 m a.s.l., i.e. about 16 m higher than the main passage floor. A small stream flows out of Rudolfov rov, eroding sediments away. The Rudolfov rov was expected by Gospodarič (1976) to be filled by the older laminated loam, which rested upon the erosion bottom of the channel. This loam was expected to be overlain by white chert gravel. He expected that chert gravels of this colour were old and thus that the older laminated loam could be dated to about 350 ka, like all the oldest sediments in other caves of the region (Postojnska jama, Otoška jama, Risovec, Divaška jama and Križna jama). The mineral composition of sediments indicates that the waters depositing the clastic load in the cave arrived from the Pivka basin where Eocene flysch rocks were eroded (Gospodarič 1976, Zupan Hajna 1992).

However, modern water in Rudolfov rov flows from Javorniki mountains and Cerkniško polje. This water eroded the sediments that once completely filled the passage.

The older laminated loam of Gospodarič (1976) was sampled for palaeomagnetic analyses from Rudolfov rov by Gospodarič and Šebela (Šebela & Sasowsky 1999). Normal polarization of all samples was interpreted as younger than 0.73 Ma. They suggested that the palaeomagnetic results are in good accordance with Mindel age (0.35–0.59 Ma) proposed by Gospodarič (1981). Results of Zupan Hajna *et al.* (2008) confirmed a N polarization without any R polarized samples. It appears that the profile can be placed within the Brunhes chron, i.e. the sediments are most probably younger than 0.78 Ma, as expected by Šebela & Sasowsky (1999). But without any comparative data (Th/U dating, fossils) we cannot be certain and can be also older.

Main spring of river Unica is 656 m long Planinska jama cave. It has mean annual discharge 24 m<sup>3</sup>/s (min. 0.3 m<sup>3</sup>/s, max. 100 m<sup>3</sup>/s) and is situated in the southern polje's part in Cretaceous limestone, where the confluence of waters from Cerkniško polje, Javorniki Mt. and Pivka is located.

First explorations of the cave started in 1849 by a local priest A. Urbas. It was followed by detailed study of A. Schmidl, who investigated caves in the area, measured temperatures of the waters and cave air and also measured the main part of the cave. Results were published in 1854. Later explorations were till terminal sumps were performed by W. Putick at the end of 19. century.

After 1960 the cave and nearby springs Malni were investigated for the water supply of Postojna. At present there are diving attempts in the cave to connect it with Tkalca jama in Rakov Škocjan and with Postojnska jama. Several hundred meters of passages were explored, in very difficult conditions so it seems that the connection will be made from Postojnska jama down along the Pivka river. Only this year about 1,000 m of new sumps were dived, but about 1,500 m of passages is still to be done.

The entrance part of the cave is large, passage is up to 60 m high and to 20 m wide. After the Sotočje, confluence of rivers Rak and Pivka, slightly smaller dimension of passages follow. Passages along the Pivka river are up to 20 m high, and 10–15 m wide. There are some collapse chambers which river avoids by bypass passages.

Passages of Pivka are directed towards SW and just before the terminal sump split to two. One of them ends choked with a collapse that is most likely connected with Planinska koliševka collapse dolina, the SW branc ends in a about 30 m deep sump.

The Rakov rokav passage leads towards E. There are smaller lakes and more rapids in the passage. Towards the end of the passage into the water that comes from Rakov Škocjan and Cerkniško polje a different water discharging Javorniki mountains is admixed. A part of water from this part of the cave is also feeding springs at Malni.

### Rakov Škocjan

Rakov Škocjan is a karst depression about 1,5 km long and 200 m wide. It is situated below the N side of Javorniki Mountain at elevation about 500 m between Planinsko and Cerkniško polje. Through the depression the permanent river Rak is flowing. The Rak springs from Zelške jame cave, bringing water from Cerkniško polje. Zelške jame are about 5 km long; the end of the cave is in large collapse doline Velika Šujca, where from the other side the Karlovica cave system ends. In Karlovica system is the main outflow from Cerkniško polje. Numerous collapse dolines are situated around the entrance of Zelške jame. In one of them the Mali naravni most (Small Natural Bridge) is present. Downstream the valley widens and several springs bring additional water to the Rak River. The valley is narrowed at the Veliki naravni most (Big Natural Bridge) and afterwards the Rak sinks into Tkalca jama cave from where the water flows towards cave Planinska jama at Planinsko polje. The connections of the Rak with water from Cerkniško polje and with the Unica springs at Planinsko polje were proved by water tracing and by diving. Entrance to Tkalca jama lies at 496 m a.s.l., while

the highest floods reached in 2014 reached to 515 m a.s.l. The water at the cave entrance was thus 19 m deep at its deepest.

The schematic longitudinal profile of Rakov Škocjan (Fig. 4) clearly shows the position of the spring and ponor caves, the collapse dolines and the springs. The spring side is the location of the Mali naravni most (Small Natural Bridge) and the drainage side with the Veliki naravni most (Big Natural Bridge).

Natural bridges Veliki and Mali naravni most in Rakov Škocjan are remnants of the former cave ceiling. The rocky arch of Veliki naravni most is 17 m thick. Stream Rak flows under the bridge at an altitude of 500 m. The height of the cave passage under the bridge is between 9.5 and 17 m, its width is between 15 and 23 m long and the length is 56 m. The highest measured water level in the section before the bridge entrance reached the elevation of 515 m. There is an approx. 150-meter long canyon between the Large Natural Bridge and the Tkalcica Cave entrance. The rocky arch is composed of thick-bedded and anticline-folded Lower Cretaceous limestones.

Before 1<sup>st</sup> World war Rakov Škocjan was owned by the Windischgrätz family and was closed as their private park; between 1<sup>st</sup> and 2<sup>nd</sup> World war, the Italians also closed the area for the public. From 1949 Rakov Škocjan has been a Landscape Park.

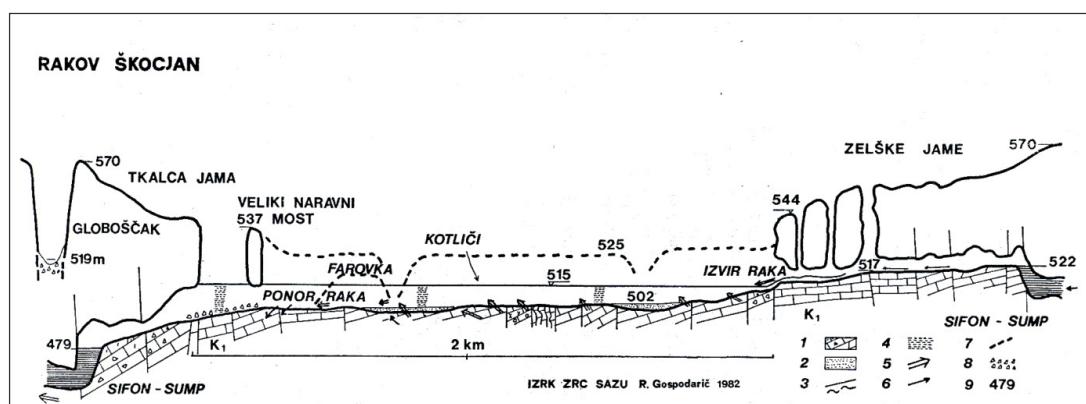


Figure 4: Cross-section along Rakov Škocjan karst depression between spring at Zelške jame and sink in Tkalca jama.

Legend: 1 – rocky bottom, 2 – alluvia, 3- fault zone, 4 – flood in 1982, 5 – karst spring, 6 – water flow directions, 7 – terraces, 8 – boulder rocks, 9 – altitude (Gospodarič et al. 1983).

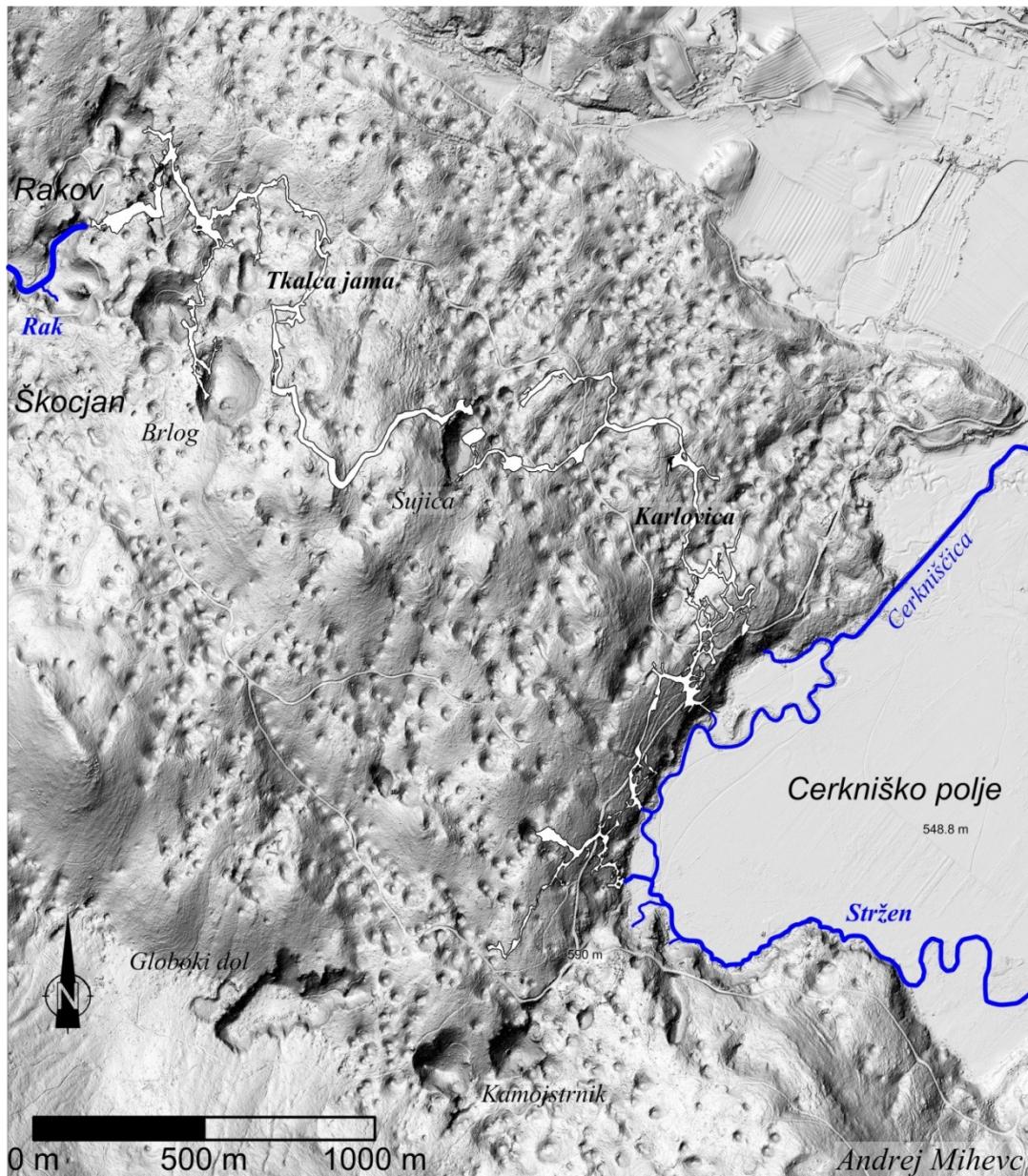
### Cerkniško polje

Often it is called just Cerkniško jezero (Lake of Cerknica), because of its regular floods forming at the bottom an intermittent lake. Lake covers 26 km<sup>2</sup> when is full; it is 10.5 km long and almost 5 km wide. Its hydrological properties caused that already in the beginning of New Age scholars from all round Europe were attracted to it. The lake becomes still more known through the Valvasor's description in 1689.

Cerkniško polje is developed in the important regional Idrija fault. In the same fault zone other poljes are developed: Planinsko polje, Loško polje and Babno polje. Bottom is formed on Upper Triassic dolomite, which is presented also on the N, E and SE side of the polje, some Jurassic dolomites are also present. On W and NW the Cretaceous limestone is present. Main karst springs are on E, S and partly on W sides of polje, only Cerkniščica drains dolomitic surface catchments area. The important karst springs are Žerovnica, Šteberščica and Stržen. Stržen flows on the W side of polje towards the ponors in the middle of the polje, from where water flows directly to Ljubljanica springs, and towards NW side of polje, from where the water flows to Rakov Škocjan. At this part of polje there are 12 ponor caves. They are connected to Karlovica cave system to which

also the highest waters from polje flows. In the cave system there is more than 7 km of passages. Passages are generally low, because they are filled by alluvia. Thickness of alluvia in Jamski zaliv, before the caves entrances, is about 8–15 m.

During the last centuries several plans for the hydro melioration of polje have been made, few were realized, and most of them damaged natural conditions badly. In 1965 it was proposed to make Cerkniško polje a permanent lake, in the years 1968 and 1969 entrances to the caves Velika and Mala Karlovica were closed by concrete walls and a 30 m long tunnel was made to connect Karlovica with the surface, but small effect of retention in dry periods and dry years were assessed.



*Figure 5: Karst surface between Cerkniško polje and Rakov Škocjan  
(LiDAR data, Geodetski oddelek ARSO).*

## EXCURSION 2, WEDNESDAY, JUNE 17<sup>TH</sup> 2015

### Tourist cave Vilenica

Andrej Mihevc<sup>1</sup>, Andrej Kranjc<sup>2</sup>

<sup>1</sup>Karst Research Institute ZRC SAZU, Postojna, Slovenia

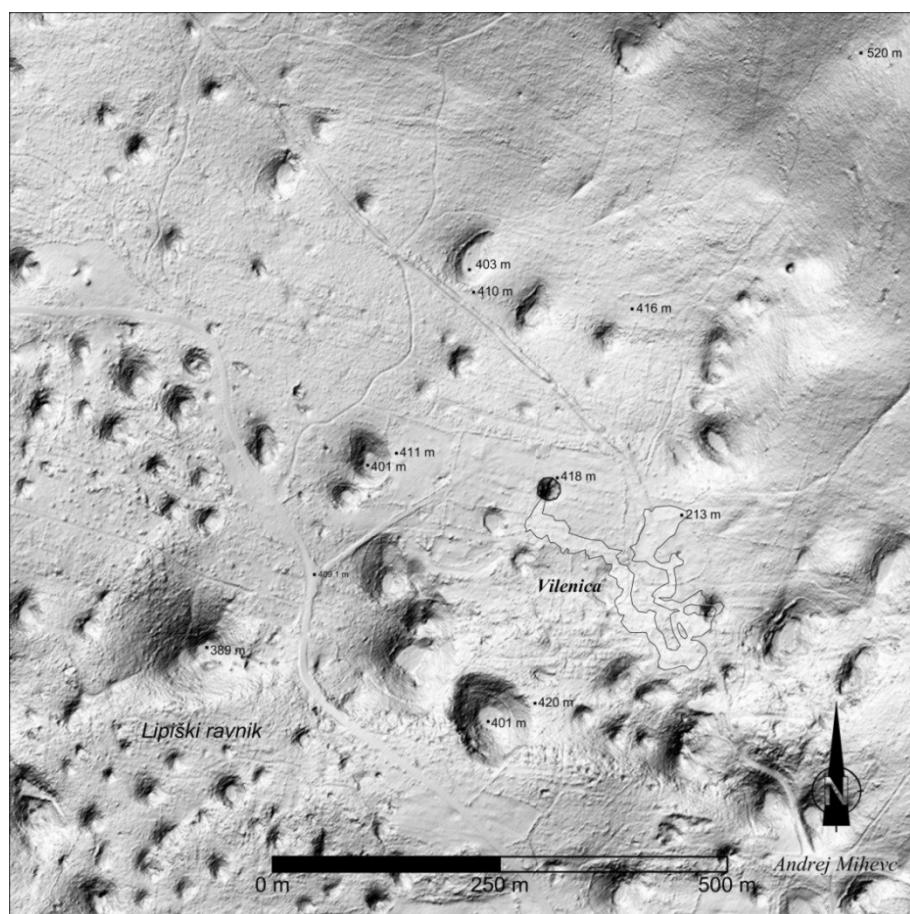
<sup>2</sup>Slovenian Academy of Sciences and Arts, Novi trg 3, SI-1000 Ljubljana, Slovenia, kranjc@sazu.si

#### Cave Vilenica

Andrej Mihevc

Vilenica is 841 m long and 190 m deep segment of larger cave system that was modified by collapses and cave infills. The entrance to the cave is at elevation 418 m on the levelled surface Lipiški ravnik (Fig. 6). It is formed in light grey bedded and massive upper Cretaceous limestone. The cave was best described by I. Gams (1974, 1984 and 2004).

Cave is developed in direction NE–SW along the same fault, but upper, touristic part, is quite different from the lower one. The upper part of the cave was probably formed as a passage with a flow in epiphreatic zone of the karst and was later transformed by collapses, so the walls of the cave are today controlled mostly by fault lines. Only on few places original walls with large scallops are preserved. At the cave entrance towards NW the same passage continuous behind the collapse fill in 550 m long Gustinčičeva jama. This cave is also transformed by collapses. Both caves are rich in flowstone formations.



*Figure 6: Levelled surface of Lipiški ravnik above Vilenica cave  
(LiDAR data, Geodetski oddelek ARSO).*

In winter time entrance chambers of Vilenica are under the influence of cold air circulation. The impact of cold and dry air is expressed with in the colour of the flowstone and rock walls in uplifting part of the cave towards Rdeča dvorana.

Lower part of Vilenica cave consists of interconnected chambers developed in phreatic zone and mostly follow fractures and faults. There is less flowstone, the difference is also in sediments. In upper parts sediments are mostly flowstone with reddish clay and sandy clay, while in lower parts more yellowish sandy clay prevail. These clastic sediments have alloigenic origin in distant Eocene flysch rocks.

From the shape of the cave and properties of sediments we can conclude that Vilenica is a very old cave which evolution is not connected with the present levelled surface or recent flow of water. Currently active caves are at elevation slightly above 50 m a.s.l.

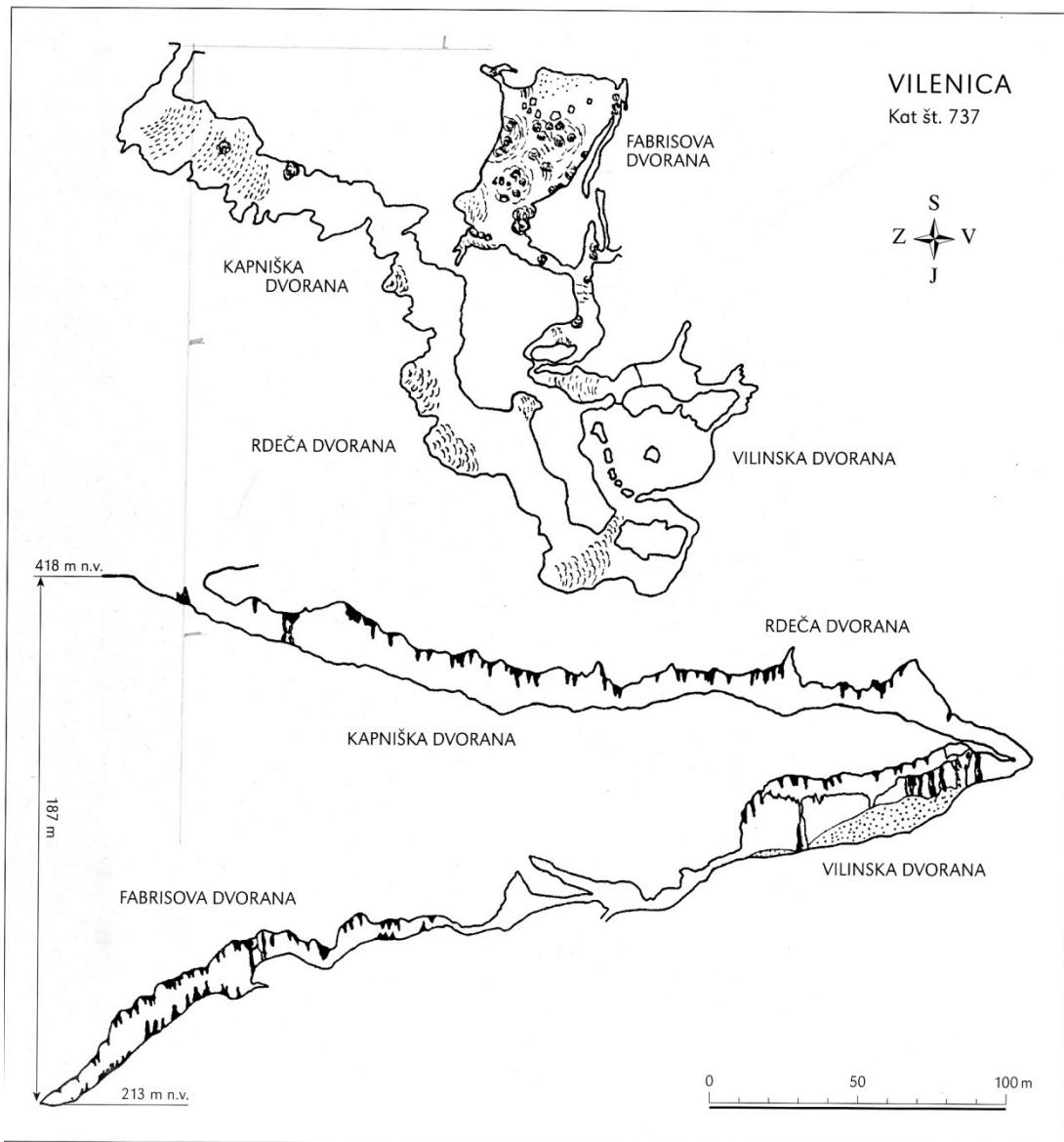


Figure 7: Ground plan and profile of Vilenica cave (after Gams 2004).

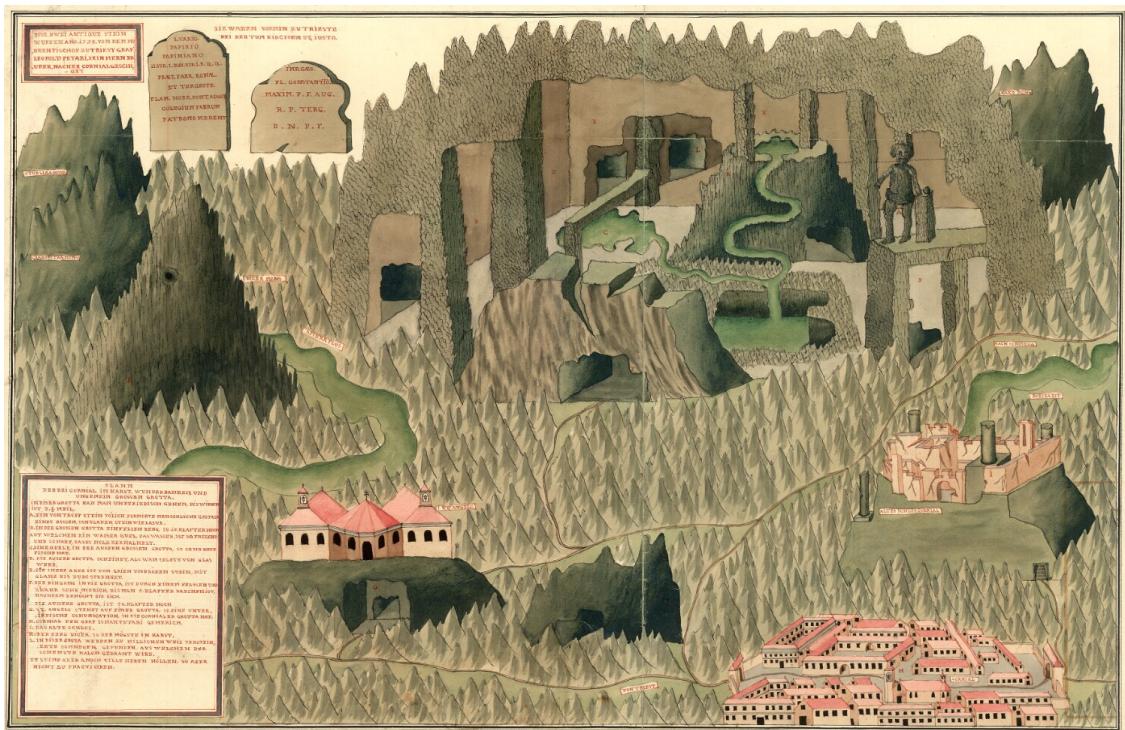
## Vilenica – a short history

Andrej Kranjc

The Cave Vilenica (Fairies' Cave) may be regarded as the oldest proper show cave in Slovenia, maybe even in the Western World. The remains of the 16<sup>th</sup> century pottery prove that the cave was already used in these times. In 1469 the first Turkish raids affected the Kras (Karst) plateau. The main settlement in the vicinity of Vilenica, called Lokev, was robbed and burnt in 1527. Since 1559 the Ottomans did not appear in this part of the country any more. According to the tradition the cave served as a hiding place to local inhabitants (Savnik & Tomišić 1968). The names of the cave through time are evidence that there was always a tight connection with the village Lokev: Corniale Höhle in German and La Grotta di Corniale or La Grotta di Cognale in Italian. Corniale, Cognale is a corrupted German name of Kornhalle. Its meaning is "granary" and its use shows that a granary belonging to the citizens of the town of Ljubljana existed in Lokev village. For centuries the main road from Vienna to Trieste passed through Lokev. Benvenuto Petazzi, the member of the noble family mentioned in the Trieste documents (Petaz, Petachys) in the 13<sup>th</sup> century already, got the rights of the Emperor to use forests around Vilenica in 1622. Thus, also Vilenica belonged to him (Puc 2000). There is a document from 1633 attesting that the count Petazzi gave Vilenica to the Lokev parish to administer it and thus the parish got the right to use the money gained by the guided tours through the cave (Macarol 2014). Because there were guided tours which had to be paid one can say that Vilenica was a show cave in the modern sense of the word, at least in 1633. Furthermore, as the count accorded the benefit of the cave to the parish, it means that already then paying visitors were coming. The cave had to be modified to enable the visits because the natural entrance is vertical; at least a kind of ladder had to be installed. Count Petazzi has been inviting friends and important Trieste citizens to visit the cave, where they were organizing dancing parties. On St. Peter and Paul Day there was a place for a band and for a dance prepared 100 m inward whereas the whole gallery with speleothems was illuminated by torches and candles. But since then there is nothing written remaining on Vilenica or its visitors up to the middle of the 18<sup>th</sup> century. Even Valvasor whose special interest were caves and who spent a few days in Lokev observing miraculous walnut tree, has not mentioned Vilenica nor any possibilities to visit it (Valvasor 1689). In 1719 Trieste was given the status of a free port. This fact certainly helped to augment the number of Vilenica visitors. More ships came to Trieste and while waiting to sail further, crews and passengers have been often visiting Vilenica. To reach the cave it was possible to hire a coach at Trieste. On the other hand, when preparing for the visit of the Emperor, members of the Trieste town council ordered the painter L.-F. Cassas to make paintings of the most interesting curiosities of the Trieste's surrounding. In 1782 he fulfilled his task. There were paintings of Škocjanske Jame Caves and the Castle of Predjama but surprisingly, there was nothing about Vilenica (Kečkemet 1978). Did Trieste councillors think that this cave is not representative enough for the Emperor?

In the 18<sup>th</sup> century two important men visited Vilenica, the director of the Emperor's collection of rarities J.A. Nagel (1748) from Vienna and naturalist B. Hacquet from Ljubljana (presumably in 1770s). As a guide-book they used Valvasor's "Die Ehre..." although Vilenica does not figure in it at all. Nagel was sent to Carniola to investigate the unusual phenomena, especially caves, which were often the object of discussions, and to bring some rare examples of minerals for Emperor's collection. Nagel described his travel in an extensive manuscript, including description, plan, and some illustrations of Vilenica. In Postojnska Jama Nagel measured the thickness of the flowstone which covered old inscriptions and found the value of 1/3 of a line (1/36 in). He compared this value with the 6 feet thick stalagmite of Vilenica and calculated its age: 91,000 years. At those times it was known that since the Deluge passed only 5,696 years. Consequently, the speleothem could not be so old; therefore Nagel concluded that flowstone is forming very slowly and irregularly. His remark on Vilenica was: "Wonderful, up to now unknown" (Kranjc 1998). This is really curious, unknown to him, and yet a show cave for more than hundred years already! Vilenica is the most

beautiful of all caves in Carniola, according to B. Hacquet (1789), who visited this cave in 1770s. His cave-guide was a peasant from the nearby village. For Hacquet, descent down the entrance was not a problem, however for further visit a rope and pole-ladder was needed. Even Hacquet does not mention that he would had to pay for the visit, nor does he mention doors or anything in connection with the church or parish being its owner.



*Figure 8: Fantasy 3-D plan of Vilenica (1751–1760) from “Atlas austriacus”, preserved in Moll’s Collection (Brno).*

On the other hand, in the “Atlas Austriacus” belonging to the Moll’s collection now kept in Brno, there is a sort of a three-dimensional fantasy plan of Vilenica probably made between 1751–1760 (Fig. 8). It is interesting to note, that besides some mines, iron-works, Predjama Castle and the lake Cerkniško Jezero, the atlas also includes the plan of Vilenica. In 1777 Vilenica was visited by the famous Venetian abbot-naturalist A. Fortis, the author of a well-known work *Travel to Dalmatia*, in the company of a German mineralogist Dembscher from Chemnitz. Fortis wrote that Vilenica has more beautiful and a larger number of stalagmites than the cave near Brtonigla in Istria, which he had visited before (Muljačić 1975). Otherwise the majority of visitors to Vilenica were passengers and crew members of ships moored at Trieste port, including also artists who were enthusiastic about the cave. In 1795 G. Compagnoni published a poem *La Grotta di Vileniza*, and in 1802 the poem *La Grotta di Vileniza detta di Corgniale* by F. Trevisani was published in Trieste. Viennese painter P. Fendi was awarded a gold medal for his canvas of Vilenica (*Berggrotte bei Triest*) at the Venice exhibition in 1821 (Trimmel 1968). In 1861 A. Rieger published a sort of a guide of Vilenica illustrated with a set of his paintings. Worth to mention is also the Emperor Franz I who visited Vilenica twice, in 1816 and 1818.



*Figure 9: P. Fendi's oil-painting of Vilenica (about 1820).*

In 1809 the entrance to Vilenica was closed by a wall and a door. The contemporary Count Petazzi left (again) all the income of the entrance fees to Lokev chaplaincy. Above the entrance a chronogram was engraved: E LIBERALITATE COMITIS A PETAZZI ECCLESIA CORNIALENSIS (By permit of Petazzis accepted by the Church of Lokev – 1809) (Puc 2000). In 1829/30 a lateral tunnel was dug thus avoiding a difficult passage and therefore enabling visitors to reach the last part of the cave, the so-called Vilinska Dvorana (Fairies' Chamber). When Kras region belonged to the Napoleon's Illyrian Provinces the cave came under the "new commune administration", which improved paths in it. In 1821 noble owners sold forests and common lands to cadastral communes and thus the cave became the property of the local commune. In the same year the Lokev chaplaincy introduced the visitors' book following the example of caves Postojnska Jama and Škocjanske Jame. Until 1836 the book was at the chaplaincy, since 1839 the inn-keeper and the new manager of the cave, Muha family, at Lokve took care of it and remaining there until it was given to the custody of Karst Research Institute at Postojna. In the book there are about 2,000 inscriptions of visitors in English, French, German, Greek, Polish, Russian, Slovene, and Spanish language from the years 1821 to 1884 (Puc 2000). Postojnska Jama and Škocjanske Jame, where the modern tourism started in 1819, were not just the model but also an important rival to Vilenica. The number of Vilenica visitors slowly diminished and accordingly the income. In 1816 the income of entrance fees was 99 guldens, in 1817 71, and in 1818 only 41 guldens. In 1857 the railway from Vienna reached Trieste. At Postojna a railway station was built, Škocjanske Jame were relatively near to the station of Divača, while Lokev and Vilenica remained quite far away. In 1887 Divaška Jama Cave, not far from Divača, was opened for tourists, often named Divaška Vilenica (Vilenica of Divača) which caused a further decrease of visitors to Vilenica. In 1841 the last ball was organized in Vilenica and the last feast day when the cave was illuminated with 1,600 candles was in 1895. Up to 1920 local people organized public festivities, as they were later forbidden by the Italian authorities because of supposed "nationalistic riots". It seems that often changes of managers and owners were not good for the cave as a natural object. At Postojna, the main hotel owner Progler demanded from the district administration to give a concession over Postojnska Jama to a private person. When they were deciding for or against awarding a concession, an important reason that private ownership

would not be good for a cave, was just Vilenica. It was shown that it has degraded from a nice flowstone cave to the present conditions, where entrance, paths, and flowstone formations have been deteriorated, exactly because it has been leased to a private person (Kranjc 2003). Later, when these regions were occupied by Italy the caves Postojnska, Škocjanske, Divaška, Velika Jama v Brščikih (Grotta Gigante), and Vilenica were under the management of the Speleological Section of C.A.I. (Club Alpino Italiano) at Trieste (Habe & Kranjc 1981).

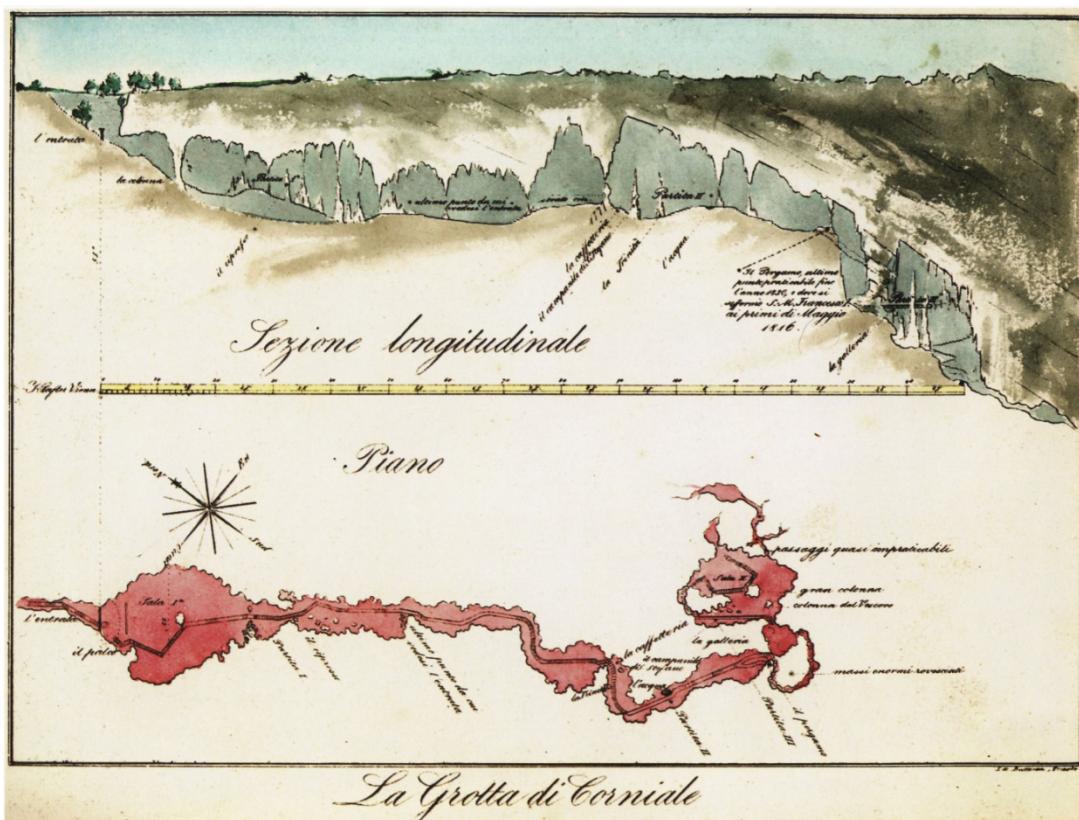


Figure 10: Plan of Vilenica published in the 19<sup>th</sup> century (Kranjc 1997).

After the 2<sup>nd</sup> WW Vilenica was deserted. The door was destroyed, the visit was not controlled, and breaking of speleothems was a general practice. In 1947 a local caving group formed, reorganized twice, in 1955 and 1959, finally forming Sežana Caving Club which rearranged, installed electric lights, and reopened Vilenica for tourist visit in 1962. The cave has made many deep impressions upon artists again and therefore the Slovene Writers Evening was organized in the cave in 1980. This event soon grew into an international meeting of writers with prestigious prize "Vilenica" being awarded. Each year it is attended by many important writers from all over the World as well as by important political persons.

### EXCURSION 3, THURSDAY, JUNE 18<sup>TH</sup> 2015

#### "Classical Karst" caves: Škocjanske jame, Velika jama v Briščikih (Grotta Gigante) and Timavo springs

Andrej Mihevc<sup>1</sup>, Nadja Zupan Hajna<sup>1</sup>, Franci Gabrovšek<sup>1</sup>, Franco Cucchi<sup>2</sup>, Alessio Fabbricatore<sup>3</sup>, Pavel Bosák<sup>1,4</sup>, Petr Pruner<sup>4</sup>

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#### Kras Plateau

Andrej Mihevc

The Kras is a low, 40 km long and up to 13 km wide, NW–SE-trending limestone plateau lying between Trieste Bay, the northernmost part of the Adriatic Sea, Vipava valley in north-east, and Friuli-Venezia Giulia lowlands and river Soča in north-west. The 45°45''N and 14°00''E lines of latitude and longitude cross the Kras near Divača village (Fig. 11).

The name for the area comes from genetic word *kras*; in Slovene it means rocky surface where soil does not cover the rocks. This term gave the name to the whole plateau Kras. From this toponym the international term – karst – for such type of landscape is derived. The name and some other terms from the area like *dolina*, *polje*, and *ponor* have also entered to international scientific terminology from here.

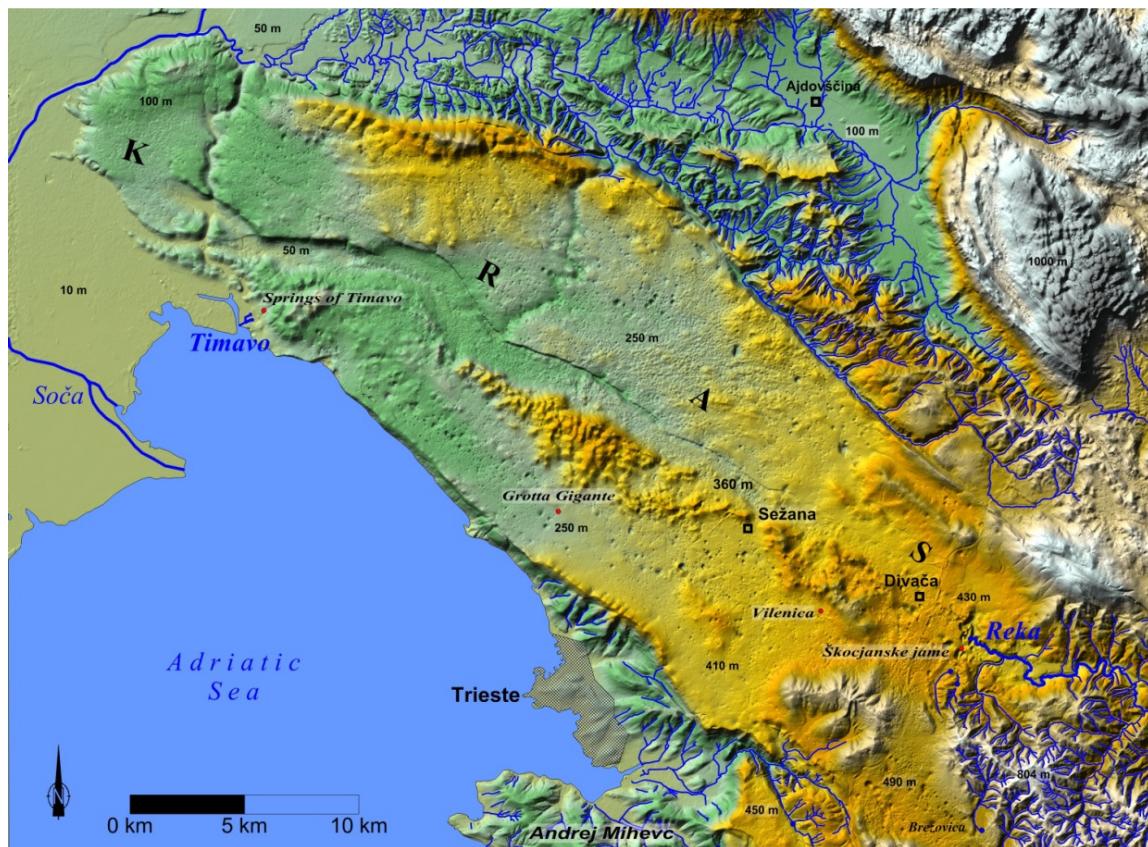


Figure 11: DEM of the Kras plateau.

Climate is sub-Mediterranean with warm dry summers and most of the precipitation in autumn and spring. Cold winters, with NE wind "burja" (bora = borealis) show strong influence of the continent. Average yearly precipitation on Kras varies from 1,400 to 1,650 mm, and average yearly evapotranspiration from 700 to 750 mm. Because of different land use, pasturing, in past centuries, the Kras was bare, with rocky and grassy surface. Last decades the bushes and trees are overgrow the landscape.

The Kras belongs to Adriatic–Dinaric Carbonate Platform of the External Dinarides composed of shallow marine fossil-bearing Cretaceous and Palaeogene carbonates. Eocene flysch rocks encircle the carbonate plateau. Kras and Matarsko podolje tectonically belong to Komen thrust sheet, which is thrust over Eocene flysch and Palaeocene/Eocene limestone of the Podgorski kras.

The main part of the plateau is essentially levelled, inclined slightly towards the north-west, with numerous dolines, caves and other karst features. About 3,490 caves are known on the plateau. In seven of them we can reach 21 km of passages of the underground Reka which flows between 200 and 300 m below the surface. There is a belt of slightly higher relief in the central part of the plateau, formed by conical hills like Grmada (324 m a.s.l.), and dissected by large depressions. The higher relief divides the Kras into two separated levelled surfaces. In the north-western part, the plateau descends to below 50 m a.s.l. on the edge of the Friuli Plain; on its south-eastern edge altitudes are about 500 m a.s.l. There is about 300 m of accessible vadose zone with caves formed at all altitudes from the surface to the sea level and below it.

No superficial streams occur on the Kras surface, because all rainwater immediately infiltrates to carbonate rocks. There are two dry valleys crossing the plateau and some NW–SE-trending belts of lower relief which are result of young tectonics.

The age of the karst of Kras plateau can be defined as the time when the karst rocks were uplifted out of the sea. For the most of Dinaric karst in Slovenia this occurred after the Eocene, since after that there is no evidence of younger marine sediments. As soon as the carbonate rocks were exposed, we can expect that the karst was formed, but there are no remnants of karst features from that time. Most likely denudation has already destroyed them.

The oldest features in the karst relief are unroofed caves. They were caves that were formed by sinking rivers, bringing alloigenic sediments to caves in Kras. At the end of the morphogenetic phase all these caves were filled with fluvial sediments. This indicates the diminishing of the gradient in the whole area. Diminishing of the gradient which ended with planation could mean tectonic phase which ended at about 6 Ma ago. After that a new tectonic phase started. Three areas faced uplift and tilting for several hundreds meters. The uplift was stronger in the SE part of the area. Karst denudation was evenly lowering the surface, so the surface remained well preserved, dissected on central parts of karst with dolines, which represent few percent of total area only. The even denudation exposed former old caves to the surface. Some of them are filled with sediments, some sediments were washed away or were never filled.

On the surface the unroofed caves are expressed as narrow and often meandering shallow trenches, shallow oblong depressions, and doline-like forms in rows and collapsed dolines. The appearance of old unroofed caves and their fills resulted from denudation, erosion and chemical dissolution of limestone above the cavities. Fills exposed on the present surface include speleothems and cave fluvial deposits. The ancient directions of flow, different catchment areas of sinking rivers and different organisation of the ancient underground drainage were reconstructed from several unroofed caves in the Divaški kras. The thickness of rock overburden removed above cavities was established to have been 50–100 m. The age of cave fills was calculated from denudation rates and the expected thickness of missing overburden to 0.7–5 Ma. This large time range resulted from the expected minimum ( $20 \text{ m.Ma}^{-1}$ ) and maximum denudation rates ( $50 \text{ m.Ma}^{-1}$ ) calculated or measured in the area.

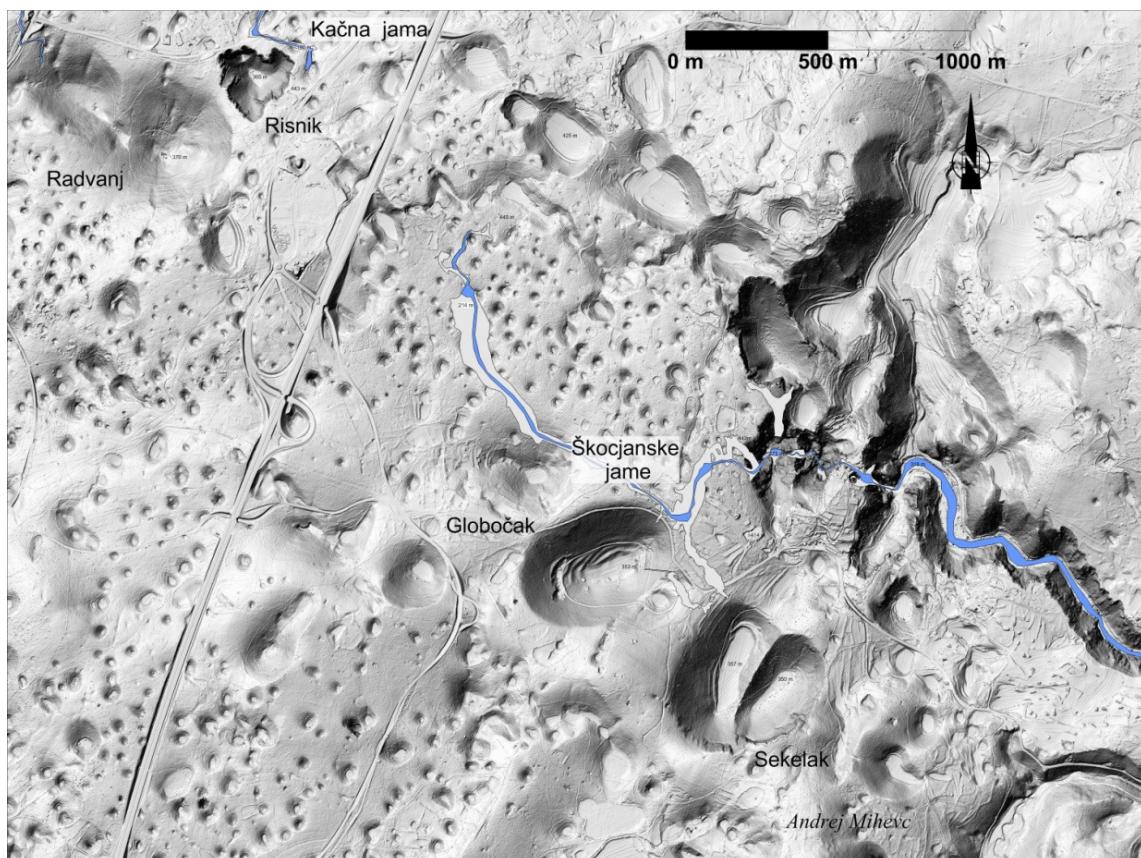
### Divaški kras

Andrej Mihevc, Nadja Zupan Hajna, Petr Pruner, Pavel Bosák

Karst surface above Škocjanske jame, Divaški kras (Divača karst) is a SE part of the Kras plateau between the sinks of Reka river and the village Divača. It is built mostly by Cretaceous and Paleogene limestone. The surface is levelled in elevations between 420 and 450 m a.s.l. and inclined slightly towards NW. The karst features here are exceptional; there are sinks of Reka river, 15 large collapse dolines and hundreds of dolines.

In the Divaški kras there are 64 known caves with the total passages length of 18,500 m. The largest caves of the area are Škocjanske jame, 5,800 m long and 250 m deep cave. They were formed by the sinking river Reka that after sinking flows towards Kačna jama, Labodnica and then to springs of Timavo.

The largest collapse doline in the area is the Radvanj double collapse doline (volume 9 million m<sup>3</sup>). It is followed by the 122 m deep Sekelak, the volume of which is 8.5 million m<sup>3</sup> and Lisični dol (6.2 million m<sup>3</sup>). Then there are: Globočak (4.6 million m<sup>3</sup>), Risnik (1.5 million m<sup>3</sup>) and others. As rooms as big are not usual in the Karst, we must assume that collapse dolines this large could develop only with simultaneous rock removal. If this were not the case, the room would fill up with caved-in rock and only collapse dolines much smaller than the primary cave would appear on the surface.



*Figure 12: The surface of the Divača karst above Škocjanske jame (LiDAR data, Geodetski oddelek ARSO).*

On Divaški kras surface and in some of the caves old allochthonous fluvial sediments have been preserved. They were brought into the caves by the sinking river Reka and its predecessors. Recent sediments, their origin and grain size in Škocjanske jame were studied by Kranjc; older

fluvial deposits, gravels and collapse rocks were studied by Gospodarič, which he has connected with Pleistocene climate change. Fluvial sediments in the karst surface, mostly chert pebbles, have been in the past associated with surface river flow of Reka, during the so-called "pre-karst" phase. Morphological analysis of several unroofed caves on the Divaški kras and paleomagnetic dating of sedimentary fills on the highway (Divača profile) and caves Divaška jama and Trhlovca, however, have indicated cave origin and the age of a few million years.

During construction of Industrial zone Risnik southwest of Divača, the works have uncovered large amounts of flowstones on the surface and more cavities filled by sediments. We analyzed two profiles; one in cave fluvial deposits and the second in the layered flowstone.

According to obtained results from samples of sedimentary profile, the presence of at least 7 different polarized segments of the profile (4 N, and R 3), indicates a minimum age of the sediments in the bottom of the profile at about 2 Ma; sediments are probably even older. Above the sedimentary profile at a distance of about 10 m, on the surface about 2 m thick flowstone was uncovered. Due to the presence of several different polarized magnetic zones in flowstone, we can assume that already the youngest flowstone layers on the top of the profile are older than 780 ka; the lower part is probably older than 2 Ma. Age of clastic sediment and flowstone in Industrial zone Risnik correlates to the other dating results of the Divaški kras. In the caves Škocjanske jame in Tiha dvorana sediments were sampled from already existing profile above tourist path; obtained results indicate the age lower than 780 ka.

### The Reka River

Andrej Mihevc, Franci Gabrovšek

The Reka river is the main sinking river of the Kras edge. The area of the catchment is over 350 km<sup>2</sup> with about 60 % of surface drainage network on Eocene flysch. The river flows about 50 kilometers on impermeable flysch rocks, continues for another 7 kilometers as a surface flow on a limestone terrain, and sinks at Škocjanske jame at the SE border of Kras. In the period 1961–1990 the minimal measured discharge of the Reka river was 0.18 m<sup>3</sup>/s and the mean discharge 8.26 m<sup>3</sup>/s. During extreme floods the discharge can surpass 300 m<sup>3</sup>/s. The ratio between maximal and minimal flow is thus over 1700.

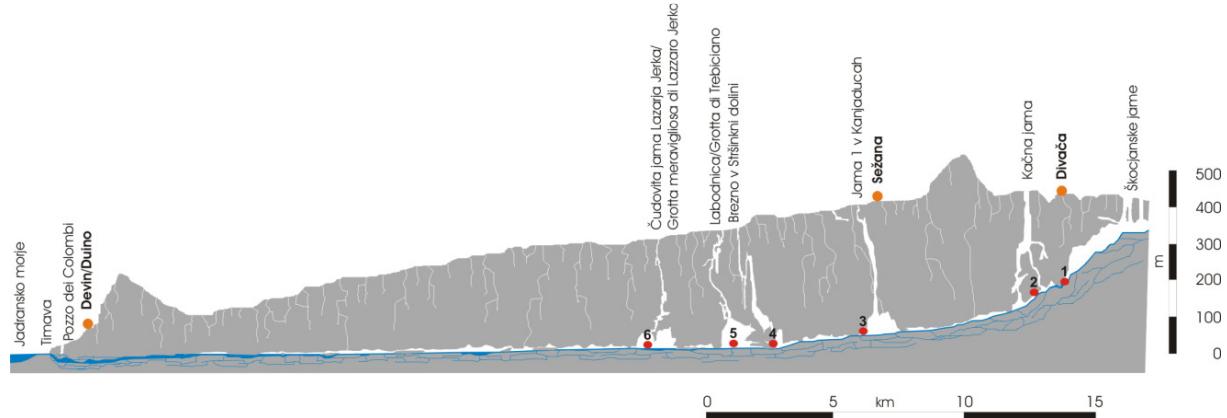


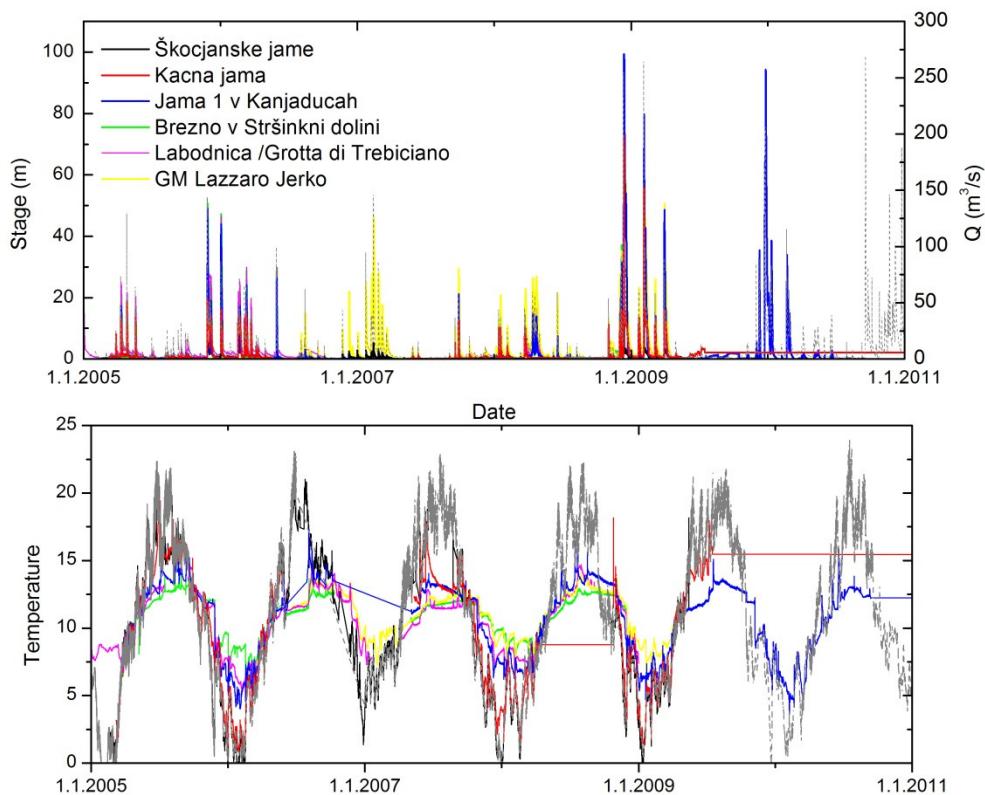
Figure 13: Simplified cross-section of the Kras plateau with main caves and measurement points.

Reka along with autogenic water infiltrates into Kras plateau, and surfaces again at springs along the NW coast of Adriatic, mainly at the springs of Timavo about 35 NW from Škocjanske jame. Springs of Timavo are also recharged from the Soča, Vipava and Raša rivers. Three main springs

with mean discharge  $30.2 \text{ m}^3/\text{s}$  are connected by a network of passages that reach a depth of about 80 m below the sea level.

Along the underground course of Reka river, several caves, up to 340 m deep, reach the ground water level (Fig. 13). In five of these caves automatic measurements of water level, temperature and specific electric conductivity have been established between 2005 and 2015. Škocjanske jame are characterized by large underground canyon, while Kačna jama is a system of water and large dry galleries along several several levels. In Jama 1 v Kanjaducah the underground flow can be followed for over 600 m along a large galery. Other caves have no distinct flow and could be (to some extent) regarded as a natural piezometers, but they are characterized by large chambers at the position of groundwater level.

The system itself is not yet equilibrated with the extreme variability of recharge, therefore it is characterized by large oscillations of ground water levels, which in some caves surpass 100 m. General overview of response to flood events is shown in Fig. 14, where levels and temperatures in caves along the underground flow is presented. Note the rapid response of the system to flood waves and distinctive yearly temperature oscillations throughout the system. Clear diurnal temperature oscillations can be observed as far as to Jama 1 v Kanjaducah when the flow rates are above  $10 \text{ m}^3/\text{s}$ .



*Figure 14: Water level and temperatures in the observed caves.*

A more detailed look into a typical flood event is shown on Fig. 15. One sees that the upper part of the system behaves considerably different than the lower part. The elevation of observation points in Škocjanske jame and Kačna jama are 214 m a.s.l. and 157 m a.s.l. respectively. In these caves the flooding is controlled by the local restrictions. Kačna jama reacts to small flood pulses, as the sump which drains low water floods at flow rates above  $20 \text{ m}^3/\text{s}$  and the water rises for about 10 m to the position of an overflow channel which drains the high waters (Fig. 16). The observation points in other caves are at altitudes between 30 m a.s.l. and 10 m a.s.l. These caves react quite

uniformly to all medium and large flood events. The rising and recession limb demonstrate well connected system with relatively uniform water table (Fig. 15) within the lower part of the aquifer.

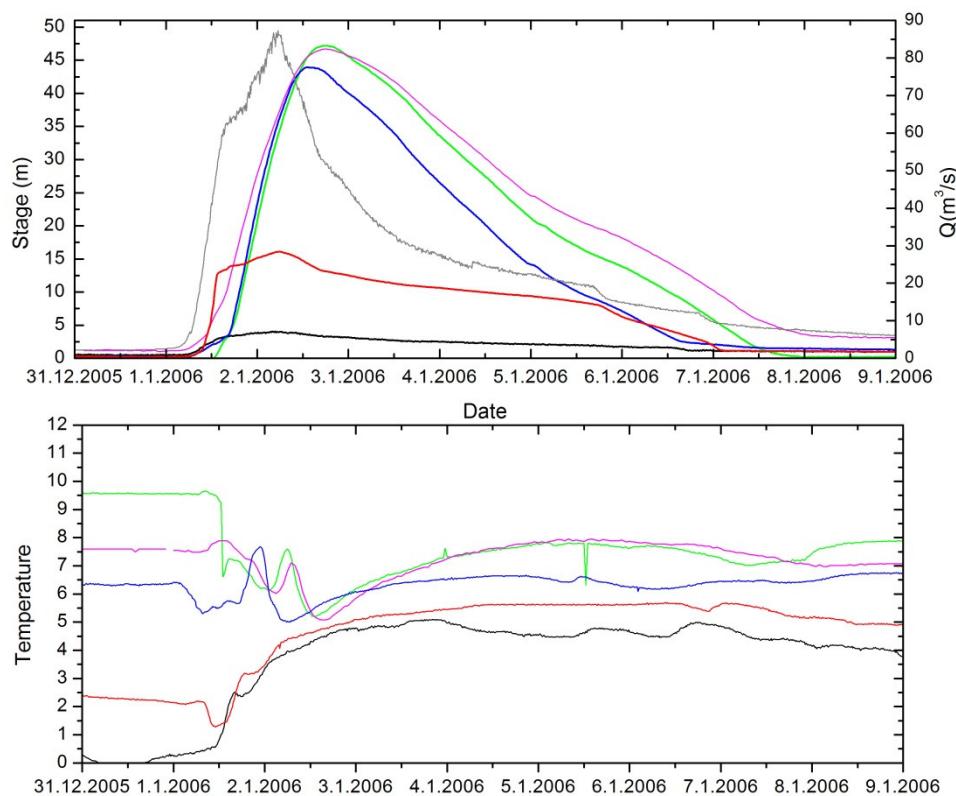


Figure 15: Response of the system to a medium scale flood event in the January, 2006.

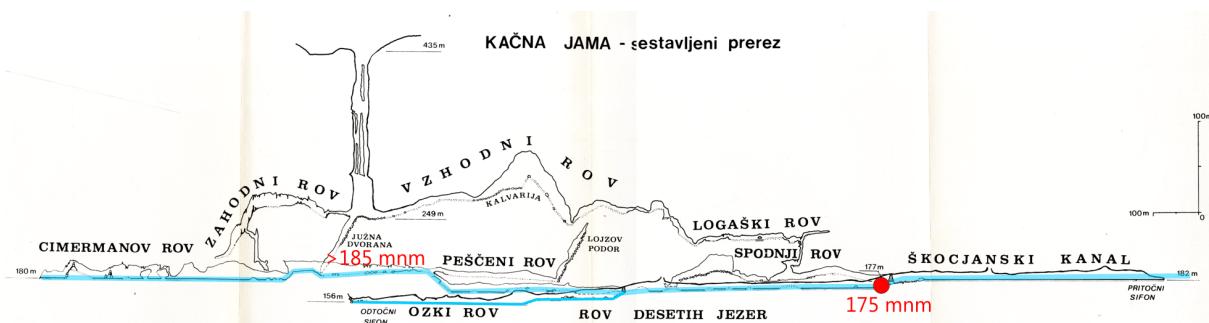
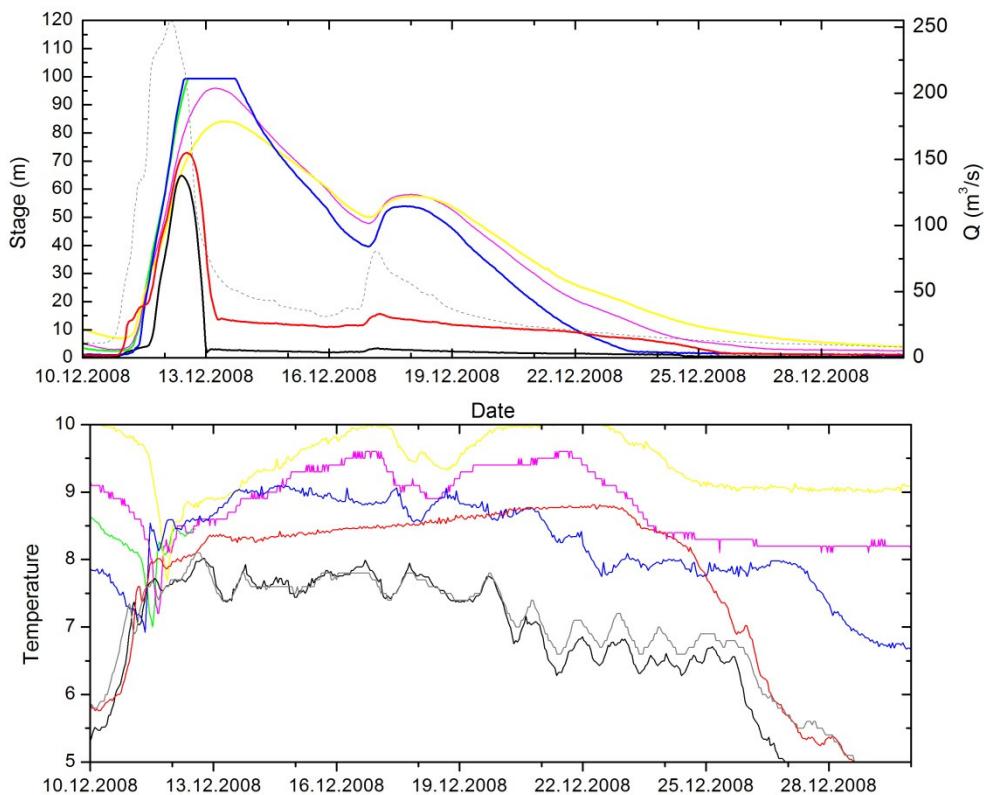
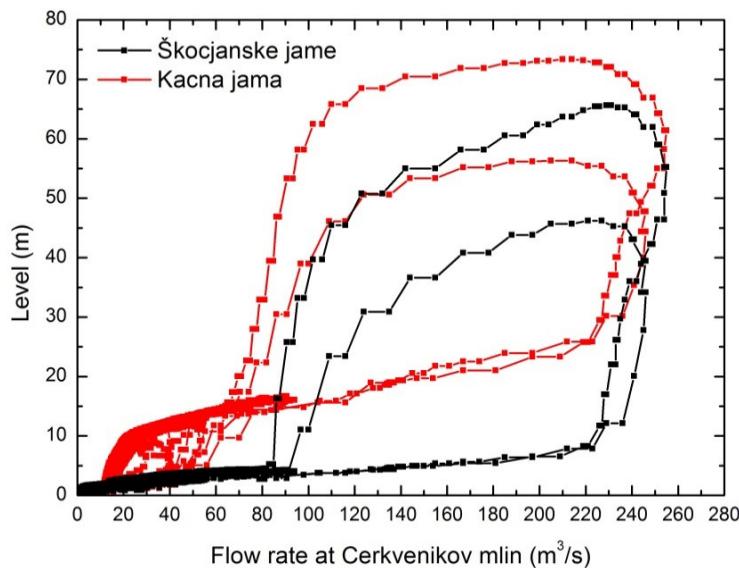


Figure 16: Simplified cross-section of Kačna jama, showing the position of observation point at 175 m a.s.l., the flow path of low waters through the Ozki rov to a sump, and the position of overflow channels (185 m a.s.l.) which drains the high waters.



*Figure 17: The passage of the highest flood recorded in all caves.*

Fig. 17 shows the largest flood recorded simultaneously in all caves that occurred in December 2008. Again, caves of the lower part of the aquifer react similarly, the loggers in Jama 1 v Kanjaducah and Brezno v Stršinkni dolini reached the limit of measurement range at 100 m. The maximum level in these caves surpassed 120 m. This is one of the rare events when the level in Kačna jama and Škocjanske jame rose beyond a level of medium floods.



*Figure 18: Water level in Kačna jama and Škocjanske jame versus flow rate of Reka at gaging station at Cerkvenikov mlin.*

Fig. 18 shows stage in Kačna jama and Škocjanske jame during two large flood events in December 2008 and January 2009. The graph clearly shows that the large level rise in both caves occurs, when recharge is higher than  $220 \text{ m}^3/\text{s}$ . We have also concluded that the increase is caused by a common restriction, probably beyond the Kačna cave.

Last, but not least. Most of these caves would probably never be known without the water level oscillations. All large chambers and galleries weree discovered through digging along the small fissures and shafts of the vadose zone. The only lead was the airflow pushed out of the large chambers during rising of the water level. An example is shown in Fig. 19 for a medium flood event in November 2005. The airflow (wind) and air pressure were recorded at the opposite sides of the boulder chock that separates the entrance (wind) and a large inclined gallery (baro) that dips steeply all the way down to the level of the Reka river. The boulder chock was broken through after a more than a century of attempts in 2003 by the cavers of the Sežana caving club. The graph clearly shows increase of pressure and wind velocity during rising of the water level.

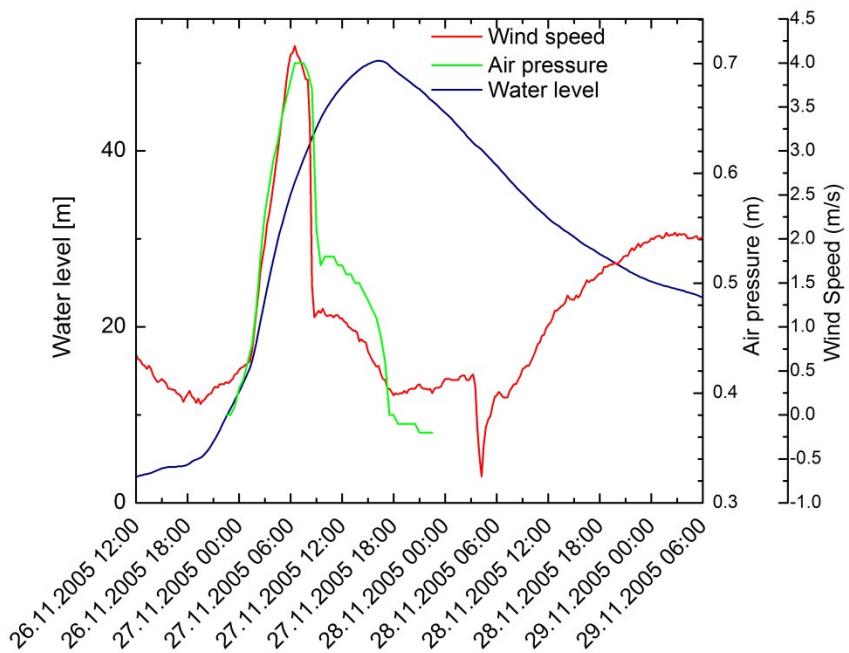


Figure 19: Water level, air pressure in main gallery and wind velocity at the entrance to Jama 1 v Kanjaducah during a medium flood event in November, 2005.

### Risnik and collapse dolines above Kačna jama

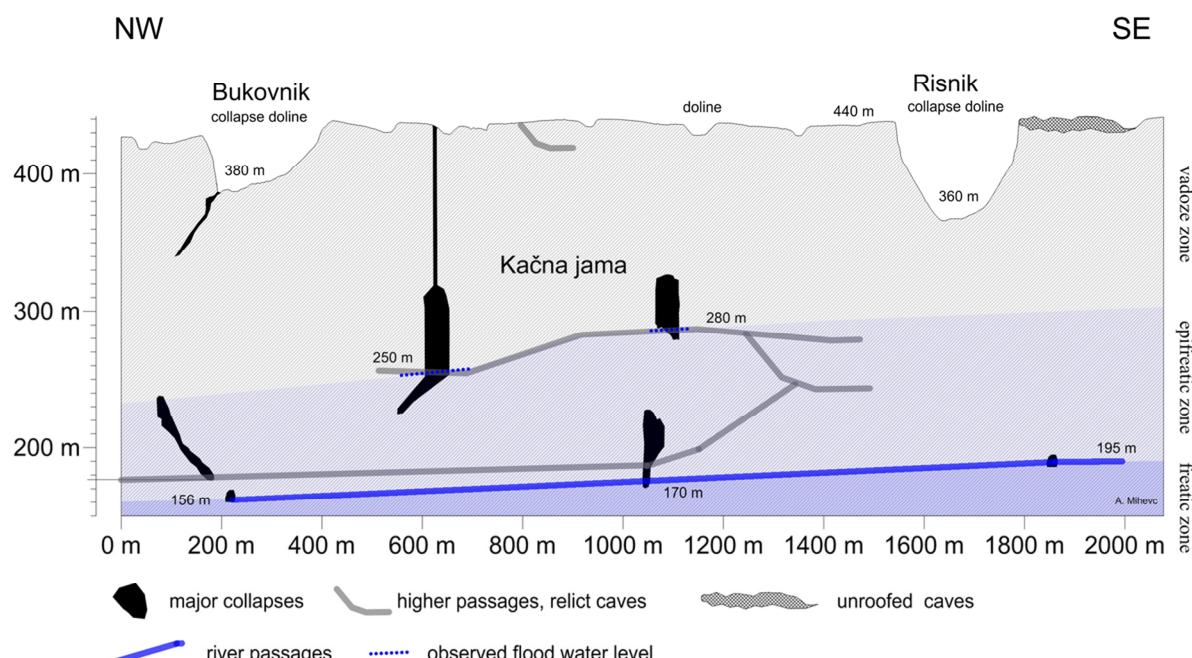
Andrej Mihevc

Main morphological element of the Divaški kras is levelled surface with inclinations less than 10°. This type of surface represents about 88% of the total area and tells us that in present conditions levelling is the main geomorphic process. The most abundant morphologic features on the levelled surface are dolines, they cover about 12% of the area. The dolines have different genetic origin; they evolved as solution dolines (7%), dolines t formed by denudation of the rock above the caves (0.16%) and collapse dolines (5%) which are formed by speleogenetic processes. They present also the largest amount of missing rock in the surface.

Good place to study the formation collapse dolines, large rooms and passages is Kačna jama cave where water oscillates for 136 m (Fig. 20)

The evolution of large chambers by collapsing and collapse dolines is a result of combination of several factors and not just simple collapsing because of rock failure in the cave ceiling. It can not be treated as decay of caves only, but as a distinct speleogenetic and later geomorphic process. Observations show that the collapses in cave chambers or collapse dolines developed in fracture zones through which the water was penetrating, corroding the rock, make it loose and make it ready to collapse. The same conditions are necessary for the chamber or collapse doline formation. The collapse rocks are dissolved on place or transported away as particles by the underground river. Some collapse chambers developed in phreatic conditions and continue to developed in epiphreatic conditions where flood waters are oscillating. If abandoned by the river and left above the oscillating karst water, the collapsing stopped or was slowed down, especially if the fractured zones were cemented by flowstone.

Collapsing begins already in early stages of cave genesis. By the general lowering of the karst water level these most favorable conditions move downwards. Later collapses occur when aggressive flood or vadose water corrodes and destabilizes the ceiling or when denudation lowers surface and thin cave ceiling.



*Figure 20: Schematic cross section through Kačna jama showing collapse dolines and large room in the cave in connection to water level oscillations (Mihevc 2009). Volume of Risnik is 1.7 Mm<sup>3</sup> and volume of Bukovnik Mm<sup>3</sup>.*

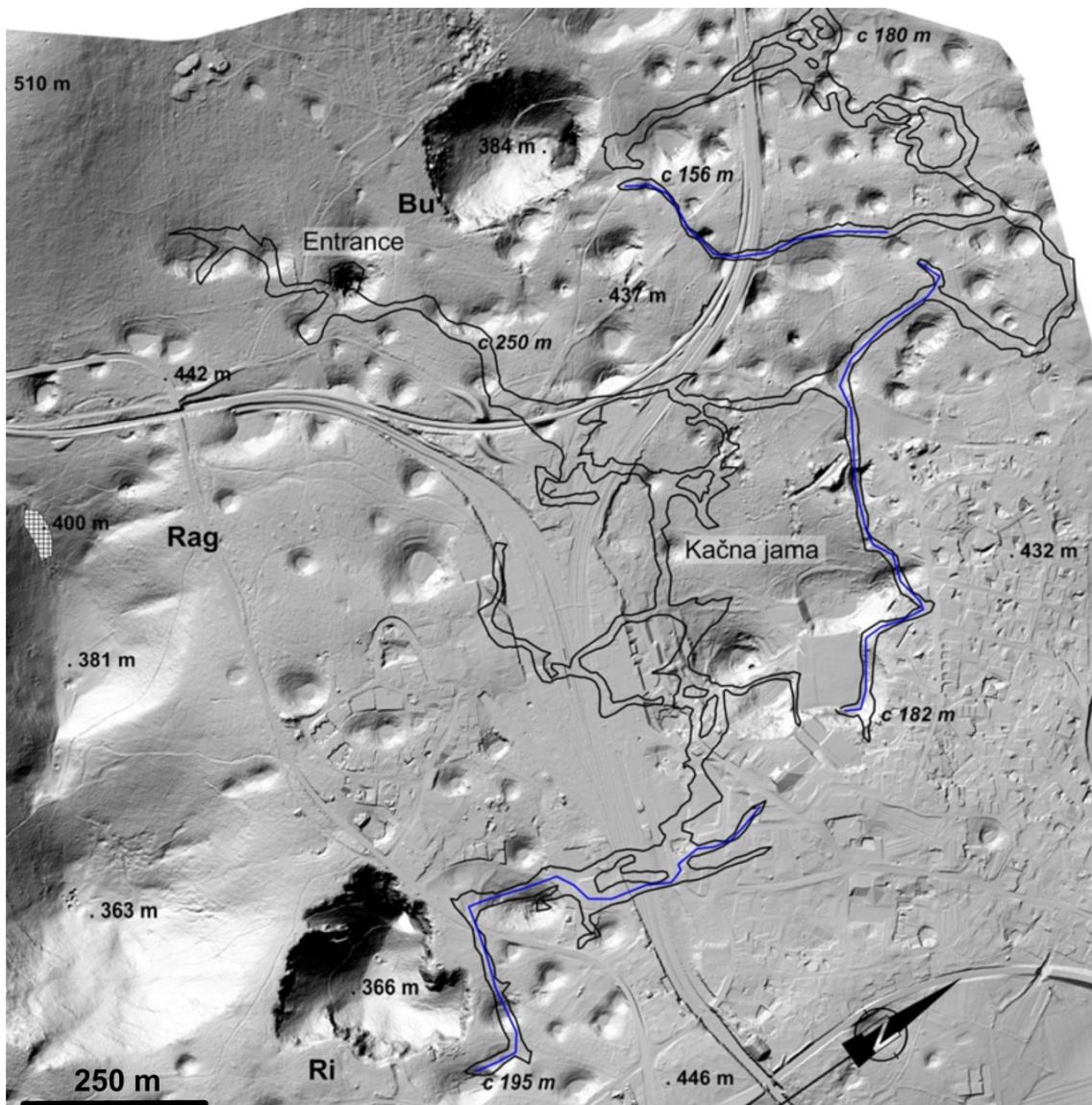


Figure 21: Surface of Divaški kras with outline of Kačna jama cave and the position of collapse dolines Risnik (Ri) and Bukovnik (Bu).

## Grotta Gigante – Riesengrotte – Jama v Briščikih

Alessio Fabbricatore, Franco Cucchi

Three names to refer to the show cave: *Grotta Gigante*, *Riesengrotte*, *Velika Jama v Briščikih*. The name *Riesengrotte* given by the first explorers; *Velika Jama v Briščikih* is the Slovenian toponym; *Grotta Gigante* is the Italian translation of *Riesengrotte*.

The cave is situated in north-east Italy:

*Borgo Grotta Gigante* 42/A, in the municipality of *Sgonico*, province of Trieste.

lat 45°42'35.6249" Nord

long 13°45'52.3286" East (map datum WGS84)

entrance level 274.00 m a.s.l.

The *Grotta Gigante* is, together with the springs of the *Timavo* and the *Škocjanske Jame*, the symbol of the Classical Karst, an area which is well-known for the peculiar development of its karst features.

Here, the slow, dissolving action of water has created a variety of landforms (some of exceptional size) which have no equal, thereby making this area (i.e. the Slovenian, Trieste and Isonzo Karst) the karst area par excellence, where extremely karstifiable limestones create all possible surface and underground karst landforms, whose density, size and type have made the area a universal symbol of karst phenomena. After all, the springs of the *Timavo*, celebrated in antiquity by Latin poets, represent, in our mind, the often rapid outflow of water from the thousands of caves, fed by rain and by the Upper Timavo River (the *Reka*), which sinks into the impressive swallow-hole of the *Škocjanske jame* in Slovenia, (a U.N.E.S.C.O. World Heritage Site) and after an uncharted, underground route of over 40 km, resurfaces in San Giovanni di Duino in Italy and then flows into the Adriatic Sea.

The *Grotta Gigante* opens into ultrapure Cretaceous limestones, a lithotype surfacing over most of the north-central area of the Trieste Classical Karst and whose surface and underground karst phenomena are particularly important. The cave has a planimetric area of 719 m and reaches a maximum depth of 252 m. It consists of a large chamber (167.60 m long, 98.50 m high, 76.30 m wide and with a volume of approx. 365,000 m<sup>3</sup>) which may be accessed by means of two wide galleries. Other galleries branch off from the main rooms. The present tourist exit is a gallery, inhabited from the Neolithic to the Iron Age, that leads to the ceiling of the *Grande sala / der große Dom* and has many branches, a large one which has been obstructed by clay deposits and another one characterised by rich concretions and rooms in which animal bones have been found. The *Grotta Gigante* formed by the ancient work of extinct underground rivers, was partly explored in 1840 by Anton Friedrich Lindner, who was searching for the underground water of the Trieste Karst for the water supply of the town, whose population had greatly increased under the Habsburg Empire. Here, the first important studies on Karstification started on an international level: that is why the science that studies the interaction between water and limestone rocks is known as *Karst* all over the world, since it began on the Trieste Karst during the search for underground water. However the vastness and depth of the cave made it an insurmountable obstacle for the exploration techniques of that time. The first, true explorations were carried out about fifty years later when two other accesses were discovered in the place now occupied by the tourist entrance. The present entrance was enlarged in 1904 and, after a few years' work to equip the tourist path, the cave was opened to the public in 1908.

### Origins of the *Grotta Gigante*

The origins of such a wide cave are related to a series of karst processes which have taken place over long periods of time, i.e. at least some million years. Chemical dissolution and gravitational processes occurred, accompanied by great collapses. As regards the *Grotta Gigante*, after a series of gallery entrenchments due to accelerated erosion during the Messinian Event, the collapses,

both from the ceiling and the walls of the cave, formed one large room. This room was also formed by cave collapses and superimposed ancient galleries which had been created over time within the rock mass. Along the left-hand side face of the *Grande sala / der große Dom* it is still possible to see the large rock blocks which were created by those collapses. Thanks to the presence of high stalagmites above the blocks, experts have been able to date the collapse to at least 160,000-200,000 years ago. The next step, perhaps in hundreds of thousands of years' time, will be the creation of a collapse doline. Inside the cave there are also filling deposits made of yellow and red clay.

A stalagmite, 140 cm high and approx. 30 cm wide at the base, which was found tipped over on the ground of the *Grotta Gigante*, was studied with the aim of defining its age and history. Four samples were taken – one at the base, one at the top and two in between – and their age was defined using the Uranium-Thorium dating method, which analyses the decay rates of uranium in thorium. Both elements are radioactive: the former is contained as an impurity in the calcite crystals forming the concretion whereas the latter, insoluble and therefore originally absent, is the result of the decay of the former element. In this specific case, the base age was estimated around 54,000 years old (+/- 10,000), the intermediate area between 20,300 (+/- 3,000) and 19,800 years old (+/- 8,000) and the top around 15,200 years old (+/- 2,000). Furthermore, the morphology of the growth rings shows a sudden increase in growth (5 mm/year on average) around 20,000-18,000 years ago, at the same time as a climate change took place (increase in heat and rain). Besides, the change of inclination of the growth axis shows that between 20,000 and 15,000 years ago a number of seismic events took place which (slightly) changed the dripping point on the ceiling or the ground where the stalagmite was based, thereby deviating its axis. Finally, between 15,000 and 12,000 years ago, the concretion collapsed on the ground and therefore stopped growing.

#### The Grotta Gigante as a laboratory cave

Inside the cave, *pendulums*, i.e. sensitive instruments able to detect the movements of the earth's crust, were installed by geodesist Atonio Marussi in 1959. The *pendulums* provide a unique historical series of continuous measurements of the deformation of the earth's crust.

These instruments are sensitive to deviations from the perpendicular, rotations and shear strains of the cave. Some movements are aperiodic, others regular, such as the Earth Tides caused by the lunar and solar gravitational fields. The upper and lower mountings of the pendulums are at a distance of 95 m, and this enables the instruments to detect tectonic movements with high precision and make them relatively immune to some of the noise which affects smaller instruments. The pendulum beam is suspended horizontally by two steel wires, the upper one fixed to the ceiling of the cave, the lower one fixed to the floor. The pendulum beam rotates in a horizontal plane around a virtual, nearly vertical axis that passes through the upper and lower mounting points. The Earth's crust (the outer brittle layer of our planet, on average 35 km thick in continental areas) moves up and down by 10 cm during the day due to the attraction of the Moon and Sun, and is accompanied by local tilting of some parts in the order of some billionths of a radiant. The movements of the pendulums have helped us to recognize the free oscillations of the Earth and the North-West direction of the long-term tilting of the cave. The marine tides of the Adriatic have a loading effect on the cave, as well as the underground karstic floods of the *Timavo* which disappears underground at the *Škocjanske jame*. The *Grotta Gigante* tiltmeters are the only existing instruments to have recorded four of the five largest earthquakes in the last 50 years: the 1960 Chile earthquake (the largest earthquake ever instrumentally recorded) and the 2010 Chile earthquake (the fifth largest megaquake recorded world-wide), the one that caused the Tsunami in the Sumatra- Andaman islands in 2004 (third largest quake) and the one in Japan in 2011 (fourth largest quake), allowing an absolute-amplitude comparison of these events. These measurements are carried out by *Department of Mathematics and Geosciences of the University of Trieste and the National Institute of Geophysics and Volcanology*.

Inside the cave you can also find the digital, broad band *Seismographic Station* run by the *National Institute of Oceanography and Experimental Geophysics* and the *Department of*

*Mathematics and Geosciences of the University of Trieste*, thanks to a cooperation agreement. The Geophysics Station is also equipped with two clinometers, which monitor the rotation movements of the cave on the horizontal plane.

The presence of water in the Karst area is measured by instruments located in a side pit (*Pozzo Coloni*) of the *Grotta Gigante* enabling continuous monitoring of the waters filling the cavities during and after precipitation. Measures are carried out in collaboration with the researchers from the University of Trieste. These instruments are part of a monitoring network measuring the Karst waters from the swallow-hole of the River *Reka* in the Škocjanske jame (Slovenia, about 30 km SE of the *Grotta Gigante*) to the springs near San Giovanni di Duino (Italy, about 10 km NW of the *Grotta Gigante*). These waters, whose underground course is known only in specific points (e.g. at the bottom of caves in Slovenia and in Italy), flow very slowly under normal conditions, but at a speed of 23 cm/s during flood events.

Outside the *Grotta Gigante*, in the surrounding green area, you can find:

- a) *the Climatological Observatory of the Karst*, which has been operating since 1966, is part of the regional meteorological network of Friuli Venezia Giulia and the Trans-European network. The traditional mechanical instruments have been complemented by a new-generation, electronic meteorological station equipped with GPRS data transmission and real time data display on the Web and on the maxi screen in the waiting room of the Visitors reception centre. Located at a height of 275 m above sea level, *Borgo Grotta Gigante/Briščiki* has an average temperature of 12.3°C (during the normal period 1971–2000) and a total precipitation of 1,342 mm distributed on average over 131 days, 7 of which snowy. On average, there are 60 days with a minimum temperature below zero, and 20 days with a maximum temperature above 30°C. The minimum temperature (-14.9°C) was recorded on 14<sup>th</sup> January 1968, whereas the maximum temperature (37.8°C) dates back to 12<sup>th</sup> August 1998.
- b) *the Epigean station* for the study of limestone erosion and surface change rates, which has been operating since 1979, investigates the extent of the lowering of limestone rock surfaces due to meteoric water. Measurements are collected using the so-called Micro Erosion Meter (M.E.M.), built by local researchers following the lines of a former English project. The instrument is equipped with a dial gauge. Data indicate mean erosion rates ranging from 0.01 mm/yr to 0.05 mm/yr for limestone and up to 1 mm/yr for gypsum. Erosion rates very depending on the minero-petrographic characteristics of rock and location. Mean lowering rates during the first 30 years of surveying range between 20-30 micron/year. Measurements are taken in accordance with the *Department of Mathematics and Geosciences of the University of Trieste*.

It is also worth mentioning:

- The studies concerning the radiography, by means of cosmic rays, for the *Chooz experiment*, which enabled to carry out a *Muon radiography* of the *Grotta Gigante*, i.e. the reconstruction of the shape of the cave's vault from the measurements of the flow of cosmic rays coming from various directions, which were compared with available geological data. The radiography was carried out thanks to the collaboration between the O.G.S. Trieste and the *National Institute of Nuclear Physics*.
- The archaeological studies, carried out by the *Regional Direction for Cultural Heritage and Landscape of Friuli-Venezia Giulia, Superintendence for Archaeological Heritage of Friuli-Venezia Giulia* and by the *Department of Humanities - University of Trieste*, which show that the *Caverna superiore / pečina pri Mainci*, was used from the Neolithic Age to Bronze Age. Here, among other things, human remains and fragments of pottery were found, dating back to the ancient

Bronze Age. A peculiar ceramic object, defined as Brotlaibidol in literary sources, probably dates back to the same period (from 20<sup>th</sup>/19<sup>th</sup> to 16<sup>th</sup> cent. BC). Very few specimens of these

relics exist in Italy and relatively few in the rest of Europe. There are numerous theories on the function of this object: a stamp, a diastimeter, a support, a bread idol, an amulet.

- The palaeontological studies carried out by the *Natural History Museum of Trieste* led to the discovery of remains of domestic animals (oxen, dogs, pigs, horses, goats, sheep, birds) of unknown age and the remains of the *Ursus spelaeus*, the symbol of Karst biodiversity in the Pleistocene Epoch. The rudists, bivalves typical of the Mesozoic Era, which lived in marine environments from the Jurassic (150 million years ago) to the Cretaceous (65 million years ago), can be admired walking on the tourist path "*Sentiero Finocchiaro*".
- The biology stations: underground fauna and flora, i.e. *Lampenflora*. The presence of the *Lampenflora*, which represents an alteration in the fragile underground environment, is continuously studied and monitored thanks to the collaboration with *Department of Life Sciences of the University of Trieste*.

As regards the cave's fauna, researches carried out since 1895 have shown the presence of about forty different species, which make the *Grotta Gigante* one of the richest and most investigated caves of the Trieste Karst. Recent researches have confirmed the compatibility between the tourist use of the cave and the presence of specialized cave fauna, which in some cases is even favoured by the presence of material introduced by man (eg. decaying wood).

As regards the cave's flora: in the first part of the entrance of *Grotta Gigante*, where there is more light, flowering plants prevail, among which ivy (*Hedera helix*) is very common. As you go down the steps of the entrance to the cave, and temperature and humidity gradually reach the cave's typical levels (11°C and 98% relative humidity), flowering plants tend to disappear and you will find a zone characterised by ferns, such as the maidenhair spleenwort (*Asplenium trichomanes*), followed by a zone characterised by bryophytes (mosses and liverworts).

- The laser scanner survey carried out in 2011, which enabled to obtain the actual measures of the cave, with a very high degree of precision, and to carry out a virtual, interactive video, which can be watched on a computer, for those who are physically unable to walk down the many steps of the tourist path. The video is also used during educational activities.
- The monitoring of radon. In 2008 the *Environmental Protection Agency of Friuli Venezia Giulia* (ARPA FVG) carried out a radon survey, thereby excluding any risk for visitors or guides. In fact, the average annual concentration values were beneath the limits established by law (500 Bq/mc). Measurements were taken along the entire tourist route, especially in those areas where people stop.

In the 2009–2012 period, further scientific investigations were carried out in other areas of the cave, thereby showing: the presence of very high values in secondary branches of the cave (that are not accessible to the public), with great differences between one place and the other; a high seasonality of radon, with peak values over 30,000 Bq/m<sup>3</sup> in the summer and an average of 100 Bq/m<sup>3</sup> in the winter. These variations, which are certainly connected with environmental and/or climatic factors, still need to be fully understood.



Figure 22: Laser scanning image from the bottom of colonna Ruggero/Rüdigersäule to Sala dell'Altare/Leo Petritsch Halle.

#### The Grotta Gigante as a show cave

The cave was opened to the public in 1908 from: about 150-step limestone staircase welded onto steel railway tracks forged at the beginning of the 20<sup>th</sup> century in Austria, joined the entrance gallery to the magnificent *Grande sala / der große Dom*. The impressive staircases lead visitors inside a natural gallery down to 101.10 m under the surface to discover the huge cave. The beauty of the path is enhanced by the presence of magnificent concretions (the best-known: the *Colonna Ruggero*, 12 m high and with a diameter at the base of 4 m; the *Palma*, 7 m high which seems to be looking for the source of the dripping from the ceiling) and charming colours: white and grey tones due to calcite and ample reddish nuances due to iron oxides. The dozens of stalagmites on the bottom have the shape of a pile of plates, a consequence of the splash dripping from a great height.

At the end of the 90s a path was opened, which begins at the bottom of the cave, continues along the rock face and through an artificial gallery and then goes through a large, natural cave (*Ingresso alto / pećina pri Mainci*) leading to the exit.

In December 2005 the new Visitors reception centre of the *Grotta Gigante* was inaugurated; a structure which was designed and constructed in harmony with the surrounding Karst environment. The Visitors reception centre consists of a Multifunctional Area (ticket office, multimedia room, toilets and guide room), a Museum Area and a Waiting Room from which the entrance to the cave can be reached under cover. The choice of the types of materials and building

methods of the Visitors reception centre was determined by their environmental impact and eco-friendliness, the specific building tradition of this Karst area as well as structural, maintenance and safety requirements.



*Figure 23: Visitors reception centre of the Grotta Gigante.*

An Environmental and Landscape Reclamation of the green area was carried out with the following aims: 1. botanical and environmental; 2. historical and landscape; 3. social and educational.

At the end of 2009 the new lighting system was inaugurated, carried out following rigorous eco-friendly, energy-saving standards. The new electrical system takes into account the reduction of operating costs, by reducing energy consumption, and at the same time the importance of the spectacular effect, by emphasizing the concretions and natural colours of the cave. The paths open to the public are provided with luminous bodies fitted to special supports for emergency and safety lighting and these emergency lamps are connected to a specific uninterruptible power supply exclusively dedicated to this circuit.

Thanks to substantial modernization, maintenance work, expert and competent management, the number of visitors increased considerably reaching 84,583 during 2014.

#### The Scientific Speleological Museum of the Grotta Gigante

In the exhibition areas of the new *Visitors Centre* of the *Grotta Gigante* you will find the *Scientific Speleological Museum*, actually run in collaboration with the University of Trieste. The Museum includes various sections: on the ground floor geology, palaeontology, archaeology, biology and on the first floor the scientific researches conducted in the *Grotta Gigante* site.

The *Scientific Speleological Museum*, is in contact with universities, museums and research institutes, both in Italy and abroad (Slovenia, Austria, Germany, Croatia). Visitors have the opportunity to discover the peculiarities of the local Karst territory, and in particular the use of caves and shelters from the dawn of history to the present age. The explorations and excavations carried out so far tell us, more or less precisely, when a cave or a rock shelter were used; why and how this happened remains a mere hypothesis in most cases. The museum exhibits local

archaeological/palaeontological finds from the Grotta Gigante and the near caves and also testifies to the scientific research carried out by universities and institutes inside the cave or in the Visitors Centre area.

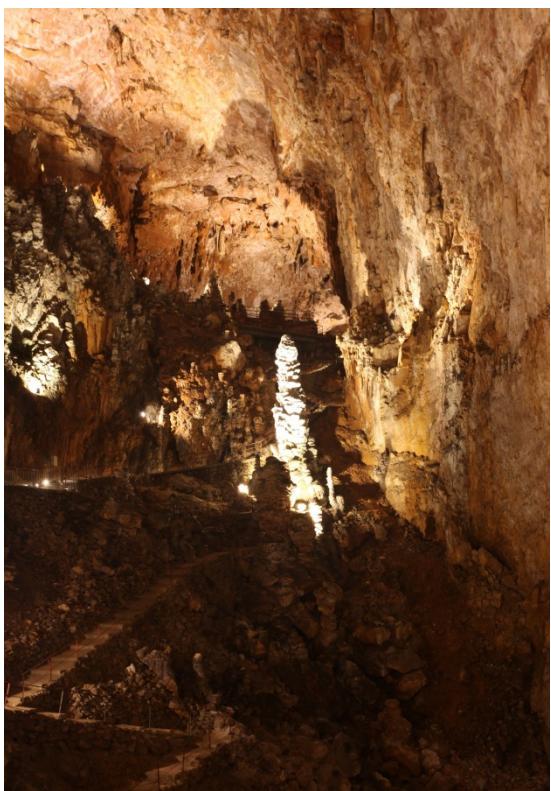
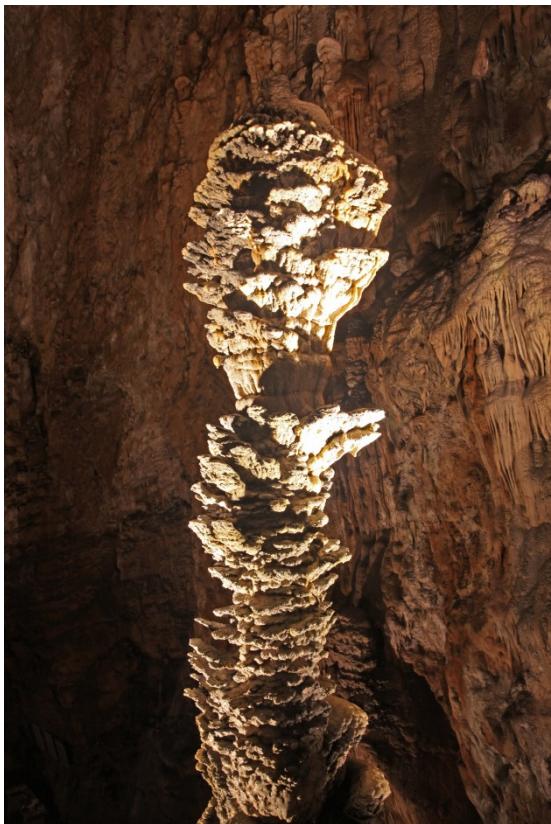
The museum's finds, as well as the archaeological, geological, palaeontological and technical/scientific information boards are there to encourage visitors to deepen their knowledge and understanding of the underground world.

Almost half annual visitors consists of students from schools of all kinds and levels, from preschool to university, for whom special educational programmes have been conceived: special tours, educational geology workshops focusing on Karst phenomena, underground biology, seismology, and mainly aimed at schools so that school trips can actually turn into educational visits for pupils and refresher courses for teachers. The cave guides are trained in order to provide the public with correct information: they are the connection between museum/cave and visitors. For this reason the Scriptum was published: a very concise manual that could improve and qualify the underground tourist offer.

The *Scientific Speleological Museum of the Grotta Gigante* aims at marrying the requirements of underground scientific research and the need to spread scientific culture as the basis of a conscious and environmentally sustainable tourism, in order to hand down the cave to future generations as part of the natural heritage. The management for tourism of a cave imposes a commercial value but must at the same time, imposes an environmentally-friendly tourist development of the delicate underground ecosystem through technical and scientific professional skills and awareness the thousands of people visiting the show cave to the issues related to the underground world.



Figure 24: Georeferenced survey of the cave on aerial photo (23. 8. 2012).



Figures 25–28: *La Palma* (left up), *La Grande Sala / der Große Dom* (right up), *Colonna Ruggero / Rüdigersäule* (left bottom), *Horizontal pendulums* (right bottom).

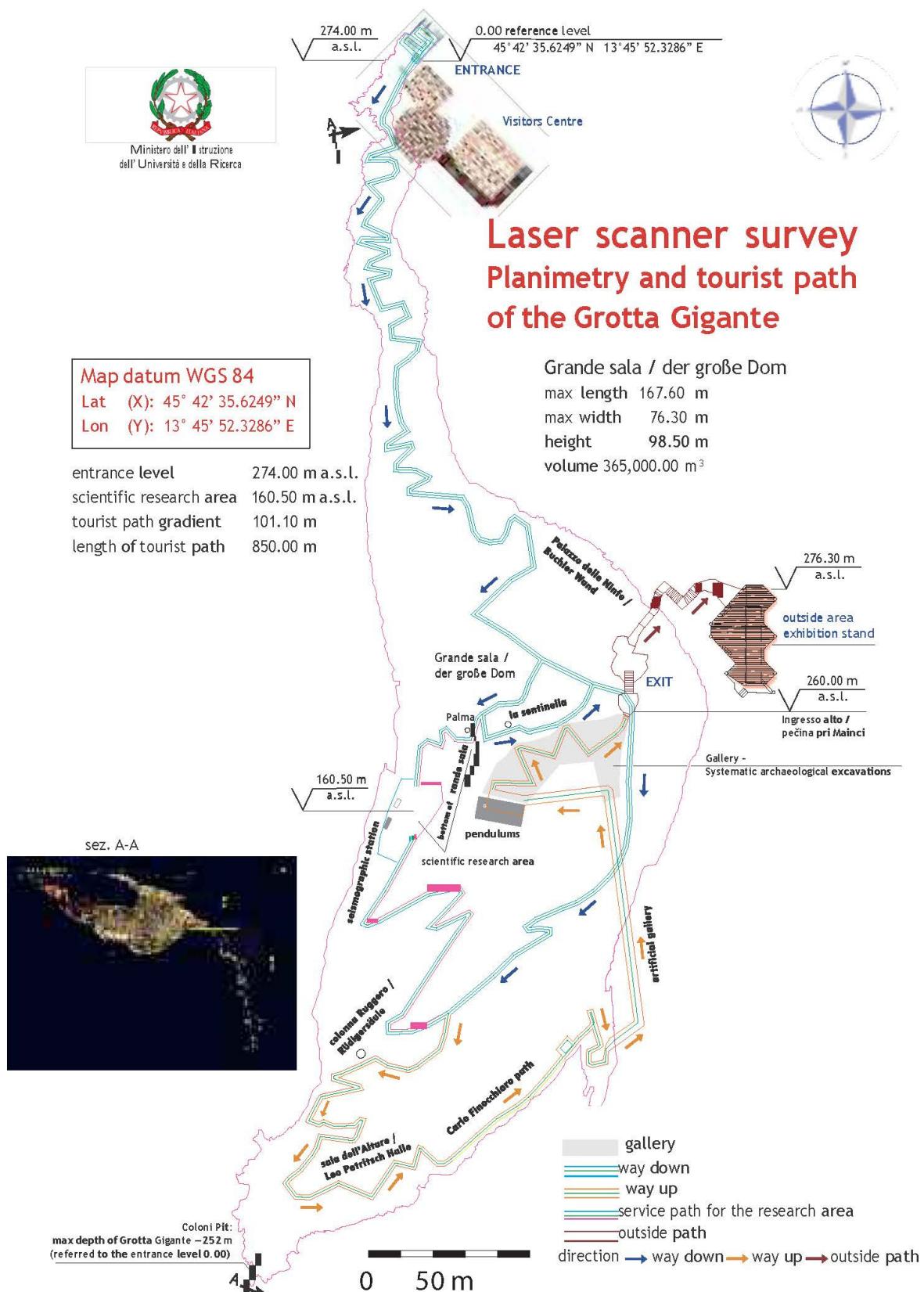
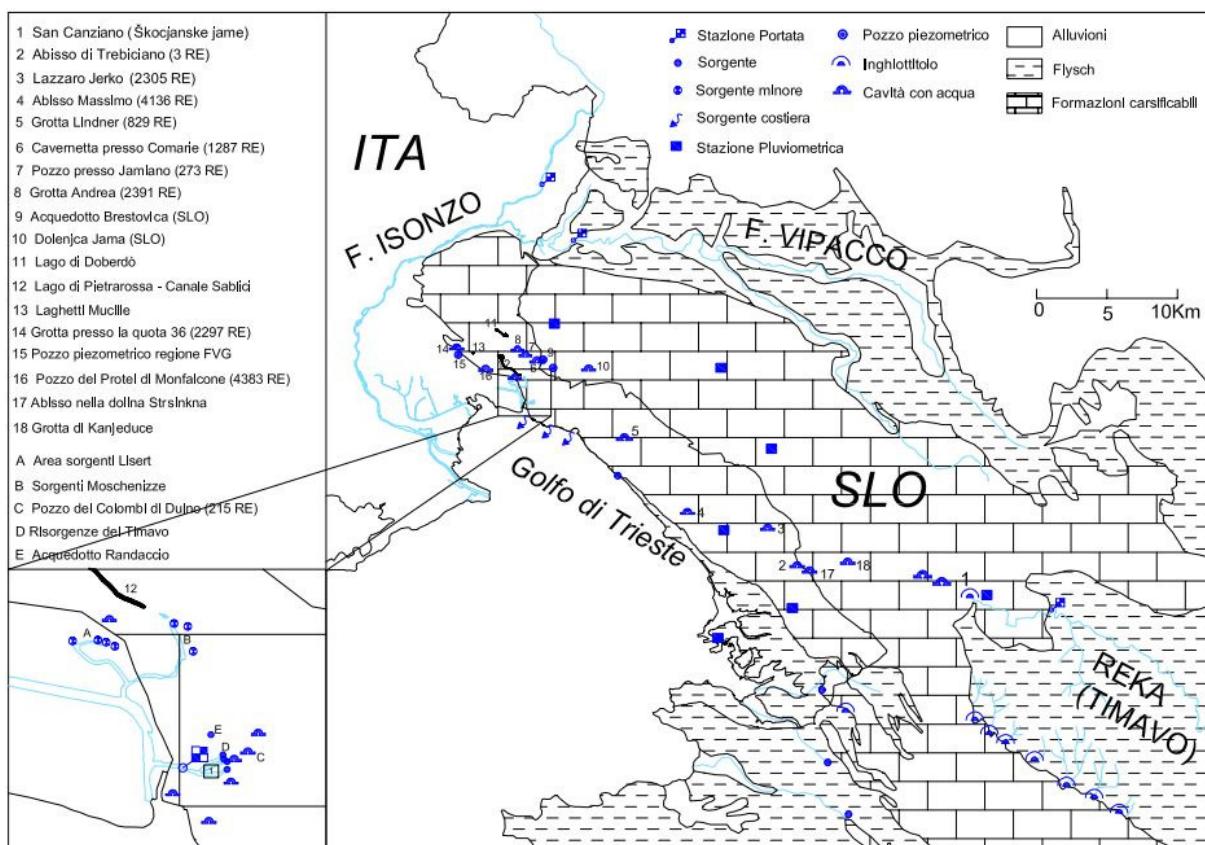


Figure 29: Laser scanner survey. Planimetry and tourist path (23. 8. 2012).

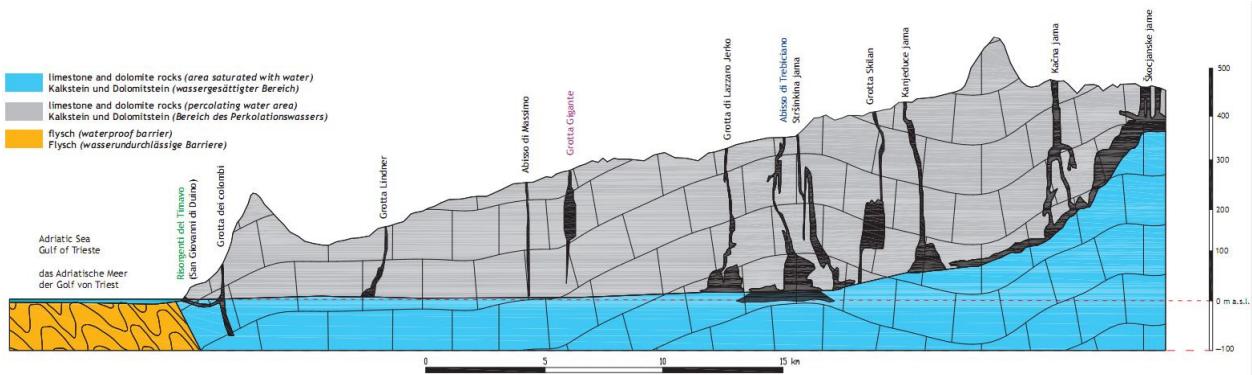
**Springs of the Timavo**  
Franco Cucchi, Alessio Fabbricatore

The Classical Karst is a vast morphokarstic unit that stretches out in the SE–NW direction. It has an almost rectangular shape, covers an area of approx. 600 km<sup>2</sup> and has at least 500/600 m karstified thickness. The Karst is the result of Karst phenomena which have been taking place for over 10 million years: only in the Italian Karst section (less than 300 km<sup>2</sup>) over 3,280 caves are known (150 of which extend over more than 100 metres and half a dozen of which extend over several kilometres), there are over 80 dolines characterised by a width of over 100 metres, and karren which extend over several dozen square km.

The river *Timavo* (the *Reka*) rises from the Mount Dletvo in the group of Mount Snežnik (near the Croatia-Slovenia border) from a series of flysch springs and flows (under the name *Reka*) on the surface, for 55 km over impermeable flysch ground sinking into the *Škocjanske Jame* after having met carbonate rocks. Here it disappears for approx 40 km on an almost unknown course and then reappears at *San Giovanni di Duino* in Italy (first – second – third spring) and flows into the Adriatic Sea. Flowing in this karst region, the Classical Karst, the Timavo river gathers a lot of hypogean water of karst origin and collects hundred of thousands of cubic meters of water from the karst plateau: this has been confirmed by tests carried out daily at Vreme (Slovenia) and San Giovanni di Duino as well as by the chemical properties of the waters.



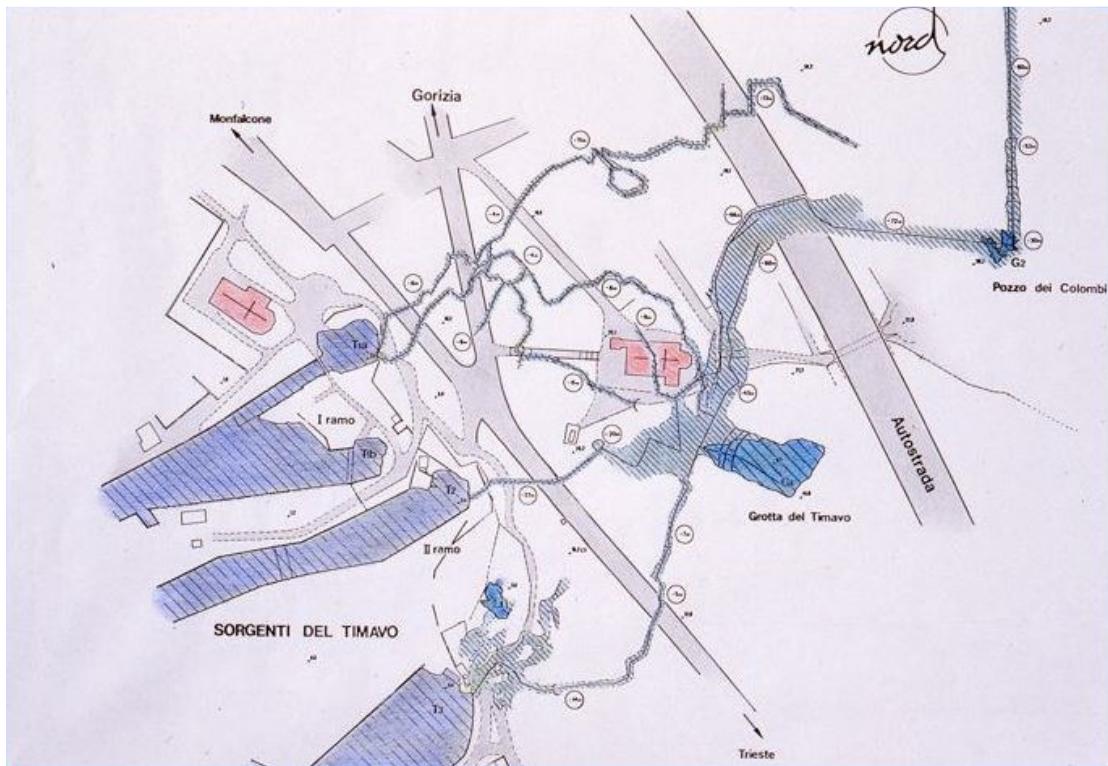
*Figure 30: The water in the Classical Karst. On the map you can distinguish limestones (bricks) from Flysch marlstones and sandstones (dotted line). In the small box the Timavo springs.*



*Figure 31: Hydrogeological section of the Classical Karst with monitored "water points" (red dots). Limestone in grey, Flysch in cream and flooded area in light blue.*

In fact, despite the numerous leaks and springlets verified along the Trieste coast, the flow at the mouth is, on average, three times higher than that at the entry in to the Škocjanske jame: some of these springs have been captured to feed the Trieste water system. Under normal conditions the water moves very slowly, whereas when in flood it can flow up to a speed of 830 m/h.

The connection between the waters entering the Škocjanske jame and those coming out at San Giovanni di Duino was ascertained in the thirties by Eugenio Boegan and the first studies about Timavo we find in his interesting book *Il Timavo* published in year 1938 by Istituto Italiano di Speleologia.



*Figure 32: Map of Timavo springs at San Giovanni di Duino.*

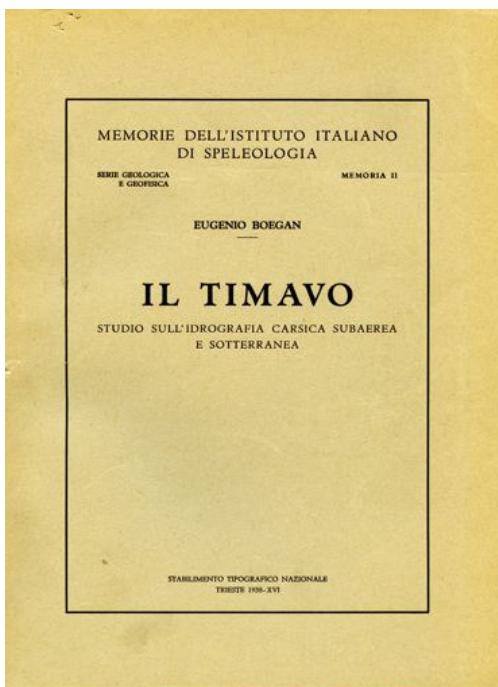


Figure 33: Book II Timavo by Eugenio Boegan.

The difficulties in the study this particular karst environment are significant but in the nineties a study (*Timavo project*) was undertaken by the Società Alpina delle Giulie and the University of Trieste. In the *Timavo project* participated actively: teams of the Federation Francaise d'Etudes et de Sports Sous Marins (FFESSM), of the Labyrinth club from Brno and many international cave divers teams from England, Germany, Italy and Switzerland.

The *Timavo project* took into consideration the hydrology, the geology and biology of catchment area of the Timavo. Up until the 1980s it was thought that the springs of the river Timavo reached a depth of 15–20 metres below sea level. However, cave diving exploration carried out at the end of the 1990s revealed that the *Timavo* springs from a depth of over -82 metres below sea level (maximum depth reached by the cave divers of an international team) and that it flows down even deeper. The collection of data and the survey of approx two km of underground submerged galleries allowed the drawing of a plan of underwater galleries and rooms in the area of the *Timavo* springs which illustrated the presence of many levels of water flow and that the water flows up from a system superior to eighty meters deep.

The survey shows in particular the connection among the first, second, third spring and the *Grotta del Timavo* (4583 V.G.) which is connected with the *Pozzo dei Colombi* (227 V.G.). Very interesting is that in a large tunnel up to a depth of -65 metres some samples of speleothems were sampled (exploration Claude Toulomdjian - French cave divers team in the nineties) demonstrating the presence of an ancient air environment and also that the gallery had been above water level.

Near the village of Divača the River Reka, which has a catchment area of 407 km<sup>2</sup>, sinks into the Škocjanske jame underground galleries for about 6 km. Here it goes through two collapsed dolines, a 3 km underground giant canyon with 26 waterfalls and disappears in the Mrtvo jezero at an altitude of 212 m a.s.l.

Taking into account the fact that the river Timavo/Reka is intercepted in several points, continuous monitoring of its underground waters has been considered of great scientific importance: the Timavo/Reka is intercepted in Slovenia in Kačna jama, Jama 1 v Kanjaducah, Brezno v Stršinkni dolini and in Italy in Abisso di Trebiciano, Grotta Meravigliosa di Lazzaro Jerko and Pozzo dei Colombi (Fig. 31).

During major floods, underground water also penetrates other caves, such as the Grotta Claudio Skilan, the Abisso Massimo, the Grotta Gigante and the Grotta Lindner. In Grotta Gigante, during major floods of the underground river Timavo, the pit Pozzo Coloni, at an altitude of 23 m a.s.l. is partially filled up due to the resurfacing of groundwater.

The aquifer connecting the Škocjanske Jame with the Timavo springs is characterised by flood impulses transferring water within 1 to 3 days. This aquifer presents a highly effective drainage system and fast water replacement, which is indicative of a highly and widely karstified system.

The Classical Karst spring system covers an area of about 10 sq km and includes the Timavo springs in San Giovanni di Duino as well as the many springs feeding the Lisert, Locovaz and Moschenizze channels and lakes Doberdò, Pietrarossa and Sablici.

The Karst basin in which the Timavo flows is very high and therefore it's a natural resource that needs to be monitored and protected.

As a scientific monitoring is very important for the hydrological system, we need to study the hydrological system and control any pollution and try to do our best in order to protect the natural environment.

For this reason a memorandum of intent was signed in June 2010 between the Park Škocjanske Jame, the Grotta Gigante and the University of Trieste in order to collaborate in the monitoring and collecting data and then to compare and publish results and data through web site or special scientific issues or events.

The aim is to monitor all caves where Timavo is intercepted and in particular compare and not only catalogue but study the data and make it available.

The same goal was set by the recent Project HYDROKARST ([www.hydrokarst-project.eu](http://www.hydrokarst-project.eu)), dedicated to defining the quantity, quality and vulnerability of underground water and its catchment for civilian use.

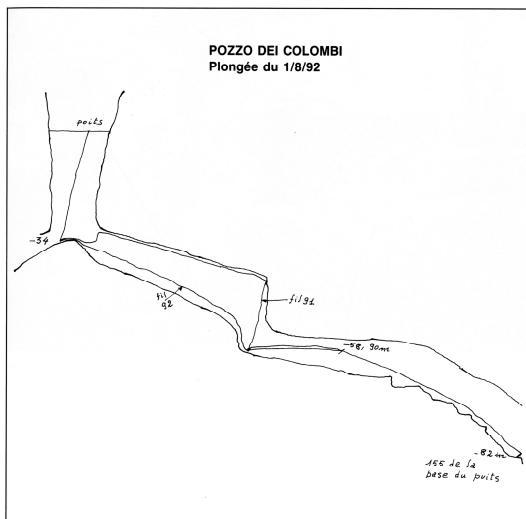


Figure 34: Pozzo dei Colombi. Timavo Project 1992.



Figure 35: Cave diver in Trebiciano.

#### Ritual use of a cave near springs of the Timavo.

The Grotta del Mitreo – a cave on the slopes of Monte Ermada, located about 500 m south-east of the village of San Giovanni di Duino – contains the remains of a Roman sanctuary used to worship Mithras, a Persian god identified with the sun, according to an esoteric cult of oriental origin. The cave was used as a meeting place and it had stone benches along the walls as well as the usual liturgical furniture with the altar depicting the god killing the bull.



*Figure 36: Grotta del Mitreo.*

#### Fons Timavi. Timavo Altar

Since ancient times the area of springs has was an important place of worship. The presence of a river that flowed from the earth was intrigued and frightened primitive people who worshiped Diomede, Hercules, Saturn, Spes Augusta, Libero Augusto and god Temavus.

The Roman authors Livy, Strabo, and Virgil mention the river. Virgil wrote that nine streams emerge from a mountain to form the river.

The small altar, discovered in 1924 amongst the ruins of the castle of Duino, bears witness of the fact that during the Roman period the Timavo River was worshipped as a river god: this is proven also by a series of inscriptions found near the springs of the Timavo River and near the town of Aquileia. As described in the Argonautica, after kidnapping the golden fleece, Jason and his men reached the Adriatic Sea right where there are the springs of the Timavo which, according to myth is a branch of the Danube.

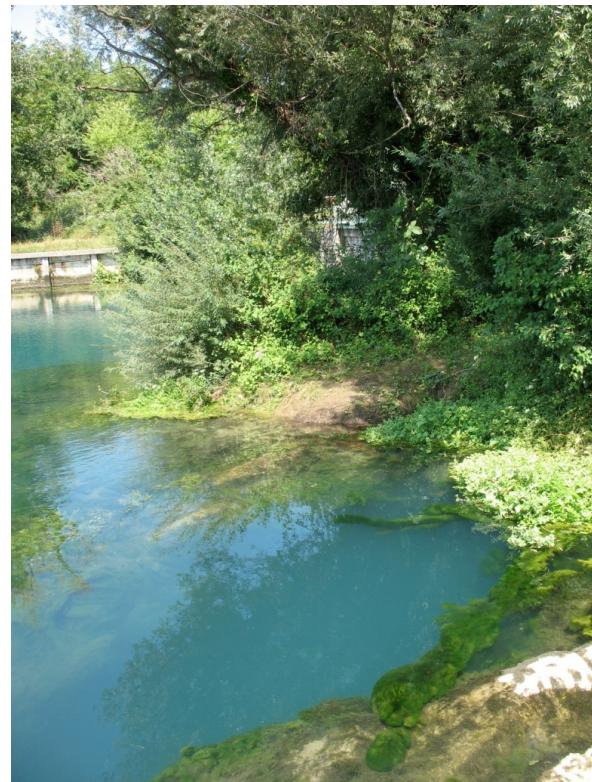
The original altar is visible at the *Civico Museo di Storia ed arte di Trieste*.



*Figure 37: Timavo. Altar.*

### *San Giovanni in Tuba*

The Church of *San Giovanni in Tuba* has been almost completely rebuilt, in part Romanesque architecture, after the end of First World War when it was almost completely destroyed. The church was originally in Gothic style (you can admire some architectural detail), was an early Christian church, which was built on a pagan temple.



*Figure 38: Spring in the Church of San Giovanni in Tuba.*

*Figures 39 & 40: Spring in San Giovanni di Duino.*



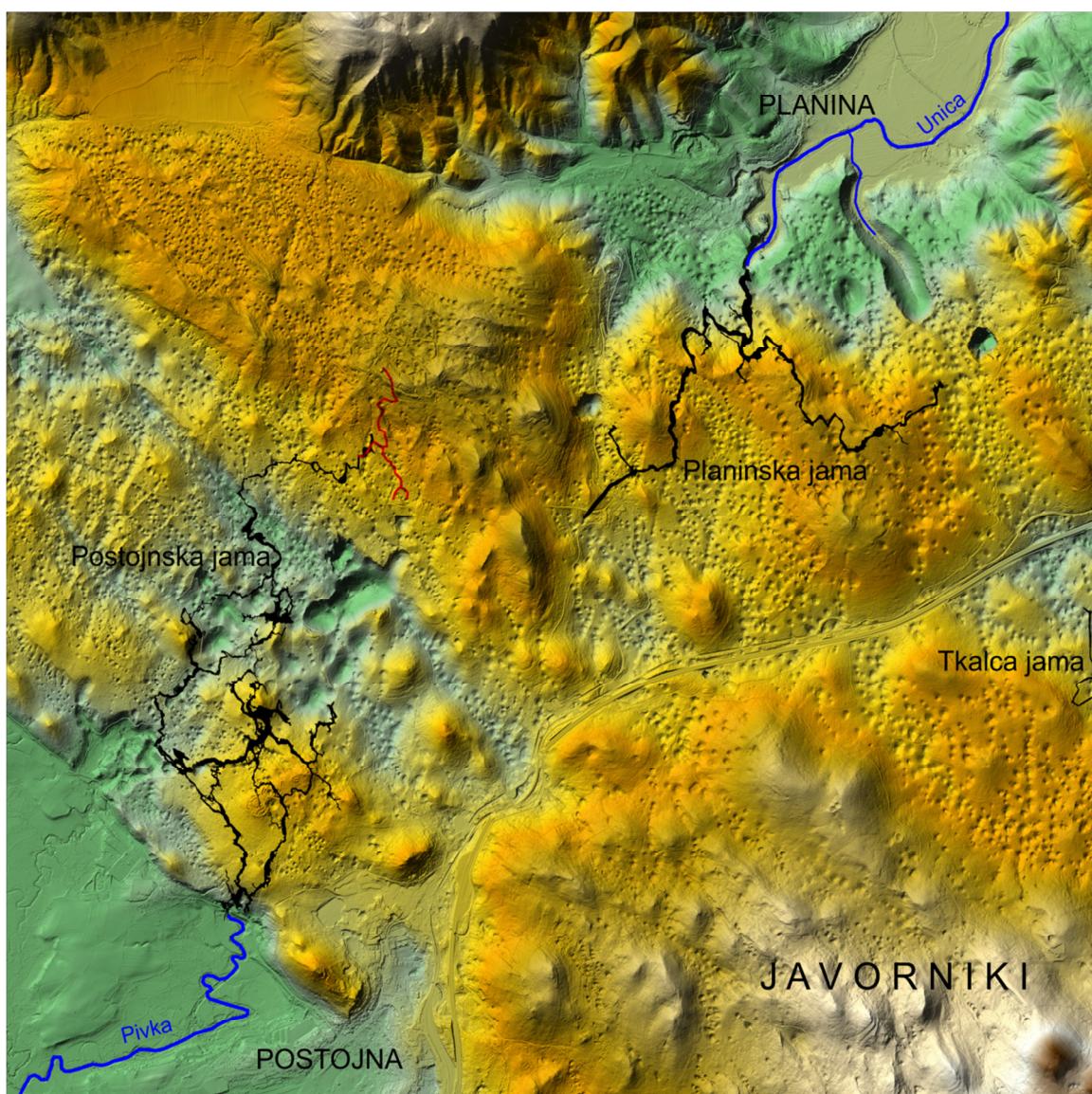
**EXCURSION 4, FRIDAY, JUNE 19<sup>TH</sup> 2015****Postojnska jama**

Nadja Zupan Hajna

Karst Research Institute ZRC SAZU, Postojna, Slovenia

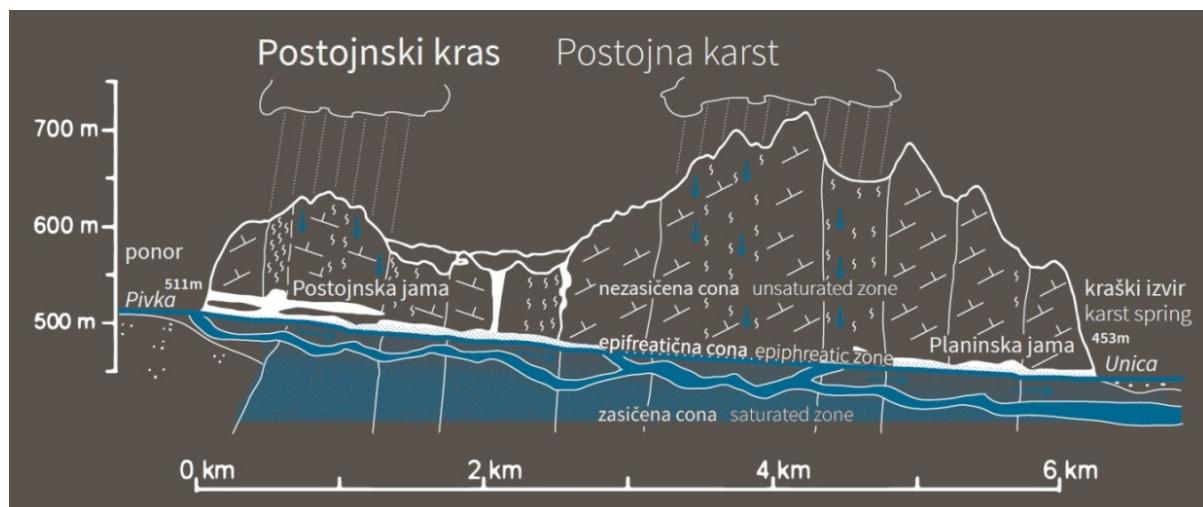
**Location**

Postojnska jama (Postojna Cave; Reg. No. 747) is developed in Postojnski kras (Postojna karst) between Pivka Basin and Planinsko polje. The surface is at about 600 to 650 m a.s.l. The evolution of the Pivka basin (flysch rocks) is defined by the altitudes of the ponors of Pivka river that drain into this cave. The gentle fluvial surface of the basin itself stands out in sharp contrast to the karst lands above the cave and to other higher karst plateaus, where there are no traces of fluvial valleys or other elements of the early fluvial relief today. These surfaces are dissected with numerous dolines. Sixteen large collapse dolines developed above some parts of Postojnska jama, blocking some of the passages. The thickness of bedrock above the cave is 60 to 120 m.



*Figure 41: A geomorphological map of the Postojnski kras between the Pivka Basin and Planinsko polje with the location of caves Postojnska and Planinska jama. Newly discovered passages (Vrhovec & Gantar, May 2015) are marked in red.*

The cave was formed by the river Pivka. Its modern ponor is at 511 m a.s.l. and the sump in Pivka jama (Pivka Cave) is at 477 m a.s.l. There are still more than 1,500 m of unexplored galleries before the river re-appears in Planinska jama at 460 m a.s.l.. In May 2015 the cave divers started to explore the most remote parts of the cave after siphons in Pivka jama.



*Figure 42: An idealized cross section between ponor of river Pivka to Postojnska jama and spring of river Unica from Planinska jama.*

### Geology

Surface geology of the Postojna karst terrain between caves Postojnska jama and Planinska jama bases on studies of Buser *et al.* (1967), Gospodarić 1976, Čar & Gospodarić (1984), Placer (1996), Rižnar 1997 from which results was compiled geology presented on Fig. 43 (Zupan Hajna 2015).

Karst between Postojna and Planina builds up about 800 m thick limestones and dolomites of Cretaceous age. Carbonate beds of various thicknesses are overthrusted, folded and faulted due to regional tectonics (Placer 1996, 2014). Important structural elements of folding are Postojna anticline and Studeno syncline, which are oriented in SE–NW direction. Significant faults are in Dinaric direction (SE–NW; dextral strike-slip fault) and in Cross-Dinaric direction (sinistral strike-slip fault); some of them are vertical.

River Pivka flows on impermeable Eocene flysch and on the contact with limestones sinks into cave Postojnska jama. River Pivka flows underground towards cave Planinska jama, from where then emerges as river Unica. The entire cave is developed in an 800-meter thick sequence of limestones confined by two distinctive dextral strike-slip fault zones in the Dinaric trend (Predjama and Idrija faults). Cave passages were mostly formed following inter-bedded slips (Šebela 1998) in the limestones of the Postojna anticline, which is oriented in the NW–SE direction (Gospodarić 1976). The cave is intersected by several fault zones in the Dinaric and cross-Dinaric direction; some faults were important for guiding the direction of the water flow and for the formation of passages, while others were simply traversed by the water flow. Large breakdown halls in caves are formed in thick-bedded and tectonically collapsed limestones in the fluctuation zone of the groundwater that dissolves the collapsed blocks.

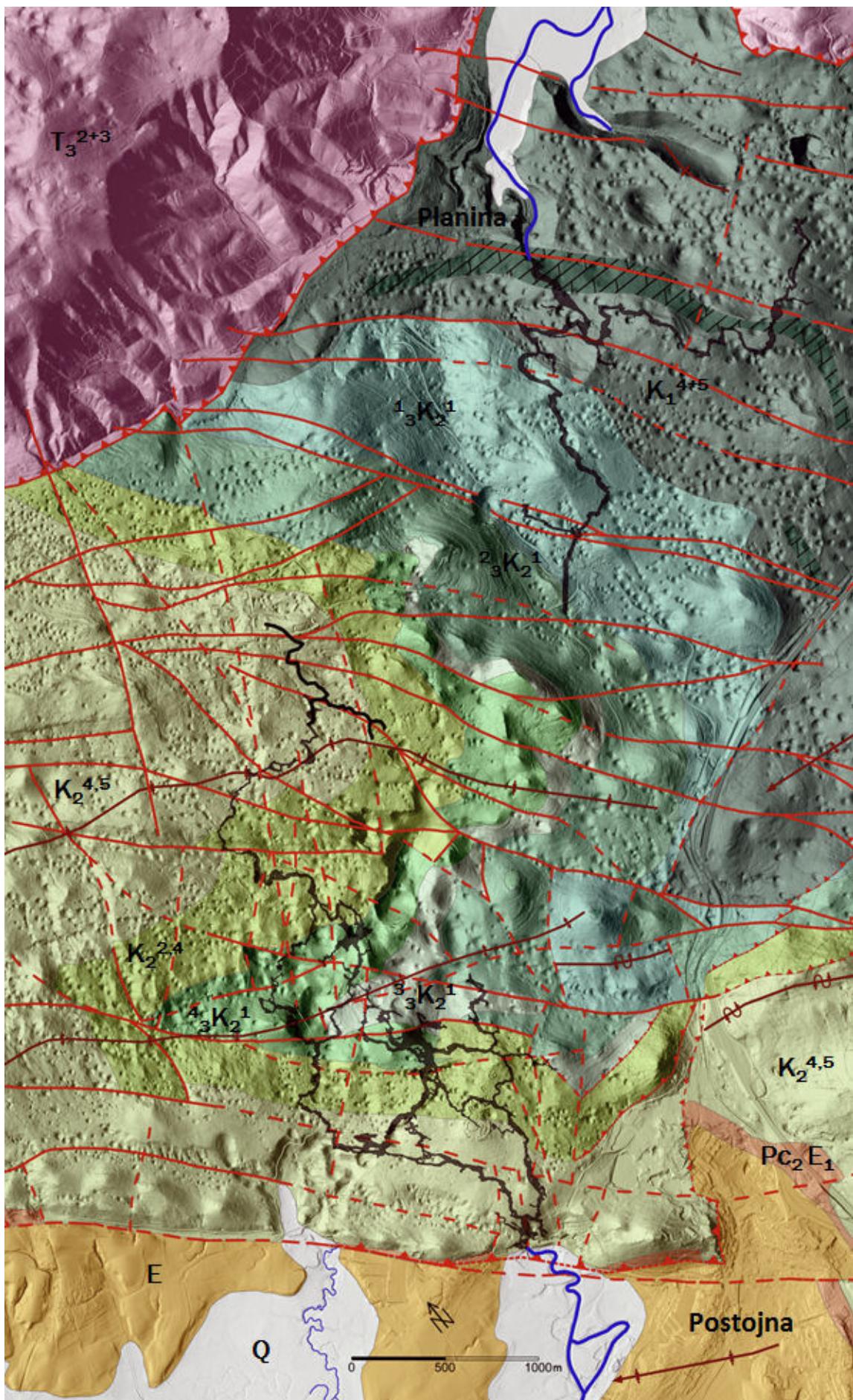


Figure 43: Geology of Postojnski kras with ground plans of the caves (Zupan Hajna 2015).

*Legend to Figure 43: Q – (Quaternary) young deposits; E – (Eocene) impermeable beds of sandstone and marl;  $Pc_2$   $E_1$  – (Paleocene, Eocene) limestone breccia and conglomerate;  $K_2^{4,5}$  – (Upper Santonian, Maastrichtian) very thick-bedded grey rudists limestone and dolomite;  $K_2^{2,4}$  – (Upper Turonian, Coniacian, Santonian) grey micrite limestones;  $^4_3K_2^1$  – (Turonian) white massive limestones (shell debris Chondrodonta);  $^3_3K_2^1$  – (Upper Cenomanian, Lower Turonian) thin-bedded grey limestones with cherts;  $^2_3K_2^1$  – (Lower part of Upper Cenomanian) gray micrite limestone with fossils;  $^1_3K_2^1$  – (Mid Cenomanian) light-gray micrite limestone with fossils;  $K_1^{4+5}$  – (Aptian, Albian, Late Cenomanian) dark grey limestone, partially dolomitized;  $T_3^{2+3}$  – (Upper Triassic) coarse grained dolomite.*

### The cave

The total length of known passages is at the moment (May 2015) more than 22 km and the calculated volume of all cave passages is 1.7 million cubic meters (Glažar & Drole 2015). The passages were formed in two levels. The upper dry section of the cave lies between 520 and 530 m.

The altitude difference between the highest point at the entrance to Magdalena jama and the lowest point at the siphon in Pivka jama is 115 m. The distance from the ponor of River Pivka into Postojnska jama to the siphon in Pivka jama is approx. 3.5 km. The known section of the Rov podzemne Pivke (Passage of the Subterranean Pivka) ends behind the third siphon in Pivka jama. From here to the Pivka branch in Planinska jama, there is about 1.5 km of unfamiliar passages. The source of River Unica is in Planinska jama, from where the river then flows on the surface of the Planinsko polje.

The stable cave temperature in Postojnska jama is 8.5 °C, but this is only the case for the cave's isolated parts. In other parts, the temperature ranges from 3 to 13 °C, depending on the surface temperature.

Active water passages are on average smaller than the passages in the presently dry sections. Flysch gravel and sand are predominant in the rocky bottom. The average water discharge is 5.2 m<sup>3</sup>/s. During flooding, the water in passages can raise by 10 m. Signs of flows with various velocities are visible on walls in scallops of different sizes.

Passages in the presently dry section of the cave were likewise formed by the water flow when the river was flowing at this level. Later, the flow of water moved lower due to a reduction in the gradient. The dry passages up to an altitude of 520 m can now only be reached by the highest waters. Passages in the presently dry section are large - up to 10 m high and wide. Their profiles here are rounded and show traces of paragenesis (transformation through sediments), such as levelled ceilings and side notches on the walls.

In all passages, the sinking river used to deposit various sediments, including gravel, sand, clay and loam. Deposits originate from weathered flysch rocks of the Pivka Basin and are in terms of their mineral composition therefore more or less the same: the predominant kinds are quartz, plagioclases and clay minerals. The remnants of deposits in the cave are aged up to several millions of years, however, in terms of their composition they are identical to the current deposits of River Pivka. Throughout their history, cave passages were repeatedly completely filled with sediments and then eroded again (this can be inferred from the remains of the ground, walls and the ceiling, as well as between layers of flowstone).

Dry passages are for the most part full of speleothems, especially those were not filled with sediments for a long time. Speleothems are of different shapes, colours and ages and large numbers of them can be seen by visitors during cave tours, although in some of the non-tourist parts of the cave, speleothems are likewise in abundance.

## POSTOJNSKA JAMA

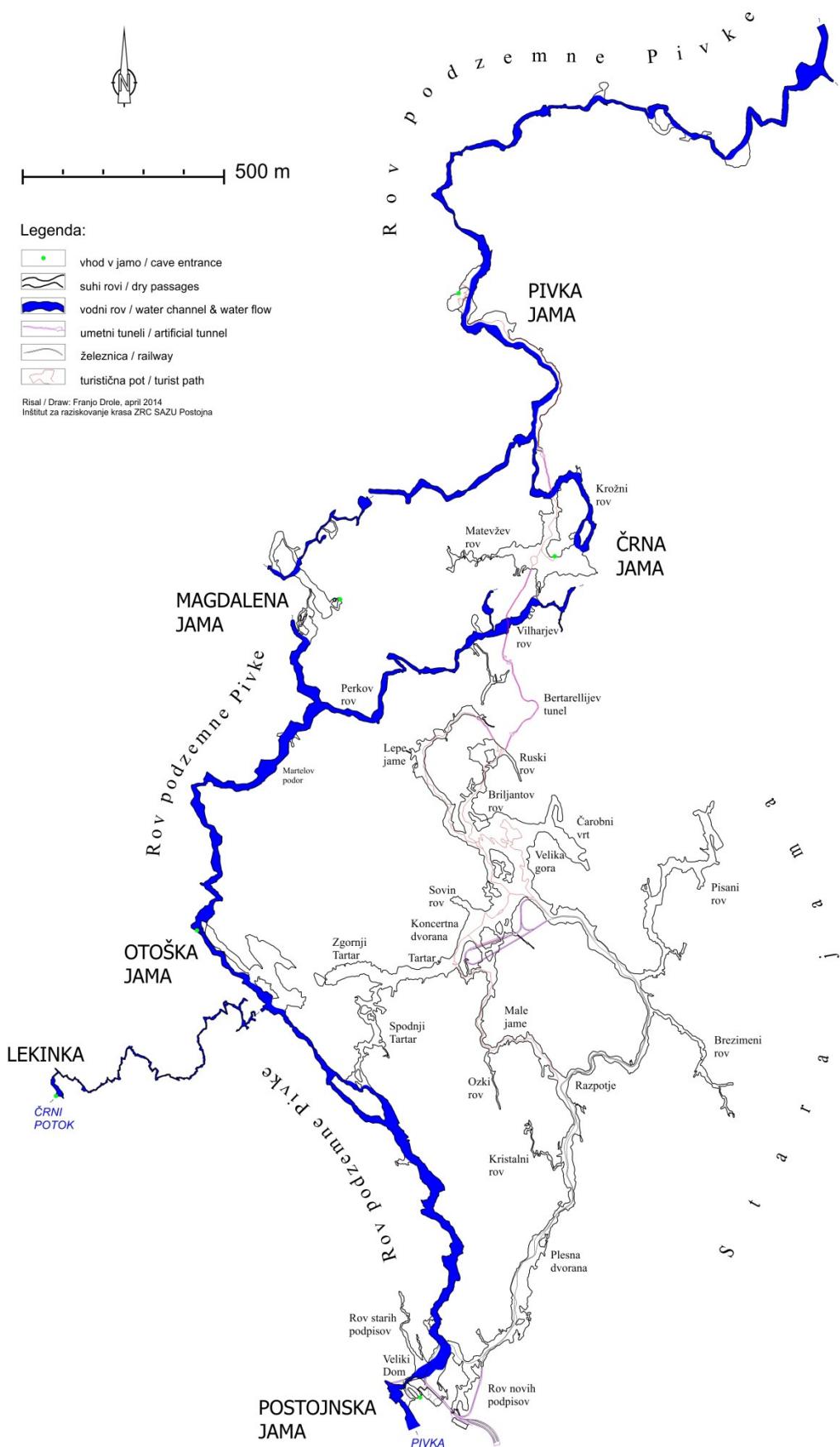


Figure 44: The ground plan of Postojnska jama with its entrances.

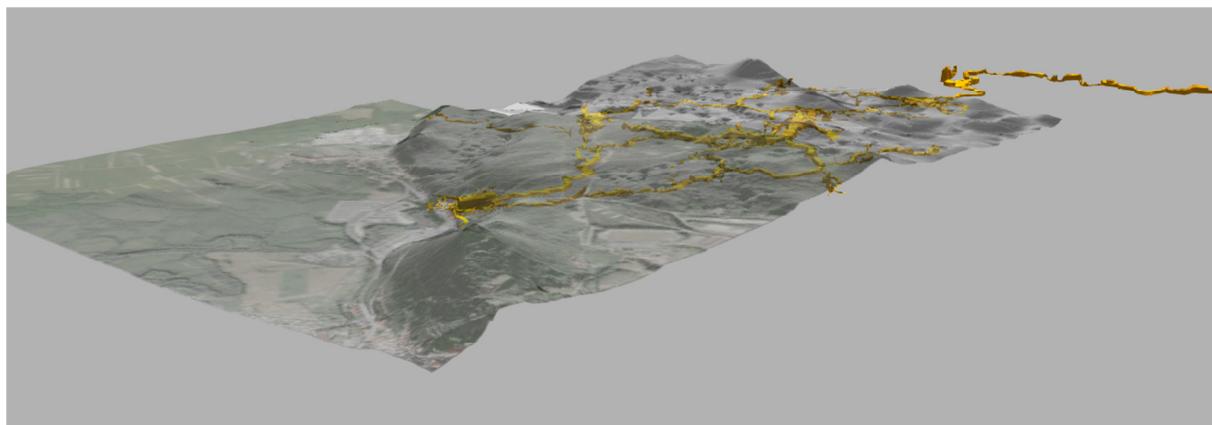


Figure 45: 3D cave map of Postojnska jama (Glažar, Drole & Hajna 2015; surface: LiDAR, orthophoto).

### Age

The bottom of the shaft, the flow of River Pivka can be seen for the last time before it disappears into the siphon. After the siphon, the cave is accessible only to divers, as the water flows through in places completely flooded and only partly explored passages towards Planinska jama.

The oldest known speleothem from Postojnska jama's is from Pisani rov (Coloured Passage). Its core was dated by using ESR and U/Th methods to approximately 530,000 years. Stalactite ages are usually not dated, but here we arrived at a similar age by using two different methods. The stalactite was dated by the U/Th method at the lab of McMaster University in Hamilton, Canada, and by the ESR method in a laboratory in Japan.

Dated speleothems from the Velika gora (Great Mountain) in Postojnska jama uncover periods of growth in warmer climes and the time of the ceiling collapse in colder climes. Porous sinter at the base of the collapse at 527 m a.s.l. is 152,000 years old. Broken speleothems under the collapse and gravel between 47,000 and 37,000 years old. Overturned speleothems on mud in the Čarobni vrt: 43,000–41,000 years old; youngest sinter rafts, three samples of 23,000, 12,000 and 6,000 years old; and the time of alluvium deposition.

In Črna jama (Black Cave) stalagmite which began to grow at the end of the ice age on periglacial gravel was dated. About 10,000 years ago black particles (mainly carbon) were deposited on its surface. That is also the time when the stalagmite stopped growing. It restarted its growth some 100 years ago as a perfectly white speleothem. The stalagmite was dated by the U/Th method at the CNRS laboratory in Paris, France.

Fluvial sediments have the same composition, regardless of their age, as they have been carried into the cave by the river from eroded and weathered remains of Eocene flysch of the Pivka Basin. Cave sediments were dated by the palaeomagnetic method (Zupan Hajna *et al.* 2008a, 2008b, 2010) by determining the periods of normal and reverse polarity in accordance with the Geomagnetic Polarity Time Scale (GPTS). Remains of sediments over 2 millions of years old from the artificial tunnel in the cave have the same composition as recent sediments.



Figure 46: Shematic cross-section of cave passages Velika gora, Čarobni vrt and Pisani rov with dating results; speleothems:U/Th, ESR, C<sup>14</sup>; and fluvial sediments: paleomagnetic.

### Speleobiology

Postojnska jama is known after the first discoveries of cave-dwelling animals (troglobiontes) in the world. In 1797 in the cave Črna jama *Proteus anguinus* (Cave salamander or human fish) was found for the first time. In 1831 one of cave guide Luka Čeč found the first cave beetle *Leptodirus hochenwartii* (the Slenderneck beetle). With these first discoveries the new explorations were done in the cave and many new species were found and described from the cave: the cave spider (*Stalita taenaria*), the Postojna Cave pseudoscorpion (*Neobisium spelaeum*), the cave amphipod (*Niphargus stygius*), the giant cave trichoniscid (*Titanethes albus*), the cave snail (*Zospeum spelaeum*) and the cave centipede (*Lithobius stygius*); consequently, Postojnska jama is known also as cradle of speleobiology as a science. Postojnska jama is a hot-spot regarding biodiversity as 114 species of cave-dwelling animals (Zagmaister et al. 2014) have been discovered and described in the cave, for 84 of them the cave is the type locality (Locus typicus).



Figure 47: *Proteus* is endemic species of Dinaric karst and was found for first time in the cave in 1797 in cave Črna jama, which is part of Postojnska jama. *Leptodirus* is the first cave beetle in the world which was discovered in Postojnka jama in 1831 and was a year later, in 1832, recognised and scientifically described by Ferdinand Schmidt as a true cave-dwelling animal.

### Tourism

The Veliki dom (Great Dome) is a hall that had been known to Postojnska jama visitors even before the inner parts were discovered. River Pivka flows into the bottom of the hall through the siphon from the ponor. When the water level rises, an approx. 10-metre deep underground lake appears here. First signature is dated from 1213 and the inner parts of the cave were discovered in 1818.

Cave Postojnska jama is the biggest show cave in Slovenia and in Europe with a total number of 36,000,000 recorded visitors in April 2015.

Postojnska jama's worldwide fame was achieved through almost 200 years of intensive tourist development: discovery of inner parts in 1818, guided tours since 1819, railway since 1872, permanent electric lighting since 1884 and another thing of great importance: despite its continuous use for the purposes of tourism the cave remains a natural attraction in excellent condition with over 500,000 visitors per year.

Sustainable management is a big challenge in show caves with such large visitor numbers. While direct physical impact of the touristic infrastructure on cave environment can be relatively easily assessed, the assessment of indirect impact of tourism is much more difficult. To this extent, long term monitoring and the analysis of the environmental parameters are crucial. Chemical and physical parameters of percolating water and allogeic recharge have been monitored for decades in the cave, but temperature, moisture, wind and CO<sub>2</sub> only for a few years.

Monitoring intends to determine the human impact on natural cave environment. Monitoring of cave air temperature began in 2007. As proved by the results, Postojnska jama is a well ventilated system; external temperature dynamics penetrate deep into the cave.

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## **UNION INTERNATIONALE DE SPÉLÉOLOGIE (UIS) / INTERNATIONAL SPELEOLOGICAL UNION**

**UIS President Welcome**

(Kyung Sik Woo)

**50<sup>TH</sup> year of the Union Internationale de Spéléologie:**

**Foundation, Life and Effects**

(Arrigo A. Cigna & Daniela Pani)

**International Union of Speleology - UIS**

(José Ayrton Labegalini)

**Impressions from the underground world of Postojnska jama and UIS**

**depicted on stamps and postcards**

(Mitja Jančar)

## UIS President Welcome

Dear Friend Cavers and Cave Scientists

First of all, I would like to congratulate the 50<sup>th</sup> Anniversary of UIS (Union Internationale de Spéléologie; International Union of Speleology in English). As the President of UIS, I would like to welcome all the national delegates, the present and past bureau members as well as other cavers and cave scientists from all over the world.

First of all, let me introduce myself briefly. I am a geologist and also a speleologist and have been teaching and carrying out a research as a professor at the Department of Geology, Kangwon National University in South Korea. In addition to speleology I have been working on carbonates past 35 years which include a variety of research topics such as carbonate sedimentology and diagenesis, paleoclimatology (and paleoceanography) using calcareous skeletons and non-skeletons, and petroleum geology including hydrocarbon exploration and gas hydrates. When I was involved in working for a cave project, I was fascinated that there are so many interesting research subjects that can be solved only from caves. Among them, various processes of speleothem growth truly gave me a strong insight for my research. Since then, I have been working on speleogenesis and paleoclimatic studies. In 1987, I organized the caving club in my university and started caving. I also established the Cave Research Institute of Korea to carry out exploration and scientific investigation and to evaluate and enhance the management of showcaves for better conservation.

UIS is the largest international organization related to cave exploration activities and cave and karst-related scientific research founded. It is distinguishable from other scientific organizations because caves can be studied only by cave scientists who can investigate harsh cave environments and also because it is interdisciplinary. Also UIS is the only organization to carry out scientific research underground. UIS is composed of about 60 member countries with two delegates from each country. I would like to emphasize the significance of caving exploration with sophisticated techniques for cave science research. Unlike other scientific research and activities, cave science would not be possible without caving. Thus, speleological research and caving are not two separate activities. This means that caving exploration and activities must be encouraged, promoted and supported for better scientific research.

The UIS Bureau has eleven members, one president, two vice presidents, one secretary general and eight adjunct secretaries. Two vice presidents have each separate role, one for Administration and the other for Exploration. We have one secretary general and eight adjunct secretaries from all over the world. As you may know, the UIS Bureau members are elected at the General Assembly every four years during the International Congress of Speleology hosted by UIS and a member country where it is held. The present bureau members were elected at the last 16<sup>th</sup> International Conference of Speleology at Brno, Czech Republic in 2013. The more information on the UIS history, structure and activities is available at the UIS homepage (<http://test3.brlog.net/>).

UIS includes five departments with 21 commissions included. The departments are; Department of Karst and Cave Protection, Department of Research, Department of Documentation, Departments of Exploration and Department of Education. The Department of Research has 12 commissions such as Archeology and Paleontology Commission, Artificial Cavities Commission, Biology Commission, Cave Mineralogy Commission with three working groups (Speleothem Protection and Conservation,

Bibliography and Mineral Ontogeny working groups and Speleothem Repository/Library), Glacier, Firn and Ice Caves Commission, Karst Hydrogeology and Speleogenesis Commission, Microbiology and Geomicrobiology Commission, Paleo-karst and Speleochronology Commission, Physical Chemistry and Hydrogeology of Karst Commission, Pseudokarst Commission, Speleotherapy Commission with four working groups (Speleotherapy in salt mines and salt chambers, Halotherapy, Speleotherapy in karst and other caves, and Assessment of potentially curative underground environment in caves, mines and other artificial spaces; measurement techniques), Volcanic Caves Commission. The Department of Documentation has 5 commissions such as Arts and Letters Commission, Bibliography Commission, History of Speleology Commission, Informatics Commission with five working groups (Caver's Multi-Lingual Dictionary, Cave Data Exchange Standards, Survey and Mapping, Publications Exchange, and Caves of the World Database), and Long, Deep and Large Caves Commission. The Department of Exploration has 3 commissions such as Cave Diving Commission, Cave Rescue Commission, and Materials and Techniques Commission. The Department of Education and Teaching has 1 commission (Speleological Education Commission).

Among them, I would like to introduce a few subjects which are regarded as some of the popular research topics in the world at present. The first one is paleoclimatology using speleothems to reveal past climate changes. This study has been claimed as the best way to obtain the proxy to understand past climate changes of the continents. Ice and deep sea records have been shown to be extremely important, but terrestrial environments are best investigated using speleothems which can be readily dated and interpreted at high resolution. Of course, future climate prediction may not be feasible without understanding past climate changes. The second one is biological research. Caves are very special environments with constant temperature and humidity, and have been isolated for a long time. I was informed that caves are one of the best potential places to find new species as well as new genes. Great achievements have been made and being processed in the field of microbiology. Most of hominid skeletons and numerous archaeological remains have been excavated and discovered in caves. These can now be dated using U-Pb techniques back to a few million years well beyond the limits of  $^{14}\text{C}$  and U-Th. Thus, caves are one of the most critical places to understand the evolution of human life and society.

UIS is also concerned with cave protection, public education and documentation. Whenever I have a chance to give a lecture to general public, I have stressed that there are two reasons to develop showcaves in addition to socio-economic development. First, through proper communication with tourists, scientific and heritage values of caves can be delivered to tourists. Second, cave protection can be most effectively achieved by proper education of general public. It is because there is no easy way to protect millions of natural caves in the world. The best places for this kind of education are showcaves. The recently revised guideline prepared by UIS and ISCA clearly states an ideal way to approach sustainable development for better protection of cave environments. UIS can develop education measures for raising public awareness of natural and cultural heritage as well as scientific values of caves by providing proper education tools.

There are two things that I worry about at present. One is competitive sporting activities in caves in some parts of the world. Truly caving can be one kind of sports, but it should be played as a non-competitive sport. Any kind of competitive caving activities should be avoided because caves can be damaged, and even destroyed to a great extent from them. The other is the vandalism in caves. There are still some shops which are selling speleothems in some parts of the world. Cave scientists

take speleothem samples for paleoclimatic research without serious consideration of cave protection and conservation. Serious selection of geological sampling should be required to minimize the damage of caves. The Code of Ethics revised recently in UIS clearly states and concerns with these problems.

Several issues were proposed to be carried out during my term. I think that one of things which need to be done is more active involvement of member countries and the expansion of new members. As far as I know, there are still some potential member countries to be a member of the UIS. Also, we need to draw an attention from all the member countries to achieve more active involvement to raise the global ownership of caves. Recently the Philippines decided to join UIS. Secondly the UIS needs to make the commissions and working groups more active in the near future. I think that more active commission activities are the most important for the prosperous future of the UIS. Thirdly the UIS is now an associate member of the ICSU (which is the International Council of Scientific Unions). We need to let the world know how important caves are and also how important the cave science is for future generations. It is our responsibility to deliver these messages to the world for better conservation of caves. For this purpose it will be good to develop a good relationship with the IUCN and UNESCO and also with other international organizations such as IUGS (International Union of Geological Sciences), IGU (International Geographic Union), GGN (Global Network of National Geoparks), etc. to extend our scope of scientific and social activities.

UIS is trying to make a big step towards better and promising future. I am very happy to announce that UIS will propose the **UN International Year of Caves and Karst in 2021**. Hopefully this large event will change the history of UIS as well as cave exploration and cave science activities in the world.

Finally I would like to invite you two conferences in the future. Asian Federation of Speleology (AFS) was founded recently in 2011. The 1<sup>st</sup> Conference of AFS will be held in Lichuan, China from Nov 5 to 13. Also the next International Conference of Speleology by UIS will be held in Penrith in Australia in July, 2017, near Sidney. I look forward to meeting you again at the conference.

Thank you again for attending the 50<sup>th</sup> Anniversary of UIS and I wish you all the best for your caving and cave research in the future. See you all again in Australia. Thank you very much.

Kyung Sik Woo  
The President of UIS

Celebration of the 50<sup>th</sup> anniversary of the International Union of Speleology – UIS is under the honorary patronage of his Excellency Mr. Borut Pahor, the President of the Republic of Slovenia.



PREDSEDNIK REPUBLIKE SLOVENIJE  
URAD

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Ljubljana, 27. marec 2015

*International Union of Speleology UIS  
Gospa dr. Nadja Zupan Hajna  
Pomožni tajnik - blagajnik  
Zakoniti zastopnik v Sloveniji*

*Titov trg 2  
6230 Postojna*

*Spoštovana gospa dr. Zupan Hajna,*

*v imenu predsednika Republike Slovenije gospoda Boruta Pahorja se vam zahvaljujem za dopis, v katerem ga prosite za prevzem časnega pokroviteljstva nad slavnostno prireditvijo ob 50. obletnici ustanovitve Mednarodne speleološke zveze – UIS, ki bo 19. junija 2015 v Postojnski jami.*

*Želeta bi vam sporočiti, da predsednik republike z veseljem sprejema navedeno častno pokroviteljstvo.*

*V imenu predsednika republike, kot tudi v svojem imenu, vam želim uspešne priprave in vas prijazno pozdravljam.*



*dr. Alja Brglez  
VODJA KABINETA*

*Poslano:*

- naslovnik
- zbirka dokumentarnega gradiva

## 50<sup>th</sup> Year of the Union Internationale de Spéléologie: Foundation, Life and Effects

Arrigo A. Cigna & Daniela Pani

### **Abstract**

After the 2<sup>nd</sup> World War, European speleologists collaborated for establishing the International Congress of Speleology. In 1949, the proposal of the Comité National de Spéléologie was accepted, and the ICS was set up. The first ICS was held in Paris in 1953, the 2<sup>nd</sup> was organised in Italy (Bari, Lecce and Salerno) in 1958. Successively, these events were organised on a four years base. At the 4<sup>th</sup> ICS, held in Postojna in 1965, the Union Internationale de Spéléologie was founded. Some details on the most important issues of the activity and connections with other organisations are here reported.

Keywords: Union Internationale de Spéléologie, foundation, development

### **Introduction**

After the 2<sup>nd</sup> World War, European speleologists agreed to setting up an international meeting. In 1949, a proposal written by the Comité National de Spéléologie was shared and acknowledged, and the International Congress of Speleology was set up.

The first ICS was held in Paris in 1953. At that time, a direct connection of the Congress with the Academics isn't documented; however, the important contribution of both the President Prof. René Jennael and the General Secretary Prof. Bernard Gèze was beneficial for the success of the event (Gortani & Anelli 1954).

The Italian cities of Bari, Lecce and Salerno hosted the 2<sup>nd</sup> International Congress of Speleology. Despite the proposal of the Italian Delegation to schedule the international congress on a four years base, the second event took place in 1958, with a one-year delay, that was catch up three years later, when the 3<sup>rd</sup> congress was organised (Anonymous 1954). The connection to the Academics was gradually reinforcing, as well as the programming of future congresses with a scientific approach.

Most of the presentations were in mother tongue; the delegate of the Vatican City, on behalf of the Holy See, delivered the greetings in Latin (Anelli 1962):

*Sedes Apostolica, quae primum particeps est Conventus ex omnibus nationibus coacti ad specus investigandos, universis studiosis qui in hanc urbem Barium convenerunt, quae maxime Sanctorum Nicolai et Sabini gloria refulget atque Orientem et Occidentem quasi necessitudine amicitiae ac beneficiorum complectitur per me salutem plurimam nuntiat Sanctus Benedictus Nursinus, specum studiosus atque patriarcha clarissimus, qui nuper a Summo Pontifice Pio duodecimo Europae christianaे Patronus renuntiatus est, divina munera adprecetur huius Concilii inceptis quae Apostolica Sedes - me internuntio – progressibus novis, consiliis optimis, conclusionibus dilucidis cumulari optat,*

*ut haec recens invecta disciplina explorans vel imos recessus terrae, in qua Deo plurima mirifica – quorum praestantissimus est homo – recondidit, maximis incrementis unique augeatur.<sup>1</sup>*

As said, to catch up the one-year delay of the 2<sup>nd</sup> event, the 3<sup>rd</sup> ICS happened in Vienna (Austria) in 1961.

Again, the attendees performed their presentations in their own language, whereas the General Secretary of the Congress, Hubert Trimmel, also the editor of the congress proceedings, reported the official speeches in German, and edited the extended abstracts in French, English and Italian. Again, the greetings from the Holy See were in Latin (Trimmel 1963):

*Apostolica Sedes, quae huic tertiae ex omnibus gentibus Congressioni terrae specubus investigandis per me interesse gaudet, salutem plurimam dicit universis doctis viris, qui, tot nationum partes agentes, in hanc praeclaram pulcherrimamque urbem convenerunt: Vindobonam dico, quae cathedrali templo a S. Stephano nitet, totius Austriae maximo decore, atque per amplam eiusdem nominis hypogei regionem, inextricabilibus viis sectam, veluti thesaurum custodit. Sancti Caelites omnipotentis Dei praesidi hisce coetibus sua prece deproperent, ut ex inquirenda scientiae veritate, quam spelaeologiae periiti omni cum studio ac sedulitate colunt, summae utilitatis fructus ipsis conctaenque hominum familiae proveniant: ardor scilicet et vis suis inceptis persequendis, habendis investigationibus rectus afflatus et stimulus, in agendo fiducia, in arduis obeundis rebus prudential, firmaque Constantia, quae eorum laude digna proposita ad laetus perducat effectus. Quae vota sunt sincerae existimationis humanitatisque nuntia<sup>1</sup>.*

The Latin style of both documents, stately elegant, is comparable to the style of the major Latin Authors. It is commonly acknowledged that Latin was the official scientific language, as it is English nowadays. Greetings like the one reported above might represent one of the last examples of high quality Latin written in relatively recent times. Latin (with Slovene and English) was used again in another occasion, as recognisable in a wall board shown in the building of the Karst Research Institute in Postojna, reporting the history of both the Institute and the Castle. We should feel proud as speleologists for using Latin, which represented the language for science for more than one

<sup>1</sup> The Apostolic See, that has participated to the first time to a congress among those interested to study caves, conveys through me the best wishes to all scientists, who are meeting in this town of Bari, which shines with the glory of the Saints Nicholas and Sabin, and link East and West with obvious friendship advantages. Saint Benedictus from Norcia, scholar of caves and famous patriarch, who recently has been elected by the Sovereign Pontiff Pius XII as Patron of the Christian Europe, might obtain divine gifts to the activity of this Congress, which the Apostolic See – through me – wishes that by new discoveries, good discussions and clear conclusions might be reached, in order that this new scientific branch will get the best results in exploring the deep space of the Earth, where God put many mirabilis objects extremely interesting for man.

<sup>1</sup> The Holy See, participating with me to this Third International Congress of Speleology, greets all the scientists who, representing different Countries, reached this wonderful city of Vienna where the Cathedral of St. Stephan, greatest honour of the whole Austria, shines and takes care, as a treasure, of the largest hypogaeum with the same name. The Saints of the Heaven plead with their prayers to the omnipotent God in order that, in the frame of the scientific investigations carried on by speleologists with study and attention, might be obtained results of the greatest usefulness for them and the whole mankind, as well as passion in their activities, inspiration for the investigations, reliance and caution in the difficult activity, constant firmness. With wishes of sincere feelings of appreciation and education.

thousand years. Moreover, many books and old manuscripts, available in some libraries, describing only local examples of caves were written in Latin. The first book describing the Underground World as a whole is the *Mundus Subterraneus* of Athanasius Kircher (1665). This book was written in Latin too. Such an interesting tradition survived to a certain degree also for speleology.

Still in a sort of "proto-history" time of UIS, i.e., a few years before its official establishment, in 1960, an International Symposium of Speleology was organised in Italy, at Villa Monastero in Varenna. This was a popular venue for prestigious meetings (for example the International School of Physics, where Enrico Fermi addressed several lectures). The main Symposium topic was "Natural deposits in caves". Many of the symposium attendees became strategic for the growth and development of the forthcoming UIS. The promoter and organiser of this event was Salvatore Dell'Oca. He was both a powerful entrepreneur and a speleologist: he funded many projects, like the speleological journal "*Rassegna Speleologica Italiana*" for about twenty years since 1950, and the editing and printing of many other proceedings and books. His devoted activity to Speleology has been beneficial not only for the development of the speleology in Italy, but also for structuring a solid communication network among cavers all over the world.

Twelve years later (1972) another seminar on Speleogenesis was organised in the same Italian location, this time with the official support of UIS, and the presence of many European scientists. Both meetings weighed on the developing of connections between the speleological and the academic world and, despite rarely organised, they became essential for promoting the connection between the scientific research and the pure caving activity. Namely, the main efforts of a few decades ago to create opportunities to meet and exchange led to the current widespread and frequent occurrence of speleological meetings.

### **The foundation of the Union Internationale de Spéléologie**

The 4<sup>th</sup> International Congress of Speleology was organised in Slovenia (Yugoslavia at that time), 12–26 September 1965 (Anonymous 1973). The event, under the patronage of Edvard Kardelj (leading member of Communist Party of Slovenia around Tito) was opened in the "Dancing Hall" of the Postojna cave, hereinafter referred as "Congress Hall" (Fig. 1). The opening was greeted by the music of a brass-band composed by A. Srebotnjak, a well known musician from Postojna (Fig. 2). Instead, the congress sessions were held in the University of Ljubljana. On September the 16<sup>th</sup> 1965, the second part of the plenary session started at 3 p.m.

"When *in the course of human events, it became necessary for...*" speleologists to establish good connections and coordinate their activities at international level, the Union Internationale de Spéléologie was then established.

Professor Gordon T. Warwick reported about the National Delegates Commission results concerning the proposed Statutes of the Union Internationale de Spéléologie, under the initiative of Professor Bernard Gèze, the Organising Committee of the 4<sup>th</sup> International Congress of Speleology and the Fédération Française de Spéléologie. The document was then delivered by Professor Albert Anavy, the text having been approved by the Commission for Statutes of the Permanent Committee of International Congresses.



Figure 1: The plaque in the Caves of Postojna.

*Maestoso*

A. Srebrenjak: Fanfare (1965)

3 Trombone  $\left(\text{D}^{\text{m}}$

$4\frac{3}{4}$   $\text{a}^3$  ff

3 Trombone  $\left(\text{D}^{\text{m}}$   $4\frac{3}{4}$   $\text{a}^3$

*rallentando molto ... a tempo*

*simile*

*rallent.*

Figure 2: The original score of the fanfare by A. Srebrenjak purposely written for the opening of the 4<sup>th</sup> International Congress of Speleology.

It is clear that the drafting of the UIS Statutes has implied long and comprehensive work from a group of knowledgeable persons. In particular, the contribution of B. Gèze was important for achieving the final release; however the talent and knowledge of G.T. Warwick was a key factor too. As a matter of fact, he lasted as president of the Statutory Commission for sixteen years, until 1981, when the name of the Commission changed into Advisory Committee.

The first provisional UIS Board, as suggested by the Organising Committee of the 4<sup>th</sup> International Congress of Speleology was unanimously approved by the twenty-three national delegates:

President - Bernard Gèze, France

Vice Presidents - Gordon T. Warwick, Great Britain; Stjepan Mikulek, Yugoslavia (now Slovenia)

Secretary General - Albert Anavy, Lebanon

Up to the 5<sup>th</sup> Congress in Stuttgart (Germany) in 1969, the UIS Board was regularly elected by the General Assembly, as it is reported in the Congress Proceedings, the UIS Bulletins and the book “History of the UIS” by J.A. Labegalini.

### **The pathway to the official UIS**

The Rèunion Internationale de Valence-sur-Rhône in France (1949) was the occasion where speleologists from different European countries proposed the creation of the Commission for the Congress Organisation. From the 1<sup>st</sup> ICS in Paris and the 4<sup>th</sup> in Postojna, when the UIS was officially established, the Congress Organisation Commission represented the core unit of the upcoming UIS. Referees from Czechoslovakia, France, Gran Bretagne, Greece, Italy, Switzerland, United States of America and former Yugoslavia territories were part of the Commission.

Members of the Commission had a relevant connection to universities and, at the same time, were eminent cave explorers. Again, the scientific character of speleology played a key role in assuring a stable development of the Union. In fact, emphasising the sportive aspect of caving, most typically related to physical skills of an individual, with respect to the scientific character of speleology could pose a risk to the continuation of the exploration activities.

Before the modern structured speleology, some very important activities occurred. As an example, the International Bibliography of Speleology, coordinated by Hubert Trimmel from 1950 to 1970 (Trimmel 1954) is probably one of the most relevant. From 1970 to present, the “Speleological Abstracts” is edited and published under the management of the Commission for Bibliography. With reference to the bibliographical abstracts, speleology was considered by chemists and other scientists as a highly organised science within the scientific disciplines. At the beginning of the new millennium, a legal entity registration of UIS, an unofficial association ever since its foundation, was sought. Postojna was proposed as headquarter, and the Karst Research Institute kindly offered an office within its premises (Fig. 3). UIS was therefore registered at the District Municipality of Postojna under the Slovenian Law, the 20<sup>th</sup> of June 2002 (registration number ID: 211/1146149).



Figure 3: UIS Board members in front of the Karst Institute, Postojna, seat of UIS, in 2010.

### **UIS, UNESCO and ICSU**

In 1975, UIS was included in the UNESCO list of Non-Governmental Organisations - Category C (Mutual Information Relationship) (Anonymous 1975). At that time South Africa was included in the list of the UIS members and, due to the apartheid ban and after an intense correspondence between UNESCO and UIS, South Africa was excluded from the Union (an action acknowledged not applicable later on!) (Anonymous 1983). UIS was therefore included into the UNESCO Category B (Information and Consultative Relationship) in spring 1983 until 1994, when UNESCO renewed the structure, and UIS was differently classified.

In 2010, UIS became a member of International Council for Science in the category of Scientific Associates. A detailed description of the evolution of the relationship between UIS and UNESCO are reported in Labegalini (2013).

### **UIS, ISCA and other organisations**

In November 1989, the establishment of the International Show Caves Association was the aim of the meeting in Frasassi, Italy. At that time, the article n.1 of the ISCA Constitution stated: "... *The Association is within the structure of the International Union of Speleology*". This would help avoiding potential disagreements between the two organisations.

Later in 2002, during the 4<sup>th</sup> ISCA Congress in Postojna, the two Presidents José Ayrton Labegalini (UIS) and Jorge Cabezas Fontanilla (ISCA), signed a Memorandum of Understanding between UIS and ISCA. During the 5<sup>th</sup> ISCA Congress in Bermuda in 2006, a new Constitution of ISCA was approved and the art. 1 statement was no longer needed.

An important objective was achieved in November 2014 with the “Recommended International Guidelines for the Management of Show Caves”. After a long period of discussions, a final text of this document was approved by ISCA General Assembly, and with the UIS and IUCN agreement this is now a shared international recommendation.

UIS also established connections to other international organisations, ex., the FEALC (Speleological federation of Latin America and the Caribbean) in 1982; the FSCE (Speleological Federation of the European Community) now FES (European Federation of Speleology) in 1990; the BSU (Balkan Speleological Union) in 2002.

### **The International Congresses of Speleology**

At the end of the 2<sup>nd</sup> World War a revival of the speleological activities occurred, particularly in Europe where the war had stopped most of the research, whilst the information about caves location was often utilised by partisans and rebels (Pavan 1989), as happened many years later in Cuba.

The 1<sup>st</sup> International Congress of Speleology was hosted in Paris as an initiative of European speleologists. After the 4<sup>th</sup> Congress in Postojna, the event organisation was raised to a professional level. The growth of the initiative was rather slow, yet with a positive trend, as reported in Fig. 4.

First to tenth ICS, only oral presentations were provided; starting from the Beijing ICS, poster presentations were also included. Fig. 4 shows the number of papers and number of participants to ICSs. A general positive trend is recognisable, sometimes with large fluctuations caused by different reasons, including the competition with similar events or the congress venue appeal. The number of participants increased more steadily; in some cases, other reasons influenced this trend. In recent years, scientists must publish their results in journals with a good Impact Factor, whilst the conference proceedings generally do not have an Impact Factor. The quality of the papers included in the ICS proceedings is, however, much improved. The positive trend of the number of participants is definitely more evident. Some shifting from the general trend is due to specific local influences as the location or organisations difficulties. The influence of the scientific aspect is anyway clear. Guaranteeing a high quality event planning is mainly achieved if the scientific motivation, more than the sportive one, powers the organisers, not to reduce the importance of the sportier side of speleology, always important for the occurrence of scientific activities. High quality of sport caving largely relies on the age of cavers, and after a great activity season only few people keep interest in speleology with age. Single cavers may be moved by scientific motivations, allowing the continuation of the interest in spite of the age progressing.

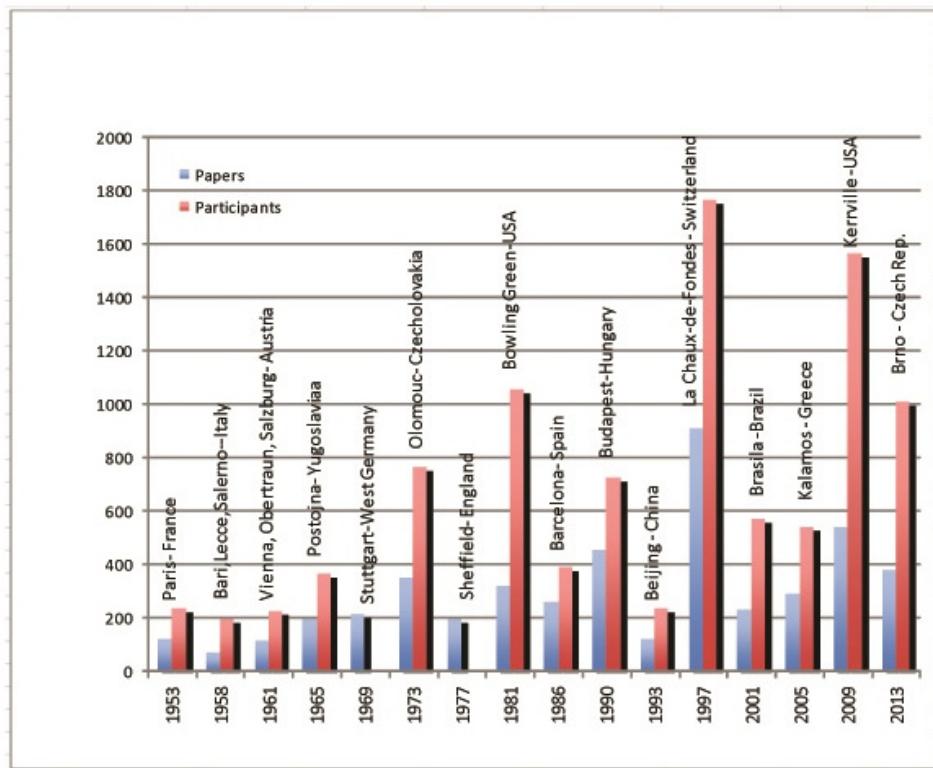


Figure 4: Number of papers and participants to the ICS.

### The International Journal of Speleology (IJS)

The International Journal of Speleology is published starting from 1964 and, ever since 1978, it represents the official journal of the International Union of Speleology. During forty nine years of continuous activity, the journal has issued 42 volumes, including more than 600 articles concerning several branches of speleology. The first four volumes (1964 to 1972) were edited by G. Claus (USA), joined by R. Husson (France) and G. Nicholas (USA) for volumes 2 and 3. The first two volumes were printed in Germany, and then the printing moved to the Netherlands. Due to the high cost of printing, the journal faced financial difficulties around 1977, and new options were sought (a detailed history of the IJS is available in Labegalini, 2013).

It was during the first session of the General Assembly of the 7<sup>th</sup> ICS that the delegates were informed of a possible agreement with the editor of the "International Journal of Speleology" of transforming the IJS into the official scientific journal of UIS. It was commonly agreed that an important journal as IJS could not cease. Such a decision was extremely productive, as it allowed the continuation of the journal up to present.

The Dutch editor agreed to unclaim the copyright and, once negotiations were completed, in 1978 UIS took over with the responsibility of publishing the IJS. Under UIS liability, the IJS faced again financial problems. A solution was reached when the Italian Society of Speleology (SSI) took legally over the property of the IJS, and assumed the financial responsibility for the printing, although the journal remained the official scientific publication of UIS. The limited number of subscriptions, however, promulgated the financial problems of the journal. Contributions were provided by some universities

(Rome, Trieste), the National Council of Research of Italy (CNR), the Museo di Speleologia "V. Rivera" (L'Aquila, Italy) and UIS itself.

Jo De Waele took over as Editor-in-Chief for the preparation of Vol. 34 of the IJS, to be distributed in 2005. Under his management, the journal underwent through a tangible change. The page size was increased to an A4 format; coloured covers were adopted, and on-line access was introduced. With these transformations, the IJS went back to an international level, with an international editorial staff, international editorial board and an international readership. The direct consequence of these improvements was the Impact Factor rate, from 0.9 in 2009 to 2.057 in 2010 and 2.000 in 2011. The IJS became one of the most important scientific cave and karst journals currently available and the number of issues per year was increased from two to three.

However, in 2009, after nearly thirty years, the Italian Speleological Society gave a two-year notice that they would no longer handle the administrative aspects of the IJS. Other possibilities would have to be investigated, and legal advice sought about the possibility of surrendering it to an international publishing company. The IJS is now being handled and printed by the University of South Florida Libraries in Tampa, FL, USA. It is an open access journal hosted on the Berkeley Electronic Press platform (University of California, Berkeley), which offers online submission procedures and online publication.

The IJS is available for free in pdf format through the IJS website ([www.ijsspeleo.it](http://www.ijsspeleo.it)) or (<http://www.scholarcommons.usf/ijss/>) and the Karst Information Portal ([www.karstportal.org](http://www.karstportal.org)). Hard copy versions were available up to 2012 (the Vol. 41 (2) was the last one in printed format), but as of 2013 only the digital format is available. An index of the IJS since its inception is available on the IJS web page, (<http://www.scholarcommons.usf/ijss/>), as well as pdf's of all papers printed.

### **UIS now and in the future**

In the past half a century, UIS has achieved a widespread geographic distribution and from a European initiative only is now a valid international organisation. Much is still to be achieved.

The UIS organisation chart includes several thematic Commissions and Working Groups tailored on specific themes of interest and activity with speleology. Mentioning the valuable work already done and in progress, should the contacts between these working groups and the Board be constantly updated.

The UIS statute should also be regularly updated; this to regulate and support the evolving needs of the members and the upcoming new members. The relationship with other organisations dealing with karst and caves should be developed according to clear principles, never forgetting the fundamental points aiming UIS, i.e., the protection and the best conservation of caves and cave environments, and a scientific approach to speleology. The profit and personal advantages should never prevail. Anyone should contribute to the development of UIS, but the reverse must be carefully avoided.

Major commitment of financial and human resources is being made worldwide to develop technology functional to collect considerable amount of information with the aim to increase knowledge. Modern UIS should promote a greater use of available technology for speleology, i.e.,

exploit technologies for assisting speleological activities and for enhancing and optimising the use and sharing of speleological information, in a process of homogeneously increasing knowledge. UIS should support the reinforcement of the activity of the technical Commissions and Working Groups with the aim to draft guidelines and create standard procedures applicable worldwide for handling data, as to accelerate the activities of standardisation of data formats for a more effective exchange and integration of information. This will help the internationalisation of activities, beyond the administrative boundaries that often affects the approach to the discipline.

As part of a process of advanced and optimised use of all geospatial information already available and produced by the speleological activities, UIS should act as a platform of services for the integration, processing and management of data produced by all speleological activities worldwide. UIS should stimulate the development of new technological tools dedicated to caving (lasers, scanners, and drones). Research centres and universities play here a key role, as well as initiatives of individual cavers involved in development of technology. The UIS should generate new exploration opportunities at regional and international level.

The voluntary approach of the Union helps avoiding personal interests to prevail; however, as the Union activities and number of people involved grows, personnel regularly paid might become a need. When money is involved, personal interests might increase, and a special care must be assured to avoid such an inconvenient.

The contribution of UIS to activities of speleologists in foreign territories may be instrumental to avoid misunderstandings. The presence of UIS and its help should therefore be strengthened.

In some Countries, the influence of sportive institutions has recently become relevant. Although this represents a support to speleology, the scientific approach should never be neglected. Sportive cavers are instrumental to scientific speleologists; their activities should be synergic and never in competition. This is to say, caves must never become the place for any sport competitions, because a cave environment is not renewable, instead must be always protected

Last but not least, UIS should aim, in a very near future, to support the procedures of establishing the International Year of Cave and Karst: after 50 years of a very fruitful development, such an event will be an important milestone for UIS.

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## International Union of Speleology – UIS

José Ayrton Labegalini  
UIS Past-President

### Introduction

The *Union Internationale de Spéléologie* (UIS) is the international body for caving and speleology. Formed in 1965, its voting members consist of a delegate from each member country. This delegate represents the country's cavers and speleologists, rather than its national body(s). An elected Bureau runs the affairs of UIS between the 4-yearly General Assemblies held at the International Congresses. The actual speleological work of UIS is done by the members of its Commissions and Working Groups, which are open to everyone who is interested.

The acronym UIS stands for the *Union Internationale de Spéléologie*, in the original French. Although the name may be written differently in other languages, the original acronym is maintained.

The UIS is a non-profit, non-governmental organization which promotes the development of interaction between academic and technical speleologists of a wide range of nationalities to develop and coordinate international speleology in all of its scientific, technical, cultural and economic aspects.

### History

Speleology only took its first steps towards recognition as a science when techniques developed at the end of the 19<sup>th</sup> century. In the mid-1900's, the international speleological community, mostly Europeans, had the idea of holding international speleological congresses. In a meeting on August 22-23, 1949, in Valence, France, the decision was taken to hold the first in Paris, France, in 1953. Since then, International Speleological Congresses have been held in Italy (Bari, 1958), Austria (Vienna, 1961), Yugoslavia (Postojna, 1965), Germany (Stuttgart, 1969), Czechoslovakia (Olomouc, 1973), Great Britain (Sheffield, 1977), United States (Bowling Green, 1981), Spain (Barcelona, 1986), Hungary (Budapest, 1989), China (Beijing, 1993), Switzerland (La Chaux-des-Fonds, 1997), Brazil (Brasilia, 2001), Greece (Athens-Kalamos, 2005), and the United States (Kerrville, 2009). The next will be in the Czech Republic (Brno, 2013 - see <http://www.speleo2013.com> in due course).

The initiative of some of the speleologists at the 1965 congress led to the proposal for the creation of an international entity to unite speleologists from around the world and coordinate their speleological activities. The UIS was then founded on September 16, 1965, during the closing session of the 4<sup>th</sup> International Congress of Speleology in Ljubljana (Slovenia). The first statutes were approved, and the first board of officers elected: Bernard Gezè (France) as president, Gordon T. Warwick (England) as Vice-President, Stjepan Mikulec (Yugoslavia) as second Vice-President, and Albert Anavy (Lebanon) as General Secretary. The internal regulations were approved in 1969, and the latest alteration in the statutes was made in 1997.



Figure 1: 4<sup>th</sup> ICS – 1965 – Postojna/Ljubljana.

## Structure

At present, the UIS is presided over by the following officers: a president, two vice presidents, a general secretary, and eight adjunct secretaries (the number is defined by the General Assembly). Each must be from a different country. These officers are elected at the General Assemblies held during the International Congresses. The board includes an Advisory Council, consisting of the ex-presidents and other past officers.

To coordinate the technical and scientific development of international speleology, the UIS created various departments, each composed of Commissions and Working Groups, each of which has its own individual president and members. These groups work independently, organize their own meetings, develop projects, interact with other institutions, often publish their own bulletins, and may maintain web-sites. Their presidents, however, are elected at a General Assembly held during an International Congress of Speleology and they report on their activities at that time.

The number of Commissions and Working Groups is not fixed, and new ones can be created or old ones eliminated if necessary. Working Groups are created for a specific period of time, whereas the Commissions are permanent as long as they have activities. The creation of a Commission or Working Group is always the result of the initiative of some scientist or technician in that area. Interested parties have only to contact the commission President and request that their names be included so they can participate in meetings, discussions, seminars, and symposia.

In order to supervise the work of exploration and international expeditions, the UIS instituted a **Code of Ethics**. This code, although it does not have the force of law, provides ethical guidelines for such activities to promote the development of speleology, increase our knowledge about international speleological heritage, and foster interactions between speleological communities.

To integrate the speleological activities of the member countries and among those who appreciate the speleology around the world, the UIS maintains a Documentation Center in La Chaux-des-Fonds, in Switzerland, via the Swiss Speleological Society. In the same spirit, UIS has developed the **Multilingual Dictionary of Speleology** (at present with twelve languages represented) and keeps up-to-date the **International Speleological Calendar** of events related to speleology around the world.

### **Present**

At present, the UIS has 54 member countries, located on all the continents of the world, and is open to the affiliation of all national associations and federations. The majority of the commissions are active and provide a copious scientific production; the UIS also publishes the IJS - International Journal of Speleology (via the University of South Florida Libraries) and the UIS Bulletin (for the dissemination of news from the Secretary General); the Bibliographic Commission also publishes Speleological Abstracts, an annual bibliographic listing of speleological literature (the latest printed was Volume 44, in 2008). UIS also maintains a website containing information about speleological contacts around the world. This website provides access to the UIS Statutes, the Internal Regulations, Code of Ethics, issues of the UIS Bulletin, the Multi-Lingual Speleological Dictionary, the calendar of coming speleo events, a list of member countries, a list of the addresses of the officers of all the internal organizations, a list of the national delegates, and a list of the Commissions and Working Groups, as well as many links with the websites of all the national organizations of most countries. The web address of the UIS is: <http://www.uis-speleo.org>. Since July 20, 2002, the UIS has had a fixed address: Titov trg 2, Postojna, Slovenia, in space provided by the government via the Institute of Karst Research of the Slovenian Academy of Arts and Sciences, where all the UIS Archives are now stored.



*Figure 2: UIS has its official seat at the Karst Research Institute ZRC SAZU in Postojna since 2002.*

**THE UIS BUREAU FOR 2013 - 2017****Honorary Presidents**

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*Zdenek MOTYCKA, Czech Republic*

*Nadja ZUPAN HAJNA, Slovenia*

If you are a speleologist, whether a scientist or an explorer, or simply someone who likes speleology, enter into contact with the UIS and have your speleological group contact the national federation or society of your country. Encourage your group to join the UIS, and encourage your national association or federation to become a member of the UIS so it can select a delegate and vote at the general assembly. Help the UIS grow and create a truly international speleology, whether developing new techniques, exploring new caves, studying new theories, practicing rational speleological tourism, preserving the natural heritage, publishing information, or encouraging sustainable development. Enjoy speleology in your own way, but participate. Don't wait to see what the UIS can do for you, but rather see what you can do to help develop speleology. Continue to enjoy speleology in the place and way you always have, but share what you do with the rest of the international community.



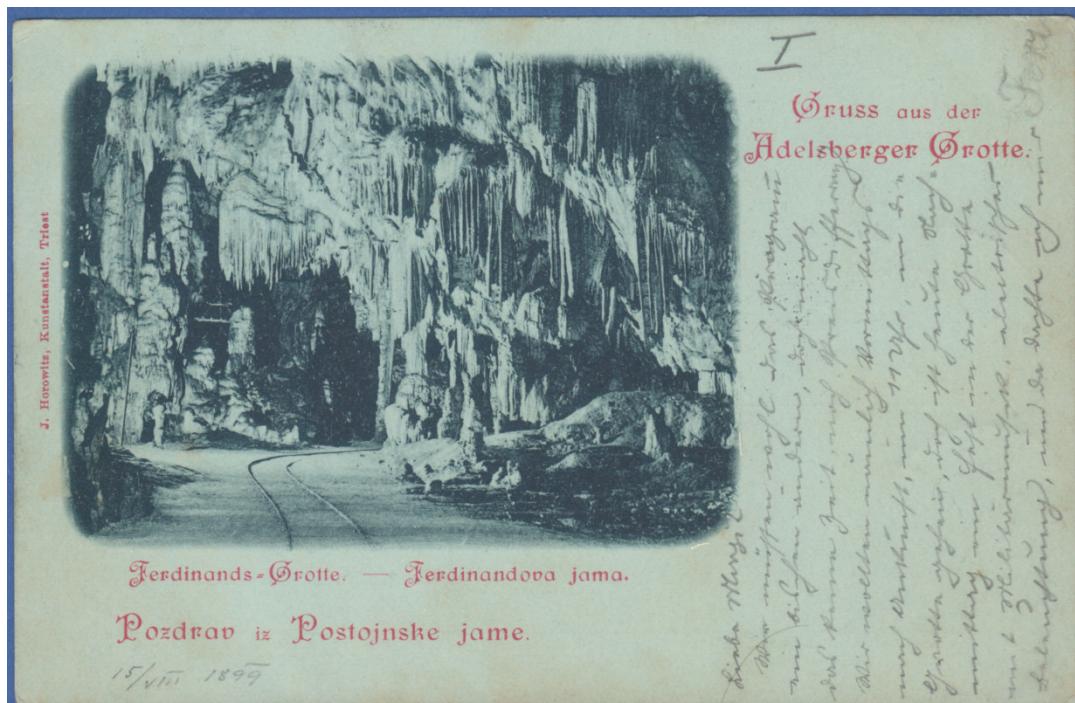
## Impressions from the underground world of Postojnska jama and UIS depicted on stamps and postcards

Mitja Jančar

FND Piran (Philatelic Numismatic Association Piran)

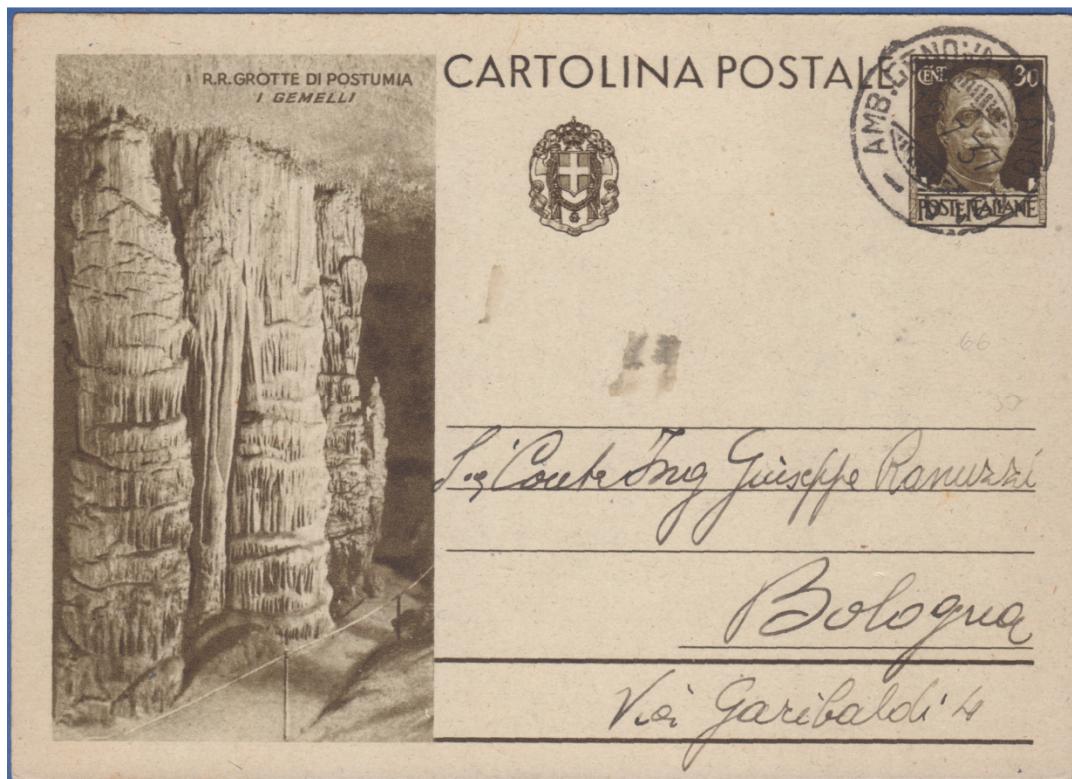
In the following figures motives on stamps and postcards from Postojnska jama and of International Union of Speleology - UIS issued on various occasions are presented.

In philatelic literature the date of the opening of a post office in the Postojnska jama is not written. Until we find older prints, the valid date is August 15, 1899 as the first day of the Post operation in the cave. This is the first underground post office, which is also boasting the longest regular operation.



In 1926, the postal administration of the Kingdom of Italy planned issuing of a series of four stamps with motifs from the Postojnska jama; everything remained as draft.

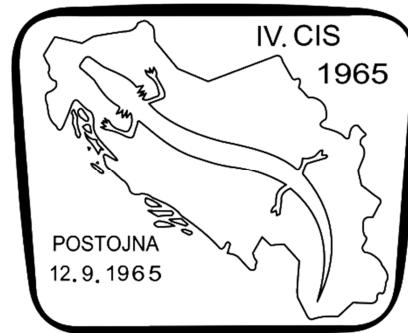
Efforts of Postojnska jama finally paid off in 1937 when the Italian post administration issued a series of six postcards with motifs from the cave (see figures below). Postojnska jama also holds primacy in this respect.







A commemorative envelope with a commemorative stamp (12. 9. 1965) was designed for IV. International Congress of Speleology during which the International Union of Speleology was founded.

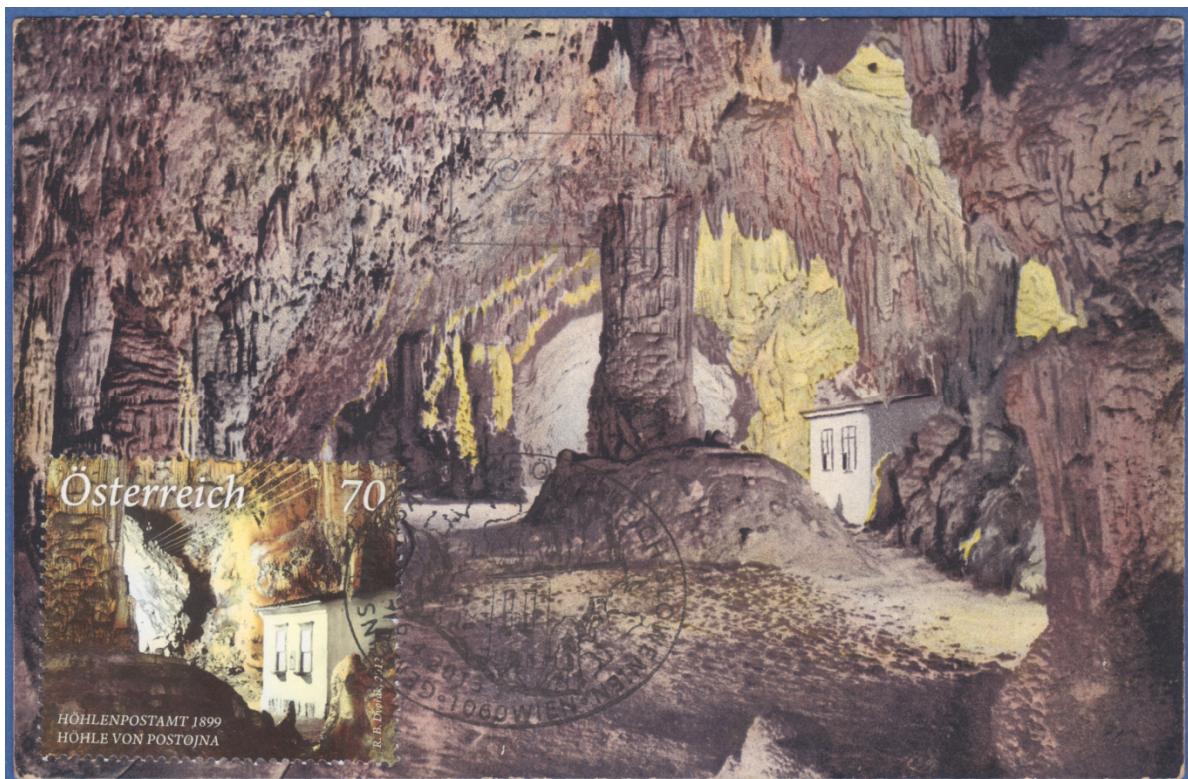


In 2013, the Austrian and Slovenian postal administration issued a joint issue with the same motif - the first post office in the cave. On the stamp on the first day, which was used in Postojna, the replica of the first stamp from 15. 8. 1899 was for illustration.





Maximum card with Slovenian stamp.



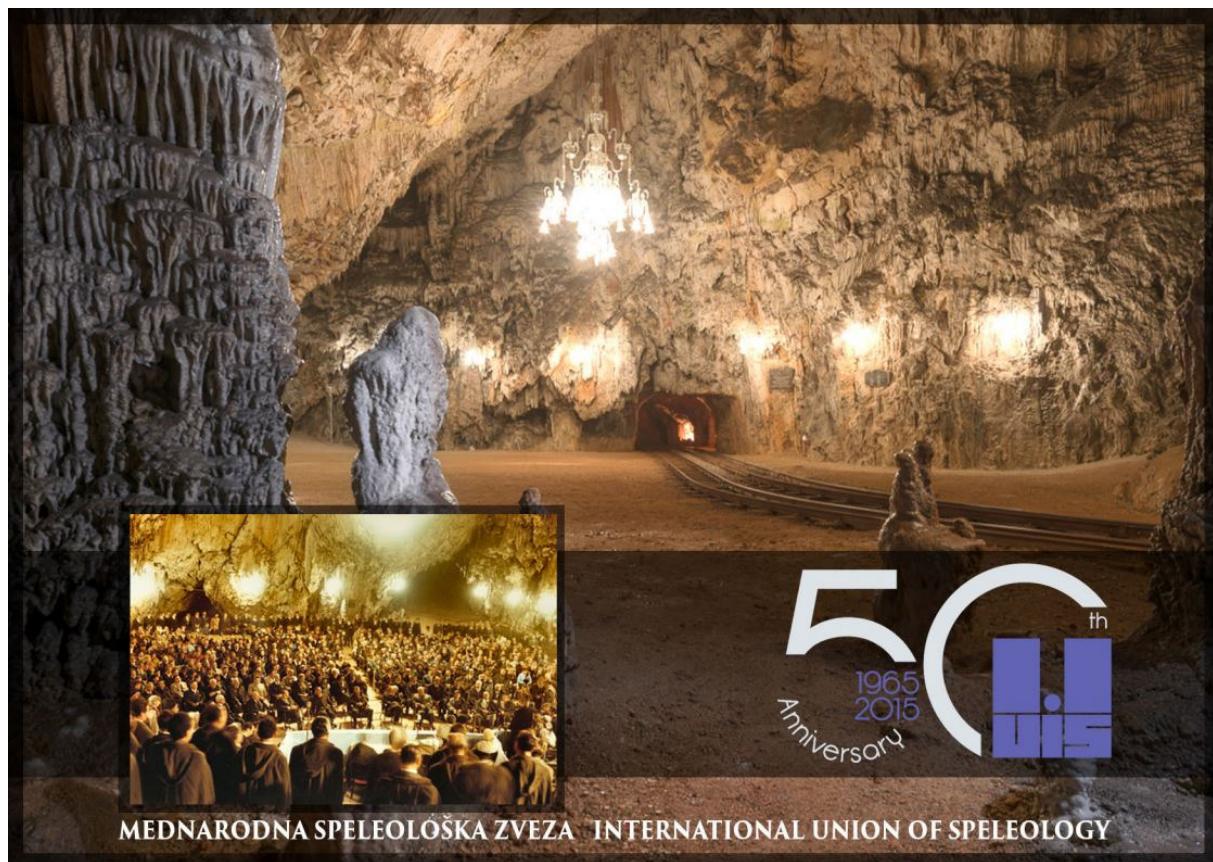
Maximum card with the Austrian stamp.

The envelope with illustration of commemorative stamp which will be in use on 19. 6. 2015. Commemorative stamp in the best possible way tries to repeat the event from 50 years ago. The design was made by M. Jančar for International Union of Speleology.



On 29. 5. 2015 the Post of Slovenia published a post stamp, postcard, and a seal for the 50<sup>th</sup> Anniversary of establishment of International Union of Speleology\_UIS ([www.posta.si/](http://www.posta.si/)).





## **ABSTRACTS**

\*In alphabetical order

**Black coatings in Črna Jama (Postojnska Jama) as evidence of Mesolithic events**P. Alfonso, S. Šebela<sup>1</sup>, N. Zupančič, M. Miler, S. Skobe, H. Grčman<sup>1</sup>Karst Research Institute ZRC SAZU, Titov trg 2, 6230 Postojna, Slovenia, sebela@zrc-sazu.si

Črna Jama as part of the Postojnska Jama system got its name after prominent black coatings on the cave floor, partly on the cave walls and in a few cases on cave ceiling, covering an area of about 7400 m<sup>2</sup>. The natural entrance to Črna Jama is from the southern edge of a collapse doline. Among the cave guides and karstologists it was supposed that due to documented historic visits to the cave the smoke of torches used by visitors and guides produced black coatings on speleothems. Flowstone covering 1 mm thick black coating is not dark but has lighter color, indicating that the layer of black coatings probably belongs to one significant event.

SEM/EDS analyses of the black coatings showed elevated C content and presence of Fe and/or Mn, P, S, and Cl in EDS spectra, which is consistent with an organic C source. Radiocarbon dating of black coatings from Črna Jama, carried out, at Centro Nacional de Aceleradores (Sevilla, Spain), showed an age of 8394±35 BP suggesting the Mesolithic period. The stable isotope value of  $\delta^{13}\text{CPDB}$  is -29.41±1.50‰, which is a typical value for biomass used for burning.

There are no known archaeological remains in Črna Jama and no Mesolithic sites were identified in the surroundings of the cave. The studies of present-day cave micro-climate showed that in 2014 the average annual air temperature for Črna Jama was 5.61°C with a minimum air temperature of 2.8°C and a maximum of 6.9°C. This is the part of Postojnska Jama with the lowest cave air temperature during whole year. We suppose that even during the Mesolithic Črna Jama was not suitable for living due to the low temperatures. The cave entrance opens towards the north, and the present air circulation suggests the lowest air temperatures during the winter months when cold outdoor air enters the cave and also cools the cave and/or exchanges cave air with cold outdoor air flowing into the cave at the bottom of the cave's entrance.

We interpret the black coatings in Črna Jama as traces of biomass burning outside the cave due to natural and/or human-induced forest fires in the Mesolithic period. Favorable cave entrance morphology and cave micro-climate caused large amount of smoke from forest fires to enter the cave and deposit on the older light colored flowstone.

Keywords: black coatings, pyrogenic carbon, Mesolithic, Črna Jama, Slovenia

**"Rio Vaat Project": Hydrogeological investigations for understanding the groundwater resources of Faeit mountain chain (Carnic Prealps – NE Italy)**

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The "Rio Vaat project" was funded by Gruppo Speleologico Carnico "Michele Gortani"- CAI of Tolmezzo in collaboration with Gruppo Grotte Novara-CAI of Novara and Club Alpinistico Triestino of Trieste with the financial support of Municipality of Cavazzo Carnico and Bordano and the Province of Udine. The major aim of the project was understanding the groundwater resources of the Faeit mountain chain in terms of the characteristics and dynamics of the aquifer system and of groundwater protection in the framework of the natural ecosystem protection programme of the municipalities. Particular attention was given to this area interested by the water supply system for the local community. The name of the project is done to the Vaat stream and its intermittent overflow karst spring known as Rio Vaat Cave located at the foothill of Faeit mountain. The explored part of the cave is located in dolomitic rocks that overlap limestones in the whole area of Faeit chain.

These rocks are very fractured but there are no evidence of karst morphology on the surface. Otherwise on the mountains northward of Sella Chianzutan (Mount Lovinzola) there are many cave entrances, the karst is widely developed and it is known to be in connection with springs located NW of Rio Vaat Cave (Verzegnis area). The main research was focussed on understand the hydrogeological behaviour of the Vaat overflow spring in relation with the whole basin context, which is the contribution of the surface on the catchment area and how the total subsurface area contributing to groundwater flow. The results achivied were made possible by the multidisciplinary approach and by intesive and continuos investigation campaigns for two years. In addition to the Vaat cave other 20 sampling sites were chosen as river, resurgences and springs and a pluviometer collecting the meteoric water was installed in the significant area. The hydrogeological investigations were based on the continuos monitoring of the siphon inside the cave by a multiparameter probe (water level, T pH, conductivity), on the measurement of the T, ph, conductivity and discharge in addition to the isotopes analysis of  $\delta^{18}\text{O}$  and  $\delta\text{D}$  for each sampling sites and for the water siphon. All the measurements and the water collection were carried out monthly for one year. All results were correlated with the rainfall curve provided by ARPA (Regional Agency for Environment Protection). The second phase of the project was focussed on a dye test. This large amount of data getting the conclusions that there are two components which enter the watershed: the autogenic recharge and the allogenic recharge (Ford & William 2007; Krešić 2013). For the autogenic recharge there are local aquifers which present modest extension and the medium-high salt content (conductivity 300-350  $\mu\text{S} / \text{cm}$ ) located in Quaternary conglomerates in accordance with literature data, isotopic analysis (content  $\delta^{18}\text{O}$  and  $\delta\text{D}$ ) showed no delay compared to the local rainfall. Water is originates exclusively inside the watershed bounderries, the inflow includes the infiltration of surface/meteoric water. The allogenic recharge interests the Rio Vaat hydrological area, this is water originates at a distance and has the potential to infiltrate in a local aquifer. It is assumed that the presence of a unique wide aquifer which extends roughly below the Faeit up to Sella Chianzutan, the northern limit of the mountain chain considered. The conductivity of surface waters along the chain is almost equivalent (conductivity around 200  $\mu\text{S}/\text{cm}$ ), the water level of the siphon in the Rio Vaat cave is affected by the rainfall recorded in Sella Chianzutan and the isotopic signals show a delay of 20-30 days compared to the local rainfall. The tracement revealed a hydrographical connection between the snowfield of Avrint (Sella Chianzutan mountain area) and the Vaat springs area. The hydrological balance setting on Rio Vaat area shows the catchments area and a watershed surface layer of not less than 12 km<sup>2</sup>.

Keywords: hydrogeological investigation, isotope analysis, karst springs, Carnic Prealps NE Italy

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**Research frontiers in speleogenesis. Dominant processes, hydrogeological conditions and resulting cave patterns**  
**Philippe Audra**

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Speleogenesis is the development of well-organized cave systems by water flowing through initial fissures of a soluble rock. Epigenic caves induced by biogenic CO<sub>2</sub> soil production are dominant, whereas hypogenic caves resulting from uprising deep flow not directly connected to adjacent recharge areas appear to be more frequent than previously considered. The conceptual models of epigenic cave development moved from early models, through the "four-states model" involving fracture influence to explain deep loops, to the digital models demonstrating the adjustment of the main flow to the water table. The relationships with base level are complex and cave levels must be determined from the elevation of the vadose-phreatic transitions. Since flooding in the epiphreatic zone could be important, the top of the loops in the epiphreatic zone can be found significantly high above the base level. Paragenesis corresponds to the upward development of conduits as their lower parts fill with sediments. This process often records a general baselevel rise. Sediment influx is responsible for the regulation of long profiles by paragenesis and contributes to the evolution of profiles from looping to water table caves. Dating methods allow identification of the timing of cave level evolution. Ghost-rock karstification corresponds to a 2-phase process of speleogenesis, with a first phase of partial solution of rock along fractures in low gradient conditions leaving a porous matrix, the ghost, then a second phase of mechanical removing of the ghost by turbulent flow in high gradient conditions opening the passages and forming maze caves. The first weathering phase can be related either to epigenic infiltration or to hypogenic upflow, especially in marginal areas of sedimentary basins. The vertical pattern of epigenic caves is mainly controlled by timing, geological structure, types of flow and base-level changes. Accordingly, we define patterns as juvenile, perched above underlying aquiclude; for dammed setting, a looping pattern reflects the generally irregular recharge, resulting in flooding that produce loops in the epiphreatic zone, whereas water-table caves reflect a flow regulated by the presence of semi-impervious covers or caves at the equilibrium stage allowing transmission of flow without flooding. Successive base-level drops made by valley entrenchment make cave levels, whereas baselevel rise is defined in the frame of the Per ascensum Model of Speleogenesis (PAMS), where deep passages are flooded and discharge through vauclusian springs. The PAMS can be active after any type of baselevel rise (transgression, fluvial aggradation, tectonic subsidence) and explains most of the deep phreatic cave systems except for hypogenic.

Hypogenic speleogenesis corresponds to cave development by deep upflow independent of adjacent recharge areas. Due to its deep origin, water frequently has a high CO<sub>2</sub>-H<sub>2</sub>S concentration and a thermal anomaly, but not systematically. Numerous dissolution processes can be involved in hypogenic speleogenesis, such as deep-seated acidic sources of CO<sub>2</sub> and H<sub>2</sub>S, "hydrothermal" cooling, mixing corrosion, Sulfuric Acid Speleogenesis (SAS), etc. SAS particularly involves condensation-corrosion processes allowing the fast expansion of caves above the water table, i.e. in an atmospheric environment. The hydrogeological setting of hypogenic speleogenesis is based on the Regional Gravity Flow concept, which shows at the basin scales the sites of convergences and upflows where dissolution focuses. Each part of a basin (marginal, internal, deep zone) has specific conditions. The coastal basin is a sub-type. In deformed strata, flow is more complex according to the geological structure. However, upflow and hypogenic speleogenesis concentrate in structural highs (buried anticlines) and zones of major disruption (faults, overthrusts). In disrupted basins, the geothermal gradient "pumps" the meteoric water at depth, making loops of different depths and characteristics. Volcanism and magmatism also produce deep hypogenic loops with "hyperkarst" characteristics due to a combination of deep-seated CO<sub>2</sub>, H<sub>2</sub>S, thermalism, and microbial activity. The resulting cave patterns can include geodes, 2-3D caves, and giant shafts in phreatic conditions; along

the water table, SAS with thermal air convection induces powerful condensation-corrosion and the development of upwardly dendritic caves, isolated chambers, water table sulfuric-acid caves; in the vadose zone, "smoking" shafts evolve under the influence of geothermal gradients producing air convection and condensation-corrosion.

Likely future directions for research will probably involve analytical and modeling methods, especially using isotopes, dating, chemical simulations, and field investigations focused on the relationships between processes and resulting morphologies.

**Keywords:** speleogenesis, epigenic cave, base level rise, cave level, cave pattern, epiphreatic cave, flooded karst, juvenile cave pattern, looping cave, mature through caves, per ascensum model of speleogenesis, vauclusian cave, water-table cave, paragenesis, ghost-rock karstification, hypogenic cave, sulfuric acid speleogenesis (sas), condensation-corrosion, regional gravity flow, hyperkarst, geode caves, 2-3D caves, giant phreatic shafts, upwardly dendritic caves, isolated chambers, water table sulfuric caves, smoking shafts

### **Update on the Hypogenic caves of Sicily**

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After the preliminary studies performed in different hypogenic cave systems in Sicily, recent explorations allowed to recognize another area where some caves, linked to hypogenic processes, were identified.

The Sicilian hypogenic karst systems which have already been investigated are: Monte Inici system, Acqua Fitusa Cave, Monte Kronio system.

Monte Inici system is located in north western Sicily and, as far as known to date, it is composed of the Eremita Cave and the Cacci Abyss, formed in Lower Jurassic limestones and dolomitic limestones (Inici fm.), and Middle-Upper Jurassic reddish-gray limestones with ammonites (Buccheri fm.). This cave system appears to be linked to the thermal water forming the Gorga ( $T = 49^{\circ}\text{C}$ ) and the Terme Segestane ( $T = 45^{\circ}\text{C}$ ) hot springs, located eastward and at lower altitude respect to the cave systems. The cavities are inactive 3D maze caves, reaching both a total length of over 2 km, and a depth of about 300 m. They are characterized by large galleries connected by deep shafts, and morphologies linked to condensation-corrosion processes, such as mega-scallops and big cupolas. Different types of chemical deposits, among which gypsum and phosphate minerals were found, whereas alluvial deposits are lacking. An important role in the evolution and widening of the subterranean voids seems to be played by air flow.

Located in central Sicily, the Acqua Fitusa cave opens on the north eastern side of La Montagnola hill. It is a great example of inactive sulfuric acid cave formed close to the piezometric surface level.

The Acqua Fitusa cave is a sub-horizontal cave, about 700 m long and 25 m deep, carved in Upper Cretaceous calcareous breccia with shallow water fragments (Rudist breccias member of Crisanti fm.). Actually the H<sub>2</sub>S-rich springs, with the classic rotten egg smell and with a temperature of ~25°C, lies northward and at lower altitude respect to the cave. Condensation-corrosion processes are responsible for the origin of different small and large size morphologies, i.e., condensation-corrosion tables, wall niches, ceiling cupolas, megascallops, weathered walls, boxwork, replacement pockets, etc. Gypsum crystals and crusts were surveyed at different heights.

The Monte Kronio karst system opens north-east of Sciacca town (southern Sicily), along the southern scarp of Mt. Kronio or Mt. San Calogero, formed of Triassic to Miocene platform and pelagic platform carbonate deposits.

The karst system consists of different cavities characterized by rising hot air and vapor flow with temperature of ~38 °C, connected to the presence of thermal chloride-sulfate alkaline water with a temperature ranging between 32 and 55 °C. The cavities are located at different altitude, and are formed by sub-horizontal passages connected by deep shafts or steep passages, but there is not always a passable connection between the different branches of the caves. Some galleries breach the southern scarp of Mt. Kronio through small openings some of which emit hot air, other ones aspire cold air from outside. Walls and ceiling of the caves are weathered and important gypsum deposits, in form of powders or crusts, were observed.

The new investigated area is located in the western sector of Sicily, nearby the Montevago village (AG). Here three hypogenic caves were explored, surveyed and studied. Personaggi, Personaggini and Barone caves develop in platform limestones (Inici fm., Lower Jurassic) and in scarp to basin limestones (Buccheri fm., Lower-Upper Jurassic). Caves formation is linked to the presence of thermal chloride-sulfate alkaline waters that actually form the Acqua Pia spring system characterized by a temperature of 40 °C.

These caves are generally sub-horizontal, with a maze pattern influenced by the geological structure; there are no true shafts, but fractures narrowing at depth; the rising branches are characterized by cupolas interpenetrating upwards. Among the subterranean morphologies drip holes, condensation-corrosion channels, condensation cupolas, feeders, pillars and partitions are recognized. In all the investigated systems there are also bat colonies and different mineral deposits which are both still under study.

**Keywords:** hypogenic caves, Sicily, speleogenesis, mineralogy

#### **Paleo environment reconstruction based on sedimentology investigations and dating analysis: case study in Kalahroud cave, North of Esfahan, Iran**

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Kalahroud Cave (Lat. 33° 22' 21" N, Long. 51° 34' 35" W, at 2,323 meters above sea level near the village of Kalahroud, Esfahan Province, Iran) is an interesting and complex cave formed in Cretaceous limestones. The cave has formed in the foot wall of the Kalahroud Thrust. The limestones are thick to massively bedded with thinner shale layers, locally tectonized, and overlain (capped) by insoluble strata. Stratigraphic dip is approximately 15°. The cave entrance is in cliffs ~35 m above the floor of a strike-aligned river valley with a channel that is active only in rare storms. The region is semi-arid, with only 51.8 mm average annual precipitation and a mean temperature of 22.1 °C. The explored cave is 4,503 m in length and has three morphologically distinct parts. Precipitates include the calcite rafts, widespread popcorn and cave coral on walls and pits, anthodites, frostwork associated with ferruginous shale bands, and dogtooth spar. Very significantly, cemented rinds of highly weathered

bedrock overlain by dense layered calcite are the oldest chemical deposits, reminiscent of those in Wind Cave, South Dakota, USA. ICPMS U-Series dating\* shows that the oldest rafts in the largest pool are ~9000 y B.P. in age, and the uppermost are modern. Clastic sediments are limited to breakdown and colluvial debris flows in the entrance passage, abundant clay fines in the notch chambers and tributaries. There do not appear to be any vadose stream deposits. After sedimentary studies it was obvious that the origin of mud accumulation in the cave chambers and distinct branches are completely different. Muds which form the mud masses in the tow big rooms are from the upstream unites which were carried by the river to the cave through the storms. But the fine sediments which fill the muddy branches floor and blind passages are the marls that are weathered and destroyed by the time. In the other hand, the muds exist in first part of the cave are allogenic but those in muddy branches are autochthonous.

From field observations, two main factors in cave development were tectonic uplift and deformation facilitating groundwater circulation, and dissolution with prominent rest levels (notching). Surface river entrenchment has drained and truncated the upper cave and there is only net deposition in the notch chambers.

**Keywords:** clastic sediments origin, dating analysis, Kalahroud Cave

### **Longest and deepest caves of Dinaric karst: Last 25 years of speleological research of Velebit Mt, Croatia**

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We shall present story about discoveries and explorations of the deepest and longest Caves currently known in both Croatia and entire Dinaric Karst region. These caves comprise three caves deeper than 1 km and 27.8 km long Kita Gaćešina cave system, all situated within the Velebit mountain range.

Velebit mountain range, with its 145 km in length, is the longest Croatian mountain. The area of Northern Velebit, where the deepest caves are situated, is composed almost entirely of carbonate rocks ranging from Middle Triassic to Paleogene Age. The largest part of Northern Velebit is composed of Jurassic carbonates (>2.5 km thick), predominantly limestones. Specific properties of strongly karstified Oligocene to Miocene tectogenic carbonate breccias also play significant role in morphology and speleogenesis of the caves. Speleological explorations have revealed a complex geology of Northern Velebit through determined occurrences of the breccias to great depths. For example, in Lukina Jama Cave System (depth 1,431 m) these breccias are prevailing to the depth of - 950 m, but appear in alteration with bedded Jurassic rocks from -250 m. A similar situation occurs in Slovačka Jama (depth 1,320 m) as well. This poses a number of questions related to their genesis and stratigraphy.

In almost 25 years of exploration, only in Northern Velebit area 348 caves were explored, 3 deeper than 1,000 m, 5 deeper than 500 m. Basic morphological features of Velebit caves are verticality and the incidence of major verticals with absence of horizontal passages. The biggest discovered verticals are located in Patkov guš (P553), Cave system Velebita (P513), Meduza (P333)

and in Cave system Lukina jama (P329). Five verticals are deeper than 200 m and 100 m verticals are quite common.

The majority of Croatian caving associations participated in the cave research but the most of those expeditions were organized by the Speleological Committee of Croatian Mountaineering Association. During all these years of research an excellent international cooperation was formed with cavers from many European countries and USA.

The longest presently known Cave in the Dinaric karst, Kita Gačešina Cave System is situated in the Crnopac Massif on the southernmost part of the Velebit mountain range. Geologically massif is composed of Oligocene and Lower Miocene carbonate breccias in its central parts, surrounded and underlain by Jurassic limestones, similar to the previously described North Velebit area. In contrast to the North Velebit, polygenetic multilevel caves are here discovered, probably due to the long history of water flow from higher Lika region to the Zrmanja river valley through the subterranean passages in the massif. Speleogenesis of the caves in the Crnopac Massif probably have lasted continuously from the beginning of the massif uplift (upper Miocene).

Mechanical properties of the carbonate breccias play a significant role in the cave morphology. Mechanical stability due to the low frequency of cracks and joints in these massive breccias enables the preservation of underground passages and chambers of very large dimensions.

In more than 10 years of intensive research Cave system of Kita Gačešina – Drazenova puhaljka reached the length of 27,802 m, depth of 737 m and became the Croatian and Dinaric karst longest cave. Speleological exploration is still not close to the end. Nearby cave Munižaba (9,715 m long and 510 m deep) is one with biggest underground spaces in Croatian part of Dinaric karst.

**Keywords:** caves, Dinaric karst, Croatia

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#### Gadime Cave- Pearls of Kosovo

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Kosovo is characterized for the complex geological structure, which belong to all geological ranging from Paleozoic through to Kuaterneri. In karst terrains multiple surface and ground relief forms are created, of which caves are the most important. Gadime Cave is the most famous and important in Kosovo, and the only one prepared and opened for the tourists.

Gadime Cave - Nature Monument of Special Importance, is located in the village Lower Gadime of Lipjan's Municipality, 3 km from Prishtina – Ferizaj – Skopje highway. The cave with its canals is located on the so called "Mërturi" hill, while the entrance is located at the bottom of the river Klysura at 580 m altitude.

It was discovered in 1967. After discovering it, the cave has been taken under the legal protection in 1969, with a total area of 38.6 ha. Due to rare nature values, cave ornaments, interesting cave

characteristics and appropriate position, the cave was prepared and opened for visitors in 1976. While in 2009, the Government of the Republic of Kosovo announced, Nature Monument of Particular importance, with a total area of 38.6 ha.

Gadime Cave represents a unique karst phenomenon not only in Kosovo but also beyond. It is developed in a lentil Paleozoik age limestone with marble small spatial dimensions schistose permotriasic fused. The fact that the channels and, galleries of this cave are created in Paleozoik marble, makes this cave even more special and very rare in the world.

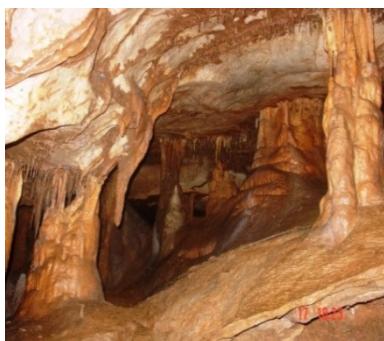


Photo 1 and 2: Gadime Cave.

The cave is also considered very special due to the presence of aragonites which for cave ornaments are very rare occurrence. These crystals, in the cave are shown in the gallery of Aragonite which are characterized by different forms and directions of alignment which make the cave particularly interesting and fascinating.

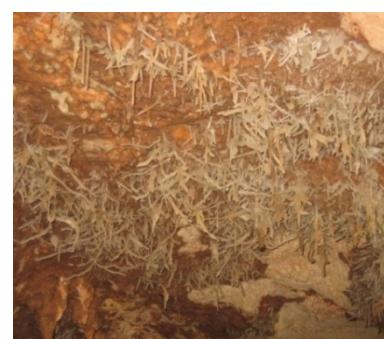
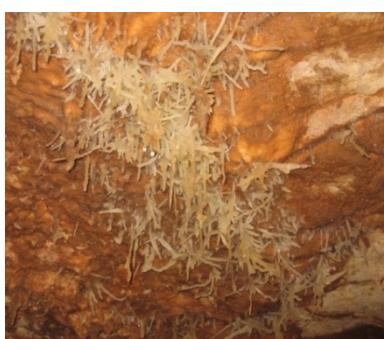


Photo 3 and 4: Aragonites- Gadime Cave.

In hydrological terms, the Gadime cave is rich with groundwater. At the same horizon all kinds of cave waters are presented: condensed waters, dripping waters, flowing waters and silent ones which turned the Gadime Cave into a unique particular hydrological monument.



Photo 5 and 6: Hydrological - Gadime Cave.

The cave is developed in three floors: the upper floor is not explored, the middle floor is explored partially and adapted for visitors, whereas the lower floor is flooded by water and clay. Continuing research in the cave is one of the most priority actions, in order to increase the scientific, educational, tourism and other values of the Gadime Cave – the Pearl of Kosovo.

**Keywords:** Gadime cave, ground relief forms, aragonites, hydrological, geological structure, groundwater, Kosovo

### **First outcomes from a recently explored cave system in the Apulian murge of SE Italy**

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The Murge of Apulia (SE Italy) show some of the most remarkable surface and underground karst landforms in the region. Canale di Pirro, a 12 km-long polje elongated in about W-E direction, is the most striking surficial feature. In its vicinities, the longest cave systems of the region are present: the Castellana caves, with over 3,350 m of development, and the Pozzo Cucù cave system (1,200 m-long) are the most significant on the northern side of the polje. To the south, on the other hand, the cave system at the Zaccaria quarry, and that of the Sant'Angelo cave, both at the outskirts of the town of Ostuni, are respectively, 1,500 and about 1,000 m long. All these systems are predominantly horizontal, with the Castellana caves reaching the deepest value at -122 m.

Within the Canale di Pirro, several caves have been included in the regional register of natural caves since the second half of the past century, most of them being of limited development and depth. The only exception was the Grave di Santa Lucia, a 250 m-deep cave that starts with a 65 m-deep shafts leading to a wide cavern produced by multiple breakdown events.

In recent years, after long months of tiring works of excavation, one of the main swallow holes of the polje (Grave Rotolo) was transformed into a real access. Soon after the first explorations, the discovery of an extremely promising cave system was evident. Following the initial series of shafts, leading to a depth of -90 m, a long sub-horizontal development brought to the impressive terminal pit, some 200 m-deep, ending with a lake. This latter was explored by a cave scuba diver, thus bringing the overall depth of the system to -324 m, that is the deepest cave in Apulia.

This article describes the first outcomes from the (still on going) explorations, and presents some considerations about geomorphology of the cave system, and its stages of formation and evolution. The Grave Rotolo system is at present the object of a monitoring and research project, aimed mainly at evaluating the groundwater quality, and defining the boundaries of the catchment areas feeding the system.

Keywords: exploration, karst, Apulia, Italy

### **Cerovačke caves – 100 years of exploration, scientific research and touristic use of the one of most important cave complex in Croatia**

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"Cerovačke caves are situated at the foot of the northern slope of Crnopac massif (SE part of Velebit Mt.) on the southern edge of the Gračac karst polje. There are three caves: Gornja (Upper) Cerovačka 1,290 m length, Srednja (Middle) Cerovačka 390 m length and Donja (Lower) Cerovačka cave around 4,200 m length (explorations are in progress). Upper Cerovačka cave was known to local inhabitants as the Kesića cave or the Cave in Kesića cliff. Lower Cerovačka cave was discovered during the construction of the Lika railroad in 1914. For the beginning of their research most credit goes to the railway supervising engineer Nikola Turkalj. Therefore, the name Turkaljeve caves can also be found. The adaptations of caves for tourist purposes started in 1951, in 1961 they were protected as geomorphological natural monument and electric lighting was installed in 1977. Today the caves are governed by the Velebit Nature Park Public Institution. These caves have been explored by the famous Croatian speleologists like Mirko Malez, Zlatko Pepeonik, Srećko Božičević and others.

Due to dominantly carbonate structure of this part of Velebit, waters flow subterranean through Crnopac massif, generally towards the south. Underground waters get water from the sinking streams that come from karst poljes in Lika and Gračac area and flow underground towards south. So, the Cerovačke caves have very strong geospeleological significance. They are, together with other big known caves on Crnopac (Kita Gačešina cave 28,629 m length, Munižaba cave 9,175 m length) part of inactive zone of this hydrological karst system which drains surface waters from Gračac karst polje.

Cerovačke caves are also an important palaeontological, archaeological and biospeleological site. Remains of the Pleistocene animals like cave bear and cave lion were found there, as well as many other animals especially smaller rodents and birds. Also, bone remains of Palaeolithic human Homo sapiens fossils were found. Archaeological artefacts (pottery fragments, metallic, bone and stone findings) show that the Lower Cerovačka cave was used since the Middle Bronze Age (1,400-1,200 B.C.). Cerovačke caves also have a very rich underground fauna. Upper cave is type locality for three species, while Lower cave is type locality site for five species.

Numerous speleological and scientific researches in these caves are also carried out today. So, priceless scientific, speleological and tourist importance of the Cerovačke caves can be seen. We can conclude that they are among the most valuable caves in the Croatian karst. It is very important to continue with speleological explorations in order to discover new, so far unknown parts. It is also necessary to continue with systematic scientific researches.

**Keywords:** Cerovačke caves, speleology, history of speleology, show caves, Velebit, Croatia

### **Geomorphological-geological significance of the Olimp pit on Northern Velebit Mt. (Croatia)**

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Olimp pit is located in the Northern Velebit National Park at the altitude of 1,370 meters above sea level. The depth of the pit is -537m and currently the Olimp is the 12<sup>th</sup> on the list of the deepest caves in Croatia and also the sixth one in the Northern Velebit National Park. The cave was found in 1998, but the main exploration began in 1999. The most intensive exploration was conducted in 2000 and 2006. The cave is a simple knee-morphology. It consists of a number of vertical channels and small shelves between them. The deepest vertical channels are 92 and 90 m deep, and the average depth of all verticals in the cave is 38 m. In dry season the cave is hydrologically active from the depth of -300 m, while in the wetter period water appears much higher. The upper part of the pit, to a depth of about -350 m, is made up of the Paleogene so-called "Jelar" or "Velebit" carbonate breccia, and the lower part of the cave was formed in carbonate, well layered rocks, most likely late Jurassic age. This difference affects the less pronounced, but still noticeable differences in the morphology of the channels. The tectonic fractures that had an influence on the genesis of the cave have the directions N-S and NW-ES. The bottom of the pit is a collapsed hall. A narrow passage (6 m deep) between the collapsed blocks was found and a watercourse flows through it. The data obtained in this study also helps in geomorphological and geological studies of the Park's wide area.

**Keywords:** jama Olimp, karst, speleology, geospeleology, NP Sjeverni Velebit, Croatia

**Geological and geomorphological conditions for karst and cave development in the NE peripheral zone of Dinaric karst (Dunjak area, Croatia)**Neven Bočić<sup>1</sup>, Maša Paić<sup>2</sup>, Uroš Barudžija<sup>3</sup>, Neven Šuica<sup>4</sup><sup>1</sup> University of Zagreb, Faculty of Science, Department of Geography, Division of Physical Geography, Marulićev trg 19/II, Zagreb, nbocic@geog.pmf.hr<sup>2</sup> Croatian Geomorphological Society, Marulićev trg 19/II, Zagreb, mpaic3@gmail.com<sup>3</sup> University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Department of Mineralogy, Petrology and Mineral Resources, Pierottijeva 6, Zagreb, uros.barudzija@rgn.hr<sup>4</sup> Society for research, protection and promotion of geological heritage "Petris", Kralja Tomislava 19, Karlovac, neven.suica@gmail.com

Dunjak area is located in the transitional zone between the Dinaric Karst and Peri-pannonian part of Croatia. Geomorphologically, this area is a transitional zone between the karst area in the southwest and fluvial in the northeast. The studied area is composed of the Lower Triassic sedimentary rocks dominated by mica sandstones and carbonates (limestones and dolomites). The aim of the research was to determine the fundamental geological and geomorphological features as well as the conditions of the development of the surface and underground karst formations in the study area. It has been found that the investigated area fluvio-karstic characteristics developed by karstification processes and reorganization of the previous surface drainage network. Determined surface karst and fluvio-karst forms are: blind valleys, dry valleys and sinkholes. The most important underground form is the Dunjak cave – an inactive karst conduit. Geomorphological map of the area and the Dunjak cave map with geological and geomorphological features were also done. The basic stages of development of surface and underground karst features were determined.

Keywords: karst, fluviokrst, speleology, geospeleology, speleogenesis, Croatia

**Knowledge flow in K.K. Monarchy – Czech engineers Hráský and Putik on Slovenian karst**

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Among many different characteristics of the second half of 19<sup>th</sup> century Austrian Hungarian monarchy was also unified university area where students and graduates travelled freely between different places and cities where today exist national states and their borders with different legal rules enacted. They had try to find new and better knowledge and job. Some parts of this big Central European state were more developed than others and concentration of well educated and able people was higher than in other less developed parts; such examples were cities of Vienna, Budapest, Brno and Prague. In these centres large fluctuations of people were presents; there were tendencies to find jobs and positions in them, however due to high demand there was not enough space for all and others have to seek opportunities elsewhere. Beside people exchange this was also large knowledge flow. Young graduates from these centres often looked for opportunities where working conditions were more familiar to them and among them language skills were not the least important. This was the reason why in 19<sup>th</sup> century in the present day Slovenia many educated Czechs and Slovaks were employed and why many of them have established successful business enterprises and other advantageous services. Their role in the development of present day Slovenia still has to be investigated as well as their efforts in the Slovenian karst exploration. Present paper is small contribution in this direction.

Czechs engineers play prominent role in the development of karst and cave science and exploration in the Slovenian territory and its vicinity of today Croatia, Italy and Austria. Among them is well known legendary over two meters tall Viljem Putick (1856–1926) who explored several of important caves especially in the region of Notranjska. His work and achievements are relatively well investigated and known. He prolifically published about his work and was socially active among the local people where he had investigated caves. This was the reason why even after his death in some places public memory about him remains. By education he was forestry engineer starting to work in year 1888 in Villach – Austria in amelioration of mountainous torrents but soon he was transferred to Carniola to the forestry department responsible for the amelioration of Notranjsko polje system. He naturalised and remains loyal citizen of Yugoslavia after the World War First.

The other less known figure who did also important job in karst investigations, especially in the area of Dolenjsko, was Jan Vladimír Hráský (1857–1939). His caving exploration achievements were not so spectacular as Putick's; as a caver he explored cave systems between Rašica – Dobrepolje and Krka resurgence. He has published only few works about karst research which are today difficult to access and probably some of them are still unknown, hidden in state archives. In the area he left important legacy in the constructed public works such as they are ameliorations and many local waterworks. At the time of his stay in Ljubljana between years 1884 and 1897 he was appointed county engineer responsible for public works and public buildings, among his specialities were hydrotechnical works. As a prominent intellectual figure he was active in public life and among others helps to establish Slovenian mountaineering club. After his Ljubljana tenure he moved to Prague where he took over position as a professor of hydraulics and hydrology at the Technical faculty. He continued to work as a designer and planner of many public works, publishing four books and many papers. He remained active in Czech public life as a member of the parliament and university rector.

### **Iranita multidisciplinary project. Speleological Expedition in Chahar-Mahal va Bakhtiari Province (Central Iran). Preliminary results and future projects**

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The first step of the project has been the Speleological Multidisciplinary Expedition that took place in the Chahar – Mahal va Bakhtiari Province of Central Iran from 1<sup>st</sup> to 15<sup>th</sup> June 2014. The aim of the expedition in Iran focused on the general overview of the karst plateau, the first exploration of hypogean karst features as caves and the preliminary sampling activities for hydrogeological components. This project is the result of the scientific collaboration among Kowsar Water and Environmental Research Center of Teheran, Karst Water Exploring Scientific Association and Club Alpinistico Triestino of Trieste. The exploration of new (or scarcely explored) conduits and caves permits to upgrade the hydrogeological information on groundwater resources related to the sensitive and environmentally valuable areas of Iran. The exploration of hypogean cavities and the collection of data through the inventory of water occurrences, allows upgrading the hydrogeological setting of the area in order to prevent any adverse impacts on the environment and the water resources quality. The speleological exploration is focused also on improving the hydrogeological framework with the aim to establish a satisfactory water supply to the local Communities and the sensitization toward the vulnerability of karst aquifer. The working area has been localised in according with Dr. Afrasiabian and with the Karst Water Center of Sharh – Kord. The working area is located in Chahar – Mahal va Bakhtiari in the center of Iran. We planned the speleological activities under suggestions of the cavers of Sharh-Kord Mr. Saeid Mohammadihafshejani, Mr. Meysam

Nejatdehkordi and Mr. Majid Fathollahidehkordi. They met us and organized our activities inside the caves and outdoor. They suggest the visit of two caves, the Sarab Cave in Calak Mountain and the new one already discovered, the Cole Jikon Cave in Half Karton Mountain (Zagros Mountain Chain). The Italian Team was split in different working groups in charge of performing specific field activities. A group was involved in making the topographic survey and drawing of the caves. A second group was in charge to collect the groundwater samples for isotopes analysis ( $\delta^{18}\text{O}$ ;  $\delta\text{D}$ ;  $\delta^{13}\text{C}$  in carbonate as D.I.C) in the same sites the basic physio-chemical measurements data (pH, T, electrical conductivity) were acquired. The third group was the photographer team. Field activities were planned day by day in according with the Iranian cavers. One day was dedicated at the field – trip to understand the geography surface and collect water samples of the followings springs: Gerdab Ben, Dimeh (Dime Mountain), Pire Ghar and of the Zaiander river. Knowing the recharge mechanisms of water in karstic areas is of most importance in order to develop strategies of protection of the local ecology from natural hazards like subsidence, erosion, anthropogenic pollution, planning the dam structure and the natural catchment area. This first expedition in Iran implemented the collaboration among the Italian and Iranian speleological and scientific teams. Two teams together are planning a second expedition with the aim to continue the geo-speleological research activities in Chahar-Mahal province beginning a "Water program in the framework of a "Managing Karst Aquifer Project" for enhanced the hydrogeological knowledge for environmental sustainability. The goal of our mission is improving the joint researches and projects aimed at the protection of such valuable water resources and natural heritage in karst areas for the present and future use and to improve the speleological knowledge. The results outcomes from these preliminary investigations will be the issues of specific report.

Keywords: exploration, scientific expedition, Iran

### **Interaction between structural setting and underground water flow: the case of the Alburni Mts (southern Apennines, Italy)**

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The Alburni Mts are an impressive carbonate massif, the most important karstic area of the southern Apennines with around 250 registered caves. Structurally they represent a 1,500 m thick Mesozoic to Cenozoic carbonate sequence, forming a southward dipping monocline, locally overlain by Tertiary flysch units trapped in half-graben basins. The entire massif is crossed by NW-SE trending transtensional fault systems delimiting the half-graben basins, and offset by NE-SW trending faults. Seven hydrogeological complexes were recognized in the massif for their different permeabilities. The karst channel network is hierarchically organized: some channels feed a major spring (1 m<sup>3</sup>/s) with very short transit times while others communicate directly with the basal water table related to other springs. The main areas of concentrated infiltration are located between 1,000 and 1,600 m a.s.l. while the basal water table and its main emergences range in elevation between 60 and 150 m a.s.l. Several basal springs are present in the massif: Pertosa and Castelcivita caves located respectively along the northern and southwest boundaries of the structure. Another important group of basal springs are called the Auso group with very variable discharge (from several m<sup>3</sup>/s to a few l/s), connected to the infiltration of the central area by means of the channel network.

The exploration of the Alburni carbonate massif has been the goal of many speleological campaigns since the early 70s, but its geological and hydrogeological setting are still poorly known.

For this reason, in order to understand the control of tectonic features on the underground flow a geomorphological and speleological study are being carried out.

As a first basic result, we have produced a detailed morphostructural map and performed a statistical analysis of the tectonic morpholineaments. The arrangement of such geomorphological features and the major fault boundaries show that the Alburni Mts can be divided into three different morphostructural blocks. Also, we have produced some topographic profiles with the location of the hydrologically active cave systems.

Keywords: hypogean karst, morphostructural analysis, underground water flow, southern Italy

### **Northern Luzon International Caving Expedition Philippines - NLICEP 2015**

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With approximately 35,000 km<sup>2</sup> of karst areas the Philippines had by 2009 a total of 1,649 caves known by its Department of Environment and Natural Resources - DENR. However, these numbers could be conservative whereas several karst areas remain unexplored throughout the country. For that reason, between January 8<sup>th</sup> and 27<sup>th</sup> 2015, took place the NLICEP 2015, an expedition granted by FSE and NSS counting on cavers from Germany, Belgium, Switzerland, Lebanon, USA, Brazil and Philippines. The target was to explore two untouched karst areas in Northern Luzon: Balbalan and Santa Teresita.

Balbalan is located in the Kalinga Province, center of Northern Luzon, and is known for its remoteness and its over 2,000 meters mountainous landscape covered by pine forest. Explorations were restricted mainly to the Mabaca River Valley, where the Sicalao Limestone can be found upstream from Toctoc Sitio. Exokarst formations are not easily seen, although caves have been found over all compartments, from quota of 200 meters to 1,300 meters. Most caves are dry but the longest ones are river caves, such as the Dinugdugan Cave with a length of 925 meters and the Magangan Cave with a length of 891 meters. The team also has been to the Uguid Subterranean River Cave, a talus cave, over 700 meters long, located in the Saltan River Valley.

On the other hand Santa Teresita is located in the Cagayan Province, near to the northern coast of Luzon, where the karst reaches the shore (Ibulao Limestone). The lowland between the rivers Luga and Mission is characterised by cone karst formations and underground stream systems. Most caves are small or were partially flooded at that time. Several ones are meander thru caves underneath the hills, such Aridowen Zero Cave, the longest in the area (1.027 meters long).

In both areas a total of 56 caves have been documented and an approximately length of 8,478 meters surveyed. Nevertheless more caves in those areas remain to be surveyed, as well caves in surrounding areas, such as in Peñablanca, where the team did just a short visit on the last day of the expedition.

Keywords: cave documentation, Philippines, Luzon, Kalinga Province, Cagayan Province

**The impact of solar radiation on the temperature of the exposed rocks of canyon karst (Cracow Upland, Poland)**  
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Results of research are presented of the impact of solar radiation on the formation of thermal conditions exposed rock surfaces of Cracow Upland. The research included the structure of radiation balance, surface temperature and -10 and 20 cm in limestone on the south wall of the canyon karst. The researches were performed for different types of weather. The biggest mesoclimate differences were noticed: isolations, net balance, thermal heat flux in the rock and the inertia associated with the heating of the day and night cooling rocks for the weather of radiation type. The radiative flux, which comes from the warm sidewalls affects the inversion conditions and slow increase in net radiation during the night. The local differentiating factor was varied terrain. The contrasts of karst canyon in particular limestone surfaces were specified quantitatively. It were shown the importance of terrain in shaping mesoclimate even small karst areas. These characteristics determine the biodiversity and shape the ecotopes of karst canyon including vegetation on limestone rocks.

Keywords: microclimate, surface temperature, radiation balance, karst, Cracow Upland

**Hypogenic Karst Dissolution in Carbonate Rocks has Implications for Karstified Carbonate Reservoirs**

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Dissolution along zones of preferential flow enhances anisotropy in geological media and increases its complexity. Many karst models tend to be descriptive and fail to predict localization and structure of karst systems. Conduit architecture is difficult to derive from borehole data, and it can be hardly mapped even with the advent of 3D seismic techniques. Therefore, analysis of the geometry of karst conduit systems remains elusive where direct access to karst conduits is not possible. The present study investigates the relationship between lithofacies, tectonics and karstification in the Neoproterozoic Salitre Formation, located in the central-eastern Brazil. This unit comprises several systems of caves including the Toca da Boa Vista and da Barriguda hypogenic caves, the largest in South America, and focus of this study. We focused on cave mapping and morphogenetic analysis, determination of petrophysical properties, thin-section description, microtomography, and isotopic analysis. The Salitre Fm, deposited in an epicontinental sea, comprises mud/wackestones, grainstones, microbial facies, and fine siliciclastic rocks. The caves comprise 3D mazes with a network/spongework pattern. Passages occur in several levels within ca. 60 m thick

cave-forming section, limited at the top by lithofacies with low permeability and fractures. Cave development occurred in phreatic sluggish-flow environment with overall upwelling flow. It rose via cross-formational fractures and distributed laterally within the cave-forming section using geological heterogeneities to eventually discharge up through outlets breaching across the upper confining beds.

Cave formations include an assemblage indicating a period of water table conditions. Sediment fill includes deposits of dolomitic sand originated from in situ weathering of cave walls and ceiling. Caves show no relationship with the surface. Our data indicate several events of porosity evolution, such as subaerial exposure, folds and fractures, hydrothermal events (exotic minerals assemblage), sulfuric acid dissolution, dissolution at the water table, condensation corrosion, and faults and fractures reactivation. The major enhancement of secondary porosity was due to hypogene speleogenesis. Hypogene karst process may have implications to carbonate reservoirs not only through porosity enhancement, but also through their influence on regional flow systems, cross-formational communication, and migration of hydrocarbons.

**Keywords:** hypogenic karst, reservoirs

**Spatial and temporal distribution of stygobiotic crustaceans: *Creaseria morleyi* and *Typhlatya* spp.  
in Yucatan cenotes**

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Studying the distribution, population dynamics and behavior of stygofauna in their natural habitat may be difficult, technically challenging and involves risks when cave diving is involved. Nevertheless, many different taxonomical groups have been found, described and studied. Most of these studies focus on taxonomic, biogeographic studies, evolutionary or genetic trends, allowing some behavioral and ecological questions to remain unanswered. The 42 species of stygobiotic crustaceans living in underwater karst caves of the Yucatan peninsula of Mexico makes them the most diverse group in this habitat.

The Palaemonid *Creaseria morleyi* and the Atyids *Typhlatya* spp. were monitored to evaluate the depth distribution during day and night in the light transition zone of two cenotes (sinkholes) of Yucatan (Kankirixché and Tza-Itzá). These cenotes were monitored day and night every 2 months from February 2014 to February 2015 to study the distribution of organisms and changes in population size. The trophic interaction between these species was video-recorded with infrared devices in the laboratory.

Results indicate: 1) Higher densities of both genres are found in cenote Tza Itzá; 2) *C. morleyi* occurs more frequently during the night and is found only at night in the shallow areas that are, otherwise illuminated during the day; 3) Beyond the open water surface of the cenotes where *Typhlatya* spp. is not found, it exhibits a decreasing density as the depth increases 4) *Typhlatya* spp. maintains its densities similar during day and night at each depth; 5) Population size of *C. morleyi* increases at the beginning of the rainy season of Yucatan while the populations of *Typhlatya* spp. exhibit no significant change; 6) *C. morleyi* is capable of hunting, capturing and feeding on live *Typhlatya* spp.

The observed distribution pattern in *Typhlatya* spp. could be explained by the greater availability of allochthonous and photosynthetic material at the entrance of the cenote. The migration to the cenote entrance of *C. morleyi* could be explained by the trophic interactions with *Typhlatya* spp. revealed by this study and also other feeding sources such as Mysidae and allochthonous material.

**Keywords:** decapoda, caves, behaviour, ecology

### Caving in Cyprus

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Cyprus has been inhabited by mankind since the late prehistoric period. At that time, dwarf fauna was living on the island and caves were filled with bones of those beasts. Among the cave dwellers, bones of those animals in the caves were written about by Homer in the *Odyssey*. During the Renaissance a few books were written about the caves and the island has been explored mostly by the English since the 19<sup>th</sup> century and during the second half of the 20<sup>th</sup> century.

In 2003 in the northern part of the island, Turkish cavers from Ankara led a survey on 42 caves on or close to the Kyrenian Range.

The Republic of Cyprus is currently concerned with the European project for Bat protection in caves near Akamas and Cape Pyla regions. A French team recently conducted investigations on the whole of the island to determine the real karstic potential and an NGO was created in the north after that expedition in 2014.

A European caving project is programmed to start in 2016.

Keywords: Cyprus, Caving, history

### 60<sup>th</sup> Anniversary of the Sežana Caving Club

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The Sežana Caving Club (a member of the Speleological Association of Slovenia) was founded in 1955 and has been active without interruption until the present day. Members of the Club are involved in a range of activities, the most important of which include discovering, exploring and documenting caves, educating the public and protecting caves. Club members take part in cave exploration and cave visits throughout Slovenia and abroad. Since 1993, the Club has also participated international projects.

The first major successes of the Club included the discovery and exploration of the Dolenca jama and Drča jama caves – the latter is now used as a water source by the population of the Kras region. The Club's greatest achievement is the exploration of the caves along the subterranean section of the Reka river. At the end of 2003, Club members discovered the subterranean flow of the Reka in the Jama 1 in Kanjaduce cave, then just a few days later, in 2004, they found it in Brezno in the Stršinkna dolina cave and in 2011 in the Jama Sežanske Reke cave (together with members of the Speleological Section of the Trieste Slovenian Mountaineering Society and the Danilo Remškar Caving Club from Ajdovščina). An important achievement was also the discovery of the Gustinčičeva jama v Blažčevi dolini cave which is one of the best preserved known caves in Slovenia. Members have also made important contributions in the field of speleoarchaeology, making archaeological discoveries in a number of caves.

The Sežana Caving Club manages the Vilenica cave near Lokev, which is known as the oldest tourist cave in Europe. In 1961, working with several other caving clubs, companies and local inhabitants, members of the Sežana Caving Club began preparing the cave for tourist visits, opening it to visitors in 1963.

**200 Years of Exploration of the Škocjan Caves**

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The first known attempts to explore the interior sections of the Škocjan Caves (Škocjanske jame) date back 200 years, when Joseph Eggenhöfner swam the Reka river under the village of Škocjan in the swallow hole; today this section is known as the Mahorčič Cave (Mahorčičeva jama) and Marinič Cave (Mariničeva jama). Serious exploration began when Jakob Svetina and Adolf Schmidl reached the central part of the caves in 1839 and 1851. Systematic exploration of the Škocjan Caves dates back to 1884, when they were leased by the Trieste Section of the German-Austrian Mountaineering Association. Most of the cave passages that we know today were discovered before 1904. The dramatic environment with majestic halls and the roaring of the Reka made a strong impression on the locals, the cave explorers from nearby Trieste and the Austrian experts. Unlike other caves, three activities were being carried out simultaneously in the Škocjan Caves, namely cave exploration, the development of tourist infrastructure and the development of tourism itself. Cave explorers and workers built over 12 km of trails and paths through the caves, building bridges and beauty spots, all in the style of Alpine mountain tracks. Some of the paths are still accessible today. The Škocjan Caves boast a rich heritage of exploration. In addition to the technological heritage in the caves (trails, handrails, bridges, signs and boards), some caving equipment has also been preserved, including safety belts, helmets and lamps, as well as a number of texts, publications and postcards from the period.

The Škocjan Caves were added to the list of UNESCO World Heritage Sites in 1986. In a large part, this was thanks to the extraordinary work done in the Škocjan Caves by the first explorers and cave workers; along with the Karst explorations that took place at the same time, these are considered the beginnings of speleology.

**Imaging and Modelling Buried Palaeokarst Hydrocarbon Reservoirs**

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Although some of the largest hydrocarbon accumulations found in carbonate rocks are clearly related to palaeokarst systems (e.g. Tengiz-, Yates-, Renqiu-, Golden Lane fields), the associated type of reservoir and its production behaviour are still poorly understood and hence, believed to be unpredictable. On one hand, a large number of palaeokarst hydrocarbon reservoirs were, and still are, classified as 'fractured carbonates', mainly because of the similarity in production behaviour. On the other hand, where properly identified, palaeokarst hydrocarbon reservoirs appear to be difficult to model. Main reasons for this are the lack of integration of analogue data, the absence of a comprehensive 'karst facies scheme', and limited software possibilities for realistic modelling of karst networks.

Palaeokarst is referred to as a system that is not physically related in time and space to the active karst processes that formed it. From a petroleum system point of view, karst related reservoirs are attributed to four types of plays: (1) buried-hill karst, (2) plateau karst, (3) build-up karst, and (4) detrital carbonate wedge karst. This classification is mainly used in hydrocarbon exploration and highlights one common diagnostic feature of palaeokarst reservoirs - the fact that they are always occurring at major unconformities (related to 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> order sequence boundaries). Other diagnostic criteria include the lack of seismic resolution at top reservoir, specific logging tool

responses, drill bit drops and massive circulation losses, solution vugs and cavern porosity in cores, and a high variability of initial flow rates in discovery wells.

Differentiation is made between hydrocarbon reservoirs hosted in collapsed cave systems and reservoirs developed in marine ingressed karst systems (so-called 'Neptunian Dykes'). The former displays mainly autochthonous infill breccia resulted from collapse of extensive cave networks after burial. Epigenic karst surfaces, with their associated doline/cenote deposits are also included in this type of reservoir. Because coalescing of collapsed karst zones is a common feature, the resulting reservoir architecture is rather simple, overprinting the original shape of the endokarstic system. Markedly different are marine ingressed systems, mainly due to their early allochthonous sedimentary infill, preventing a system collapse. Thus, most of the original cave network is preserved and reservoir geometry is therefore complex. Moreover, facies variations of the sedimentary infill contribute to the overall heterogeneity of such reservoirs.

Karst networks are often poorly expressed features on 3D seismic due to their inherent complex shapes and lateral variability. In order to image the Karst, special seismic post-processing attributes based on coherency, phase or frequency algorithms have been tested. None of these attributes would give a full image of the Karst (mostly due to the rapid lateral variation in thickness). Therefore, these attributes were combined using a multi-attributes volume interpretation workflow in order to build a realistic Karst model. The model was then tested against drilling operational data (mud losses). The multi-attributes interpretation allowed for the merger of different Karst "signatures" while the 3D volume based approach allowed for the spatial definition of complex geometries. Karst network geometries were subsequently incorporated into a deterministic reservoir model and risked properties could be tested and further refined against 15 years of production history in an iterative dynamic simulation workflow.

Keywords: palaeokarst, hydrocarbon reservoirs, seismic modelling

### **Age of carbonate speleothems in gypsum caves and karst areas of Emilia-Romagna and speleogenetic implications**

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Caves in Emilia-Romagna are developed in evaporite rocks (gypsum) of triassic and messinian age. These rocks, although having very limited surface outcrops (less than 1 % of the entire region), host over 600 caves, comprising the longest (Spipola-Acquafrredda cave system close to Bologna with over 11 km of surveyed passages) and the deepest epigenic gypsum caves of the world (the Monte Caldina system, 265 metres deep). Considering the fast dissolution of gypsum in the current regional climatic settings, these caves have always been considered as having formed very recently, since the end of the last ice age.

Most caves often host important carbonate flowstones and other speleothems. These are formed in presence of important concentrations of CO<sub>2</sub>, that cause calcite to precipitate from the waters

saturated in gypsum, further boosting the dissolution of the calcium sulphate (incongruent dissolution). These carbonate speleothems typically form in warmer and wetter climate such as interglacials and interstadials, when soil activity is greater and CO<sub>2</sub> concentrations in percolating waters is more relevant. Calcite speleothems can be dated by the U/Th method, giving a minimum age of the formation of the passages in which they deposited.

In the framework of two PhD theses calcite flowstones have been sampled and dated in a dozen of caves and surface locations in the Vena del Gesso Romagnola and the gypsum areas close to Bologna. These analyses have identified flowstones with ages as old as 300 ka, demonstrating some caves to have existed since then.

Speleogenesis appears to have been active especially during colder periods, when rivers formed terraces and aggradation caused paragenesis to take place in stable cave levels. During warmer periods rivers entrenched and cave systems carved new lower lying levels. The abandoned levels were subject to deposition of carbonate speleothems. Speleothems show caves to have formed at least since MIS 8, and some cave systems underwent more than one glacial cycle. The oldest still active cave system is the Re Tiberio cave, in the Vena del Gesso, that started forming at least since 130 ka.

Keywords: carbonate speleothems, gypsum caves, evaporites, speleogenesis, U-Th dating

### **The discovery and exploration of Sistema J2, Oaxaca, Mexico, Matt Covington**

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Sistema Cheve, located in the Sierra Juarez Mountains in the Mexican state of Oaxaca, is one of the deepest known karst hydrological systems in the world. This area has seen extensive exploration for the past 30 years. In 2004, Cueva J2 was discovered during an effort to find a route into the yet unexplored central portion of the Cheve system that lies between the current downstream terminus of Sistema Cheve and the upstream end of the resurgence cave Cueva de la Mano. Expeditions returned to continue exploration in J2 in 2005 and 2006, pushing the cave to a depth of 1,210 meters, where a sump halted further exploration. Major diving expeditions returned in 2009 and 2013 and pushed the cave beyond two sumps before reaching a seemingly final terminus. While this dashed the hopes of using J2 as a route into the middle Cheve system, J2 now stands as an impressive cave in its own right, with a depth of 1,229 m and a length of nearly 15 km. In my presentation I will summarize the history of exploration and scientific research in J2.

### **Cave Exploration and Science Australia**

John Cugley

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Australia has a strong culture of Cave Exploration in each of the states and territories. Exploration is inherent in the psyche of most Australian cavers. From the exploration of remote locations where extensive passages lay hidden, to small pushes in well-known and much visited locations - the thirst to seek out the unknown is a constant theme in current Australian Caving activities.

Cave exploration in Australia presents its own unique challenges. Exploration at karst areas near the major cities may present challenges that are similar to those faced in your own countries.

Remote exploration, days or hours from the nearest services can present unique challenges requiring months of planning and days of travel before reaching the site from which exploration can begin.

This presentation aims to explore some of the challenges identified above unique to the Australian caving environment. It also aims to provide a concise overview of ongoing scientific programs, linked to these explorations (Including speleothem dating and paleoclimate, anthropological and speleobiology).

Keywords: Australia

### **Contemporary cave exploration in Slovenia**

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Slovenian karst was a pioneer area of cave exploration starting from mid-19<sup>th</sup> Century. Indeed, it is among the few European areas where speleology as a science emerged. Ever since, the exploration has been conducted in an extensive, de-centralized manner. The results of exploration (surveys, cave maps, reports) have been collected by the national Cave registry, which is jointly operated by the Speleological association of Slovenia and the Karst research institute of the Academy of sciences. Currently there are 11.210 caves registered in Slovenia, with an increase of about 250 new caves each year. The total length of all passages combined is close to 800 km, with an annual increase of 20 km. This paper is dedicated to the cave exploration since 2000.

By geological constrains, Slovenian caves are typically narrow, with few large chambers and of moderate length (only two caves are longer than 20 km). On the other hand, deep Alpine caves are common, with six caves over 1000 m depth, among them "Čehi 2", currently the 11<sup>th</sup> deepest cave in the world. Due to Slovenia's small size and dense road network, most caves are accessible within a day trip, many of them just a short walk from the nearest car park. In this way, cave exploration is mostly done in one-day efforts. It may take a few days for a relatively easy cave; on the other hand hundred-plus trips may be required to reach the first kilometer in an extremely narrow cave, with daily progress measured in centimeters rather than meters. However, in Alpine area, week-long camps are the preferred option. In the past 15 years only the exploration of the above mentioned Čehi 2 can be classified as a full expedition.

Contemporary cave exploration is performed in different ways: (i) Extensive search for new caves in a small area, (ii) extensive search for new passages in larger caves, (iii) exploration of Alpine caves with an emphasis in record depths, (iv) cave diving. The latter is often directed towards joining two nearby caves, often in proven hydrological connections (ponor-spring of the same underground river). In this presentation, some outstanding cases of cave exploration will be shown, with an emphasis on quantitative measures of progress. The country's deepest and longest caves will also be addressed.

Keywords: cave exploration, Slovenia, Cave registry

## Speleogenesis of Santa Catalina Cave and its giant mushroom-shaped speleothems (Matanzas, Cuba)

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Santa Catalina Cave is located 20 km east from Matanzas city, at the north-eastern coast of Cuba at about 1 km from the present coastline. It is developed on three sub-horizontal levels evolved in young Pleistocene eogenetic coralline limestones. The combination of galleries and halls with spongy features, cuspatate walls, and peculiar irregular chambers that narrow moving away from the sea suggest genesis by mixing corrosion (flank margin cave).

The cave hosts an exceptional association of speleothems. Rare morphologies like giant mushrooms and folia are always associated with shelfstones, calcite raft deposits, raft cones and cave clouds.

Geomorphological observations and in particular mineralogical, petrographical, geochemical studies as well as <sup>230</sup>Th/U-dating of the mushroom-shaped speleothems allow us to reconstruct the potential speleogenetic history of the cave.

The stipe of the "mushroom" is composed of three different phases: an inner stalagmite, surrounded by a raft cone that is covered by cave clouds. In contrast, the hat is constituted of a porous sedimentary structure. Calcite and aragonite are the main minerals, but the presence of authigenic silicate and gypsum suggest evaporative conditions.

Santa Catalina Cave appears to have developed over different climatic periods recorded in its amazing speleothems. The first phase is characterised by the dissolutional carving of the sub-horizontal anastomosing passages, when the cave was in the mixing zone between salt and fresh water. The drop of sea level and/or coastal uplift brought the cave into vadose conditions starting the growth of conventional speleothems, such as stalactites and stalagmites. <sup>230</sup>Th/U-dating of a stalagmite has shown that this occurred at least since 360 ka (Marine Isotope Stage (MIS) 9). A clear hiatus in this stalagmite corresponds to a stop in growth, possibly during MIS 8.

After a probable rise of the water table level (possibly related to the MIS 5 sea level highstands), the galleries were partially flooded. This phase saw the formation of cave pools in evaporative conditions (due to the presence of several entrances). This allowed precipitation of floating calcite rafts and the genesis of raft cones under dripping points and raft deposits on the pool floors. Another rise of the cave pool water level probably allowed the formation of mammillary calcite.

A subsequent water table lowering produced shelfstones and the mushroom hats, both located at the same altitude. <sup>230</sup>Th/U-dating has shown that this happened around 12.5-9 ka ago during and immediately after the Younger Dryas. They formed at the air-water interface, directly influenced by water table fluctuation most probably induced by tides.

The last main phase is characterised by a sudden and rapid event that caused a rapid water level fall, testified by erosion of the deposits and the fossilisation of the cave morphologies.

Keywords: flank margin cave, shelfstone, folia, cave cloud, calcite raft, Ca-carbonate speleothems

### **Geological investigation on Doridan Cave (South east of Delijan)**

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Doridan Cave is hosted in Tertiary (Oligo-miocen) limestone of Arsh mountain located in South east of Delijan. Two distinct morphological parts are characterized in the Cave. Cave entrance first passage and main rooms from the first and maze muddy branches from the second parts in the Cave which are located in a high level than Cave first parts. These ascending Passages connect some parts of Room to the maze parts. Features like Pillars, Feeders, Outlets and Copulas are the spific form belong to Hypogenic Cave systems and present in Doridan Cave in several places. It seems that the Cave pattern is spongework maze which has formed by hydrothermal flows action. Cave Sediment accumulation involve different groups of Break downs, fine Clastic masses of the Cave floor and Cave walls weathered materials. Origin of these fine Sediment is one of the important aspects of these research Sedimentary investigation, XRD analysis data, SEM interprets proved a Weathered processes origin for these Sediments and show that incomplete dissolution of limestone host Rock is the main factor to form them. Through this action solid Rock lose its main texture and changes to a pale or white amooth and soft material. However, Tectonic forces and Crashed Zone formed in the Cave and bare another factor could be concern as beside reason which can make the weathering easy to get progress. As a result some Crashed lenses and particles are existed in most parts of Cave Walls and channels. These tectonic signs are present even in Flowstones and Inlets in Cave passages. So it can be note that joints and fractures cause contact surface between Water flows and Rock particles this reveal to increasing the Weathering process.

### **Speleothem-based climate variability in the western Mediterranean basin since the last interglacial**

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Campanet Cave lies on the foothill of Serra de Tramuntana, in the NW part of Mallorca. It is a richly decorated cave developed in Upper Triassic dolomitic rocks and has a total length of 397 m. Stalagmite CAM-1 was collected from Sala del Llac, a poorly ventilated chamber near the far end of the cave. Hand drilled calcite powders were analyzed and dated on a Thermo Neptune multi-collector inductively coupled plasma mass spectrometer at the Radiogenic Isotope Lab of the University of New Mexico in Albuquerque. The  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values were measured on a Thermo Delta V isotope ratio mass spectrometer at the School of Geosciences, University of South Florida on 448 carbonate subsamples (80-120  $\mu\text{g}$  each) drilled at 500  $\mu\text{m}$  interval along the growth axis.

Twenty-five U-Th ages constrain the growth of CAM-1 from ~120 to 4.7 ( $\pm 0.3$ ) kyr BP, with a large range in growth rates, from 0.76 to 7.6  $\mu\text{m}/\text{yr}$ . The beginning of a 14 kyr hiatus occurring between 66.7 and 53.1 kyrs BP coincides with the onset of Heinrich Event 6. The significant correlation between  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  along the growth axis suggests that kinetic effects might be important. However, measurements made along individual layers do not show any enrichment, implying that any  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  covariation is externally triggered and not a fractionation effect. It is tempting to consider that the more positive  $\delta^{18}\text{O}$  values in CAM-1 reflect Mediterranean source of water vapor,

whereas the lower values are typical for precipitations originating in the Atlantic. These two different moisture sources are likely responsible for the significant difference between the  $\delta^{18}\text{O}$  values during MIS 5e and 5a, respectively. Over the past 50 kyr the oxygen isotopic signal indicates a Mediterranean source for the drip water that fed CAM-1.

### **45 years of British exploration and study of huge caves around the world.**

Andy Eavis

British Caving Association, United Kingdom, andy@andyeavis.com

The highly illustrated talk will follow the history of the cave exploration that has yielded over 500 kilometres of cave passage. Once the caves have been discovered the team have turned their attention to understanding and recording the huge voids. The culmination is the latest work of laser scanning the largest known chambers and passages. So far 6 of the 10 largest chambers have been scanned, there are some surprises!!!

### **Clastic sediments observed in the Fuchslabyrinth Cave (Baden-Wuerttemberg / Germany) and their importance for cave genesis**

Rebecca Engelhardt, Martin Trappe

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"The Fuchslabyrinth Cave is a well known cave in SW Germany. It is situated in the Hohenlohe karst area comprising mainly Middle Triassic limestones (Upper Muschelkalk). The topography is characterized by a flat peneplain which already is located within the claystone beds of the hanging Lower Triassic (Keuper). Numerous sinkholes can be observed at the surface.

Cave length is more than 9 kilometer and it is considered as a hypogenic maze cave (Klimchouk 2006, 2007). In the upper dry part of the cave an orthogonal system of narrow cave passages occur. Recent speleological research found a lower part showing a single several kilometer long passage with an active cave stream which differs in strike from the upper part. An adjacent quarry gives insights into the stratigraphy of the uppermost Muschelkalk beds and the cave position in that stratigraphic column. Additionally, numerous karstic cracks filled with clayey to silty sediments occur.

Present study focuses on clastic deposits observed in the upper part of the cave and from crack fillings of the adjacent quarry. Differences between sediments from cracks and the upper cave part can be discovered. Due to the vicinity to the surface the crack fillings are heterogenous featured by several constituents (limestone debris, clays from the Lower Triassic, chert gravels of Early Pleistocene Age, Pleistocene loessloam). By contrast cave sediments of the upper part consist completely of clay representing a distal high flood facies.

Sedimentary structures indicate a frequent desiccation of the clayey deposits. Otherwise a sustaining corrosion at the cave walls result in a chaotic relocation of the sediments, sagging structures or deformation of layers.

It can be assumed that no direct connection exists for the upper cave part and the surface but rather the supply of sediment happened laterally or from lower zones by a rising water level. For the youngest (hanging) clastic sediments such an origin is indicated by surficial clayey to silty coatings occurring at the basal walls of the cavities or within descending conduits. First results of a few gravel

deposits of the lower cave part show little chert components which can be related to a local surface cover of Early Pleistocene Age. Until now similar chert material was not observed within the upper cave part.

Consequently, a pre-Pleistocene hypogene origin of the upper cave part was followed by a later sediment supply from lateral or lower parts. According to the direct relationships with the surface a modified genesis is indicated for the lower cave part. Surficial water percolated through sinkholes directly to the lower cave stockwork without any deposition within the upper part.

**Keywords:** hypogene cave, clastic deposits

**References:**

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### **Speleology / Höhlenkunde in the Österreichisches Küstenland**

Alessio Fabbricatore

Club Alpino Italiano

For various reasons, man has shown an interest in caves since prehistory; however, National Speleology Schools as they are known today were established starting from mid-19<sup>th</sup> century.

Indeed, the Austrian School played a prominent part, and in 1894 Franz Kraus published the first scientific treatise on speleology in Vienna, die Höhlenkunde Wege und Zwerk der Erforschung unterirdischer Räume.

Several areas of the Austrian Empire were of speleological interest, the most representative being the region called Österreichisches Küstenland (the Austrian Littoral).

This work aims at analysing, from the point of view of speleological research, the influence that Austria had on the Österreichisches Küstenland territory, as well as its administrative and geological boundaries.

It analyses the Österreichisches Küstenland region from a political, geological, palaeontological, archaeological and biological point of view, in order to understand the historical and geological reasons that led the region to play an emblematic role among speleological studies worldwide, inasmuch as the terms Karst and Karstification, as well as the definitions of Karst phenomena, have their origin in this Land of the former Austrian Empire.

Other eminent figures in European culture at the end of the 19<sup>th</sup> century also studied the region from a speleological, archaeological and geomorphological point of view. Among these, the French Alfred Martel, the British Richard Burton and the Serbian Jovan Cvijić.

Then follows a comparative analysis of the major figures of Austrian-German and Italian speleological research. Among these, the founders of the group Hades, which later became part of the Club turisti triestini, of Austrian imprint, and the group Club dei 7, which later became part of the Italian-speaking Società alpina delle Giulie, are the most representative, as well as the ones who have most influenced speleology.

The contributions of the two most important figures in palaeontological and archaeological cave research are also analysed, i.e. prof. Ludwig Karl Moser, of German culture, and dr. Carlo Marchesetti, of Italian culture.



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## The Four State model of meteoric water cave genesis and its association with models for the development of plan patterns of cave passages

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Solutional cave systems created by meteoric waters circulating without confinement beneath impermeable strata are the most important type of caves in economic terms, and probably the most abundant globally. Until the 1960s a major problem in scientific understanding of their development was perceived to be their relationship to the water table: different authorities argued that cave development must occur principally above it, or below it, or along it. In a series of papers between 1965 and 1978 the author offered an explanation based on the spatial frequency and orientation of the bedding planes, joints and faults in the rock that could be penetrated by groundwater under the prevailing conditions (hydraulic gradient, quantities of recharge, etc): in it, the relationship of the conduits to the water table in the fully developed cave could display one of four distinctly different geometries, or combinations of two or more of them - the 'four state model'.

This paper will (1) review the basic arguments for the model and (2) attempt to correct some misunderstandings that have arisen in its interpretation: (3) present examples of major cave systems discovered since the model was proposed that support its arguments (i.e. that it predicted), and (4) show how features of the model development along the strike in dipping strata stimulated a series of successful hardware model investigations of the genesis of the plan patterns of meteoric water caves.

## Stable carbon and nitrogen isotopes in bat guano as proxies for paleoenvironmental reconstruction: Case studies from Romania

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Understanding the complex drivers behind Earth's past climate changes may help predict the likelihood, extent, and patterns of future changes. Cave deposits are of special interest because caves provide somewhat isolated environments that are physically and chemically more stable on short time scales, allowing for a better preservation of deposits that archive environmental conditions (speleothems, guano, sediments, etc.). Geochemical studies of cave guano using stable isotopes can provide paleoecological and paleoclimate (precipitation) records. Cave guano  $\delta^{13}\text{C}$  values reflect the dietary preferences of bats which are controlled by local vegetation dynamics, which in turn depend on local climatic conditions.

The aim of the present study is to demonstrate the usefulness of stable carbon and nitrogen isotopes in bat guano as proxies for paleoclimate changes. We show a 2500-year record of environmental change in Romania using  $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ , and (C:N) derived from precisely  $^{14}\text{C}$ -dated bat guano cores recovered from Gaura cu Muscă (GM), Zidită (ZC), and Măgurici (MC) caves.

$\delta^{13}\text{C}$  values of guano at the Medieval Warm Period (MWP) - Little Ice Age (LIA) transition changed markedly only in the GM record. In the other two caves the carbon isotopic values indicate a steady onset of LIA at around AD 1200 but without significant climatic changes before ~AD 1450, and abruptly ending between ca. AD 1870 and 1900. The beginning of the 20<sup>th</sup> century is characterized by an average of  $\delta^{13}\text{C}$  value of  $-25.2\text{\textperthousand}$  up to ca. AD 1965 (which indicate a moderate change toward warmer period). More rapid changes of 0.5 to 1.5 % are recorded in the few years after AD 1970. In this general picture, these indicate swings between several cold and warm events.

Guano  $\delta^{15}\text{N}$  values are typical of insectivorous bats (~8‰) from AD 1979–2011, however, a ~2.5‰ increase in  $\delta^{15}\text{N}$  values from guano older than AD 1979 suggests a higher trophic level. In addition, trends in modern  $\delta^{15}\text{N}$  values display significant covariation with local precipitation amount, suggesting it may be a potential proxy for paleoclimate reconstructions.

Keywords: guano, cave, stable isotopes, paleoclimate, Romania

#### Acknowledgements

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### The role of base-level changes and recharge variations in cave development

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The vertical organization of karst conduit networks has been in the focus of speleogenetic studies for more than a century. Different models have been proposed, each focusing the speleogenesis to: a) the vadose zone, where the solution is most aggressive b) the water table, where the density of flow is highest and c) to the phreatic zone, referring to the deep Darcyan flow paths. The four state model (Ford and Ewers 1978) unified these approaches by relating the geometry of caves to the frequency of penetrable fissures. The model has been successfully applied to numerous speleogenetic settings and verified with physical and numerical models. In this work we present a model which addresses the question of vertical development of karst conduits under varying base level position and irregular recharge. Such settings are typical in Alpine karst systems, which are influenced by high uplift and valley incision rates and irregular recharge. We assume an initial master conduit draining the water to the spring at the base level. Incision of the valley triggers the evolution of deeper flow pathways, which are initially in a proto-conduit state. The master conduit evolves into a canyon following the valley incision, while the deep pathways evolve towards maturity and tend to capture the water from the master conduits. The evolution of deep pathway is modelled by coupling flow, dissolution and transport in an evolving proto-conduit. The solution divides the parameter space into a region where the breakthrough of the lower pathway is preferential (formation of a loop) and a region with preferential development of an underground canyon. To this extent we introduce the Loop-to-Canyon ratio (LCR), which predicts which of the two outcomes is more likely to occur in certain settings. The model is further extended to account for the transient flow conditions; in the case of an undulating master conduit, floodwater is stored at the bottom of the loops after the flood retreat. This water seeps through sub-vertical fractures (soutirages) connecting the master conduit with the deeper pathways. Therefore, the soutirages evolve also during the dry season, and the LCR is considerably increased. The model stresses the potential importance of dynamic boundary conditions to the vertical development of cave systems. The relation of the model to the four state model, which relates the geometry to the more static structural parameters, is still a matter of discussion between the proponents of both models.

Keywords: speleogenesis, recharge variations, looping cave, water table cave, modelling

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### International Speleological Expeditions and trips with Croatian Cavers in last fifty years

Mladen Garašić

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It is presented the list of all speleological expeditions which were organized by Croatian cavers outside Croatia or were invited by other cavers or were officially organized as international speleological expeditions in Croatia in last fifty years. More than hundred of them were successfully organized and results were really great. Cooperation with cavers from e.g.: Albania, Algeria, Andorra, Argentina, Armenia, Australia, Austria, Bahamas, Belgium, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Cuba, Cyprus, Czech Republic, Egypt, Ethiopia, France, Gabon, Georgia, Germany, Greece, Greenland, Guatemala, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Italy, Jamaica, Jordan, Korea South, Laos, Lebanon, Libya, Luxembourg, Macedonia, Madagascar, Malaysia, Malta, Mexico, Moldavia, Montenegro, Morocco, Namibia, Nepal, New Zealand, Norway, Oman, Pakistan, Papua New Guinea, Peru, Philippines, Poland, Portugal, Puerto Rico, Romania, Russia, Serbia, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Tunisia, Turkey, Ukraine, United Arab Emirates, United Kingdom, United States of America, Venezuela, Vietnam,...

In Croatia there are only several hundreds of cavers and speleologists but they have great influence on speleology all over the World and big respect of the greatest world speleological organization - Union Internationale de Speleology (UIS).

Cavers have friends all over the World...

Here are some logos of International Speleological expeditions with Croatian cavers:



Keywords: Speleology, UIS, Caves, Croatia

**The cradle of underground climatology: measuring the temperatures in the ice-cave of la Grâce-Dieu (French Jura)**  
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The ice-cave of la Grâce-Dieu has been described since the end of XVI<sup>th</sup> century; it was considered as a major natural sight-seeing in Franche-Comté, and many travellers turned away from their way to visit it; the caves opens at only 520 m a.s.l. and natural ice in a so low altitude isn't a common phenomenon in Western Europe!

This vast gallery goes down until the depth of 60 meters, and visitors can admire several mounds of ice in the back of the cave. The presence of this cave in such a place in summer made people believe that water froze in summer and melted in winter. During XVII<sup>th</sup> and the beginning of XVIII<sup>th</sup> century, all the visitors are convinced of this anti-seasonal thermal rhythm and tried to explain it.

But in 1725-1726, a royal engineer, Mr des Boz came to the cave and visited it in March, May, August and November and sent a short review to the French Académie des Sciences. Twelve years later, Dunod de Charnage published the full account of des Boz's visits and the temperatures he had measured. To our knowledge, it was the first example of a serious study of temperatures in a natural cave.

The dispute should have stopped here, but there remained a doubt about the graduations of des Boz's thermometer. In 1743 and 1745, another engineer, M. de Cossigny repeated such measurements with a Réaumur thermometer. In August, October and April, he came three times in the cave and his results seemed to confirm a seasonal rhythm of temperatures. Furthermore, he surveyed the cave and drawn plan and section: this is one of the oldest cave surveys in France. But all the scientists in this time didn't accept easily these results and carried on believing in an anti-seasonal thermal rhythm.

It isn't before 1796 (fourth year of French republic) that Girod-Chantrans published in the Journal des Mines a new campaign of measurements and definitively confirmed that the cave was colder in winter! A century of hesitation had been necessary to establish simple temperature measures: the pseudo-obviousness of an underground world where everything is up side down made people incredulous with these results, and even the most rationalists weren't sure of where was the truth in a so complicated affair... These moments of science History are much more interesting since the climate discussion was coupled with considerations about the ecological conditions for a better ice preserving in the cave.

Keywords: underground climatology, ice caves, La Grâce-Dieu, Jura

**Poor mans laser scanner. A simple method in 3D cave surveying**  
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"Geodetic surveying of caves has great importance in speleology. Among the various surveying and graphing methods the most commonly employed technique involves projecting the wall layout and other formations of the cave onto a plane. Relating and interpreting the two-dimensional plan, profile and cross-section images that make up the spatial cave layout needs a trained eye, whereas a

three-dimensional model tends to be more graphic and normally requires less knowledge to understand. For the latter, 3D modelling method, surveys are carried out on site by the aid of terrestrial laser scanners (TLS). A TLS is known to operate fast and produces a dense survey that is ideally made up of several billion points to millimetre accuracy, potentially. However, the use of laser scanners has its limitations; the high cost of equipment being the primary reason, as it can be afforded only by the lucky few. Sensitivity, size and transportability of the instruments restrict their use, also.

The widely used combination of laser rangefinder, compass and inclinometer is capable of measuring only a mere few hundred points in an hour, resulting in a much sparser and less evenly distributed point cloud than of TLS devices. For the further use and correct interpretation of this sparse point cloud it is therefore necessary to reconstruct a surface interpolating our measurements. To achieve this, we have developed a robust surface reconstruction method as well as summarized the guidelines to be considered for the better spatial distribution of survey points. Both of these areas of development require a considerable amount of test measurements, for which we measured several hundred meters of conduit in three different caves of Hungary. Surveyors of the Bányász-barlang, which is Hungary's deepest cave, use the combined method with great success, for instance. Experience has shown that this novel approach takes significantly less time than the traditional mapping and does not require extensive training. As a further benefit, data processing can be appropriately automated, which indicates great potential in terms of further reducing processing time in the future, although it is already comparable in its current state to the former method regarding efficiency."

Keywords: cave survey, 3D, surface reconstruction

**Interpreting groundwater character from flood pulses and artificial tracer test -a case study of the Slatinski izvor spring (Macedonia FYR)**  
Biljana Gičevski<sup>1</sup>, Metka Petrić<sup>2</sup>, Janja Kogovšek<sup>2</sup>

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The Slatinskilzvor karst spring in the western part of Central Macedonia has a significant potential as a drinking water source. Its characteristics were studied based on tracing with natural and artificial tracers. During the rain events in October and November 2012 and February and April 2013, water level, temperature and electrical conductivity of the spring were measured in hourly intervals. Flood pulses with rapid reactions of measured parameters on rain events were compared and analyzed. In May 2013, a multi-tracer test was carried out. Uranine was injected into the Krušeska Reka sinking stream, and rhodamine B in the cave stream in the Puralo cave. Only uranine was detected in the Slatinski Izvor spring. The dominant apparent flow velocity of 250 m/h, a single peak of the tracer breakthrough curve and more than 87% of tracer recovered in this first peak indicate a rapid conduit flow. Results of the case study show high vulnerability of the observed drinking water source and confirm the need for implementation of proper protection measures.

Keywords: flood pulses, artificial tracer, karst spring, Slatinski Izvor

**Detection of depressions and unroofed caves recognition from DEM.****Application in Podgorski kras area, SW Slovenia**

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Speleogenesis is the process of formation, development and disappearance of caves. The final stage in a cave development is called unroofed cave. The study of those features can help us understand karst landscape and karst phenomena. Since the unroofed caves can be expressed as elongated depressions on karst surface, the study examines the possibility of their identification on the basis of morphometric characteristics such as elongation and spatial relations between them. The study is focused on a wider area of the Podgorski kras in southwestern Slovenia.

**Results of tracer tests and underground water flows in the southern part of Khipsta massif  
(Western Caucasus)**

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We present the results of the latest successful tracer tests in the southern part of Khipsta massif and their analysis. This part of the massif is drained by well-studied Snezhnaya cave system. The tests were carried out in the winter of 2009-2010, both in normal and in high water level. We used an uranine as a fluorescent dye, and bacterial cells *Bacillus subtilis* and *Bacillus licheniformis* as a new original absorber. Our test results confirm in general the data of the previous experiments. However, we found several new springs of the output of underground water. Measured karst water velocity has appeared extremely high (7-11 km/day or 290-460 m/h), in 3-4 times larger, than the velocity, which has been obtained in the previous tests. We also present a brief survey of other successful and not successful tracer tests in Khipsta massif which were carried out in 1973-2011. We conclude that the direction of the karst water streams in the south part of Khipsta massif is complex and ambiguous. There are several directions of water streams movement. Number of directions of the underground water streams increases during a high water level time.

Keywords: tracer tests, Caucasus, Snezhnaya cave system

**The height of the floods in Predjama 2010**

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Village Predjama is located in the northern part of Pivka Basin, in a blind valley formed by Lokva stream. Lokva sinks into the cave Jama pod Predjamskim gradom at the contact between Eocene flysch and carbonate rocks at the edge of the basin. Stream has a very small catchment area and consequently floods are not frequent. Yet past events indicate, that not entirely unrealistic.

Throughout the history, there were several cases of lake formation under the Predjama Castle. Recent documented cases date in 1824, 1851, 1965 and 1987. While the latest and the most severe flooding occurred in 2010 as a consequence of extensive precipitation that covered south of Slovenia

between 17<sup>th</sup> and 19<sup>th</sup> September. The water level reached 489.6 m a.s.l. or roughly 27 meters above the ponor of Lokva.

In order for Lokva to overflow, the key factor is not just the amount of rainfall in its catchment area, but rather the amount of precipitation on its drainage side which fills the karst and hinders runoff. It can be assumed, that for karst underground saturation, the most important factor is total rainfall over a longer time period; while Lokva's discharge, generally relies on the rainfall intensity in the catchment area. Conclusively, the most extensive floods occur as a combination of these two factors.

We can classify the floods in Predjama as extreme and rare events. Studying of them is more of an informative nature, rather than practical. Still they can suddenly occur when we expect them the least.

Keywords: Lokva stream, floods, village Predjama

### **Hungarian cavers and speleo congresses**

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First congress with speleological aspects was organized by Hungarian and German speleologists in Hungary in 1927. Besides organizers there were Croatian, Czechoslovakian and Bulgarian participants, too. Hungarians were active in that field also in the following decades and they had participated at 4<sup>th</sup> International Congress of Speleology where the Union was decided. Dr. Denes – who died in April of this year at his age 92 years – had participated in that team who worked on statute of UIS. Since that time Hungarians were also active in the life of UIS. They filled different positions from advisory secretary to president of commissions and working groups and did jobs without any positions. Hungarians organized a lot of international events e.g. UIS Congress and conferences of different commissions. This lecture gives a brief summary of Hungarian activity in the life of UIS and worldwide family of speleologists.

Keywords: Hungary, congress, organize

### **Yekke cha Cave speleogenesis, East of Golpaygan, Iran**

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Yekke chah cave is hosted in Triassic lime stones located in North West of Esfahan province, Iran. The area is a part of Sanandaj – Sirjan metamorphism zone which affected by several intrusive masses associated with hydrothermal fluids caused deep seated speleogenesis. Yekke chah cave is a tectonic-solution cave, which has hypogenic origin and its pattern, is followed by the faults of the area's main fault and joint system. The proves such as Speleothems like cave clouds results by hypogene origin and the stalactites, stalagmites and columns of vadose situation revealed that, this cave has passed multiple phases through its evolution periods. After movements of the area and uplift the cave system emerges to the surface and fluvial sediments filled the cave floor. These accumulations form a 2 m sequence of fine sediments including sand, silt and mud layers. The origin of these sediments is the surrounding rivers bed and suspended load which entered the cave system

through the past floods. Layers with different grain size show a variety in flood velocity and their origin

Keywords: Yekke chah cave, hypogen origin, tectonic, cave sediment

### Influence of cave characteristics on cave vertebrate distribution

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Distribution of cave adapted vertebrates in cave systems of Croatia has been studied intensely by Croatian herpetological society –HYLA for the last four years. Preliminary results show generally parapatric relationship between stygobiont *Proteus anguinus* and stygofil fishes due to competition. Only rare cases of sympatry and even syntopy have been recorded in food rich environments. The detailed study of *Proteus anguinus* shows occupancy patterns in cave systems depending on the hydrological and morphological characteristics of the caves. Based on the attributes like hydrological function, hydrological activity, water depth, morphology, sediment distribution in 15 cave systems, distribution of *Proteus anguinus* population has been analysed. Results show that individuals show preference to water regimes that allow more intake of organic debris. Parts of the cave systems in which water flow is reduced and thus allows accumulation of sediment are preferred. Distribution of individuals is independent of the cave depth but is dependent on water depth. This analysis will help monitor changes within known populations, as well as help cave-divers in search for new population in complex cave systems.

Keywords: cave vertebrate, parapatric relationship, cave morphology, occupancy patterns

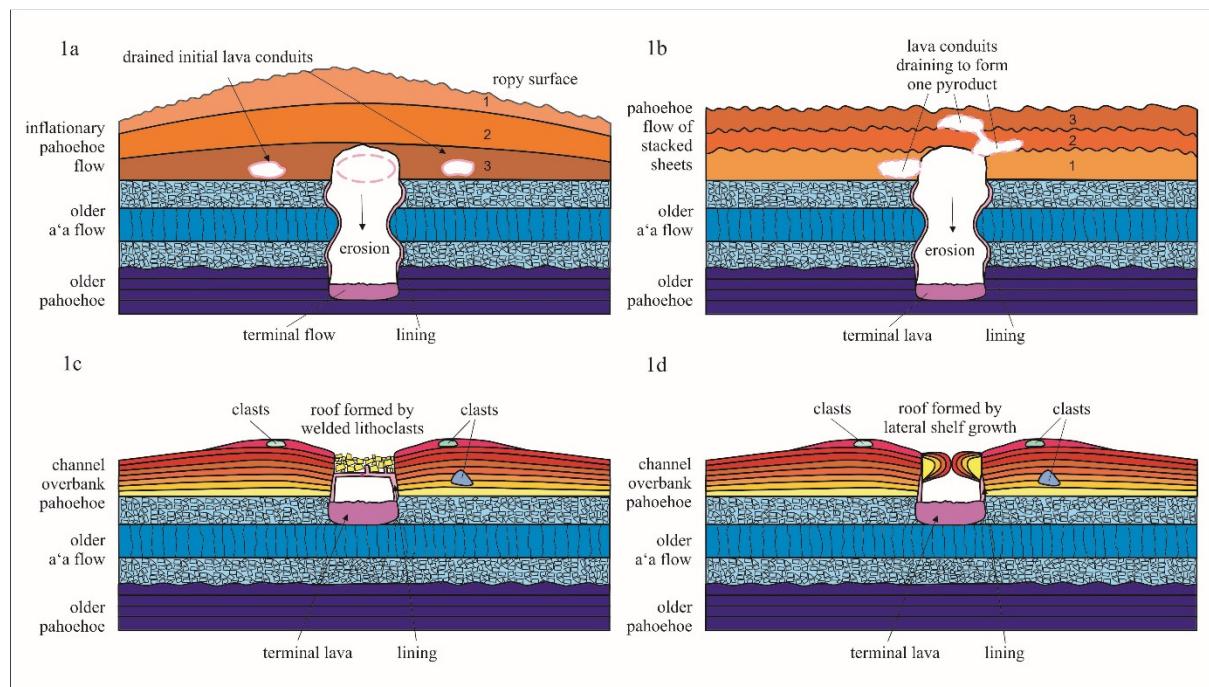
### Pyroducts, the third most common cave type on Earth

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After limestone and gypsum, lava is the third most important cave-bearing rock on Earth. In contrast to the standard notion that lava caves are simple, uninteresting and featureless circular "tubes", many different processes serve to create a score of various lava cave classes, with more being discovered. The most important type is longitudinal conduits that serve for long-distance, underground, post-eruptional transport of (with a few exceptions) basaltic lavas. They act to build low-slope (often < 2°) shield volcanoes. Initially reported from Iceland, they were first observed actively forming in Hawai'i and in 1842 named "pyroducts". Within the pyroduct type at least four different formation modes exist (Figure 1): Caves formed by inflation of the lava flow front and later downward erosion (1a), caves formed by coalescence of small ducts and consecutive downward erosion (1b), caves formed by the crusting-over of channels by floating lithoclasts, welded together (1c), and by channels crusted-over by lateral shelf accretion and consecutive closure (1d). Thermal erosion, probably both by re-melting and mechanical processes, ensures that a gas-filled cave is already created during the active phase of the pyroduct and not by "evacuating" a "tube" after the eruption ceased. Pyroducts therefore resemble underground canyons with lava rivers at their bottoms. They are the most numerous lava caves; the longest being Kazumura Cave (total length of passages 65.5 km) (Hawai'i, Kilauea Volcano) and the longest Quaternary duct-supported flow on

Earth is the 160 km long Undara flow, Australia. In Jordan, the Al-Fahda flow could have pyroducts as long as 25 km.



Keywords: lava cave research

### Laboratory modeling of cave development and rock relief on plaster

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The rock relief of a plaster tube cave clearly shows its development under different hydraulic conditions. We exposed a tube with an inflow diameter of 10 cm, a larger 20-cm wide middle part, and an outflow tube with a 5-cm diameter to a flow of water. Pockets are found on the entire circumference where larger vortexes form in the water current. Due to the higher water pressure in a tube passage, the water creates distinct notches along areas of weakness in the rock, primarily along fissures and bedding planes where deep domes with pockets form. This is a frequent characteristic in sections of plaster caves with a large inflow and limited outflow of water, although in natural caves, pockets are mostly found on the upper parts of the rock circumference because the floor can be further shaped by material carried or deposited as sediment by the water. Different networks of scallops are the trace of the characteristics of the rock on which they form and the hydraulic conditions, the velocity of the water current, and the impact of the space on the swirling of the water.

The growth of solution tubes and bedding-plane anastomoses along bedding-planes was simulated with a plaster and siporex (autoclaved concrete) block composed of six different layers all of the same thickness put together parallel to each other: two of plaster, two of plaster with the addition of cement-reinforced plaster fragments, and two siporex plates. The experiment reproduced phreatic conditions where the water in an artificial channel was forced to flow through the plaster-siporex block along the contacts between layers over a quarter square meter area. Throughout the experiment we observed the typical development of solution tubes along uniform limestone

bedding-planes (just plaster), along breccia bedding-planes (plaster with addition of cement reinforced plaster fragments), and along the contacts of all three different layer types. Between the plaster plates, several entry solution tubes tend to merge into two major ones clearly showing the influence of obstacles on water flow. Between the plates of plaster with the added cement-reinforced plaster fragments, a typical random network of solution tubes was created that relatively rapidly merged into two tubes, one of which cut through the plates. While the pure plaster plates and plates with added cement-reinforced plaster fragments almost completely dissolved, the siporex plates remained unchanged.

This type of modeling has once again proved demonstrative and useful for studying karst surfaces and caves.

### **Cave Exploration in the Divided Germany before 1989 – a Widely Unwritten Chapter of Central European Speleology**

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After 1945, different caving organizations were founded in both German states, but cooperation was a problem in times of the Cold War. As caves were believed to be of military importance, cavers of the former GDR as well as cavers coming in from other countries to this state were controlled by the former Stasi Secret Service Ministry more and more. The case of the author being editor of the West German Caving Association since decades is self-analysed, as he found most of his Stasi files still undestroyed and now open. Thinking and work of the former GDR secret service are described by this example. There are nearly no publications on this sensible topic up to now, although the archives are open. Other cavers should also have a look into their files. New light to this widely unwritten chapter of speleological research is given with traces also to other states of the former NATO and Warsaw Pact states.

**Keywords:** caving history, Germany, GDR, secret service

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### **History of "Classical Karst" Research – an overview from the Antiquity to the UIS foundation**

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Evidently the actual term Classical Karst was not known in the Antiquity. But nevertheless "the mountains" between the town of Nauportus (modern Vrhnik) and the Adriatic Sea are mentioned in the famous story of Argonauts. The first karst phenomenon, the springs of the Timava River near Trieste, was already mentioned in the Pseudoskylax periplos as an important source of drinking water. On the other hand Posidonius researches have been trying to determine the connection between the tide and the Timavus springs and he also mentioned Škocjanske Jame Caves. Humanists began to be interested in natural phenomena too and we got first mentions and descriptions of "wonderful" Cerkniško Jezero – The Lake of Cerknica in print. With the Enlightenment a real research started, following the development of the Natural Sciences. The paper mentions well known researchers such as polymath J.V. Valvasor, and more technically oriented F.A. Steinberg, and J.A. Nagel or natural scientist Hacquet. T. Gruber's proposal to monitor precipitation in the whole Ljubljanica river basin and compare it with the river water level started modern hydrological research on Classical Karst. During the 19<sup>th</sup> century modern speleological research started, mainly connected with karst management regarding flooding prevention on poljes and water supply. Classical Karst became known not only in Austria but in the whole of Europe as a land of caves, shafts, underground water, and unusual underground fauna. Proteus was scientifically described in 1768 already, and together with cave tourism, as Vilenica was a show cave before 1633 already, learned public was attracted to visit and research Classical Karst. The best known among such visitors was E.A. Martel. Towards the end of the 19<sup>th</sup> century the first caving local group was formed at Postojna, and at the beginning of the 20<sup>th</sup> century the society for Carniola as a whole. During the 1<sup>st</sup> and the 2<sup>nd</sup> WW all the adversaries paid attention to karst and its recognition. In 1929 Italy inaugurated the state's Speleological Institute at Postojna, at that time a part of Italy. After the 2<sup>nd</sup> WW caving activity reactivated and soon several local caving clubs appeared. Because of augmenting number of speleologists and cavers in Slovenia as well as in Italy, and due to fast progress of speleological techniques together with notable advance of scientific research, the researches of Classical Karst flourished as never before. The organization of the 4<sup>th</sup> International Speleological Congress in 1965, together with the foundation of UIS proved the importance of Classical Karst as well as of its research.

Keywords: Classical Karst, history of research

## Dynamics of calcite crystal growth in a Dubci site speleothem, Dalmatia, Croatia

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Stalactite from Dubci site on a saddle between the Omiška Dinara and Biokovo Mts. in southern Dalmatia, Croatia, was studied as a test of a research method which might be used to study palaeoclimatic imprint in ancient speleothems. The speleothem was found in a secondary position, next to a paleocave sediments. The sediments were dated after fossil fauna as of the early Pleistocene age (Marjanac *et al.* 2008) and the paleocave was recently "opened" during the road construction works.

The speleothem study comprised length-wise and perpendicular diamond-cutting, polishing, etching in 5% HCl, and colouring with carbonate-diagnostic reagents Alizarine Red-S and KFeCN, preparation of standard thin sections and acetate peels. Polished stalactite, thin sections and acetate peels were studied under optical microscope in order to decipher the stalactite growth pattern(s). A segment of transverse section from the stalactite centre to its outer rim was measured under the microscope, identifying and counting the type of laminae and their thickness. The stalactite was morphologically described in detail and palaeoclimatic conditions in which the speleothem was growing were interpreted. The studied speleothem was composed of three stalactites which started to grow separately, but merged during their growth. One of the stalactites was broken and is unpreserved.

On the transverse cut, 14 different growth zones with different colour and texture were determined, as well as three erosion surfaces. Each growth zone comprises petrologically different light and dark laminae. These growth zones and erosion surfaces were created in different climates. Calcite laminae were formed by precipitation from bicarbonate-supersaturated brine, though at varying climates, whereas the erosional surfaces were formed by corrosion of the stalactite by undersaturated waters in diametrically different climates compared to that of the calcite-precipitating periods. There is regularity in the distribution of white laminae which have been created in favourable climate and dark laminae which were formed in the climate less suitable for the calcite growth. The laminae distribution within a zone is not uniform, which suggests climate variations also within each cycle. Although laminae look like annual, without further research and dating that can not be determined with certainty.

The main structures recognized on the transverse cut of the studied speleothem were also recognized on the cross cut. On the cross cut big calcite crystals with radial growth from centre to outer edge of stalactite were noticed. Big crystals grow through more than one zone but laminae appearance is nonetheless undisturbed.

During the research, the speleothem was not destroyed and can be used in further isotopic research and be fitted in the existing data. There is a possibility for comparison of growth dynamics from this speleothem with growth dynamics of dated speleothems and for data to be fitted in the time frame.

Keywords: speleothem growth, laminae, stalactite, paleoclimate, Croatia

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**Geological Setting and Speleogenesis of the Anhydrite Caves „Schlotten“ in the Harz Region,  
Central Germany – State of Research and Open Questions**

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Since the 17<sup>th</sup> century, the copper shale miners have known large phreatic anhydrite caves in deep setting without natural entrances and named them „Mansfeldische Kalkschlotten“. They are situated in the Mansfeld Trough (Landkreis Mansfeld-Südharz, Saxony-Anhalt, Germany) within anhydrite rock from the Zechstein (Upper Permian). The largest of these Schlotten caves are the Wimmelburger Schlotten. The VdHK is preparing a monograph on these caves.

The formation of these largest European anhydrite caves was possible, as three geological circumstances came together: (1) Feeding inflow of carbonate-rich groundwater through a limestone karst aquifer, (2) impermeable rock (anhydrite) as hanging wall, and (3) linear water outflow through a fault zone in the anhydrite. The water feed is affected by sinking of meteoric waters into a limestone aquifer underlying the anhydrite rock. The easy-soluble, but impermeable anhydrite is the hanging wall of the caves and induces the formation of a pressurised water aquifer between limestone and anhydrite. The impermeability is caused by the quick closing of joints and faults due to gypsumification of the anhydrite accompanied by volume increase before open karst fissures and galleries can develop. So the Mansfelder Schlotten can be classified as strata-boundary caves between limestone and anhydrite rock. The cave rooms start to develop along outstanding faults. The attribute of these faults is to be horizontal shear zones with sigmoidal joints. That means that the opening distance of these faults calculated perpendicular to failure extension must be bigger than the ability of gypsumification to close it. When the carbonate-rich water meets the anhydrite rock at such a fault, the solubility equilibrium changes, and fine-grained calcites and dolomites precipitate (proved by REM, EDXS and X-Ray tests). So the water gains a secondary calcium-sulphate solubility and large hypogene cave rooms develop by density-driven convection and stillwater-leaching. The karst water regime is a siphon-drainage system. The precipitated calcites and dolomites are the main resp. genetically most important components of the dolomite silts and fine sands typical for the Schlotten caves and were traditionally named „ashes“ or „dolomite ashes“. Up to now, they were classified generally as carbonatic residuals from the anhydrite leaching which could be falsified by this study. In fact the „ashes“ are a mix of residues, precipitated (e.g. secondary composed) calcite and dolomite as well as allochthonous components.

The Schlotten caves are not restricted to the typus locality Mansfeld Trough, but exist along the whole South Harz and South Kyffhäuser Zechstein strips and even show up at the rims of the Thüringer Wald Mts. The historical term „Kalkschlotten“ should not be used any more as these caves are anhydrite caves.

Keywords: anhydrite caves, Wimmelburger Schlotten, hypogene speleogenesis, cave secondary calcium-sulphate solubility

## Fifty years of the UIS: 1965-2015

Jose Ayrton Labegalini

### UIS-Unión Internationale de Spéléologie

The book is dedicated to caving companions of former years, especially the members of the Espeleo Grupo de Monte Sião (EGMS), Cláudio (José Cláudio FAR A-CO), Carlos (Carlos FAR ACO, in memoriam), Eduardo (Eduardo GLÓRIA), Carlito (Car-los Adalberto DALDOSSO) and Nivaldo (Nivaldo COLZATO), the smallest speleological group in Brazil. Towards the end of the 1960s we became interested in caves - long before we had even heard of speleology - and spent hundreds of happy hours together under the ground, investigating new caves or taking pictures of underground wonders.

The book is also dedicated to Bernard GÈZE, the advisor and founder of the International Union of Speleology (UIS), since without his initiatives in the 1950s, this book would never have been written.

The UIS is a non-profit, non-governmental organization which promotes the interaction of academic and technical speleologists of a wide range of nationalities in a move to develop and coordinate international speleology in all aspects, whether scientific, technical, cultural or economic. Founded in 1965, the UIS has already accumulated nearly half a century of history. However, until this book, the record of that history was spread out in the minutes of meetings and general assemblies, various UIS publications, and the proceedings of the International Congresses of Speleology; moreover, much of it was never written and was available only from the memories of past presidents, secretaries and other administrative members of the UIS.

The fact that this history had never been compiled arose in 1999, expressed by Ivan GAMS (Slovenia) in a short article entitled "Call for historical study of the UIS organization," published in the UIS-Bulletin, in which he affirmed that the younger generations have only a limited knowledge of the early history of the UIS and that every day there are even fewer living witnesses of its foundation.

At the UIS Bureau Meeting of 2002, in Samcheok, Republic of Korea, José Ayrton LABEGALINI (Brazil; President) proposed that a book about the history of the UIS be written to commemorate its 40<sup>th</sup> anniversary, to be celebrated in 2005 during the 14<sup>th</sup> International Congress of Speleology in Greece. Unfortunately the project was tabled when problems arose with the organization of that Congress. 2.

At the UIS Bureau Meeting of 2007 in Aguadilla, Puerto Rico, Fadi NADER (Lebanon; Secretary General) again brought up the subject of writing a book about the history of the UIS, and LABEGALINI (Brazil; by then, past-President) was entrusted with the gathering of all the data available, although the collaboration of many other members of the UIS Bureau, especially the other past-presidents, was also enlisted.3

The work of gathering and editing the information has been arduous. The information is widely scattered and fragmented; moreover, the topics discussed at one meeting were not necessarily commented on at the next. This complicated the task. It was necessary to return to the original sources, but these reports were written in a variety of languages (English, French, Italian, Spanish and German) but not in Portuguese, the mother tongue of the author, and had to be interpreted via Portuguese before a coherent text in English could be produced.

Even though the work was difficult, it has been gratifying. It has provided an opportunity to learn about the history of the UIS and the people who worked so hard to bring the organization to where it is today. The first task was to read all the UIS Bulletins, as well as the many other documents available, especially the minutes of general assemblies and annual meetings. The proceedings of all of the congresses also had to be covered. Thousands of e-mails were exchanged, and the help of hundreds of collaborators in dozens of countries was sought.

A draft version of this book was distributed in Brno, Czech Republic, at the 16<sup>th</sup> International Congress of Speleology to numerous individuals who knew about the history of the UIS. They reviewed the information and provided important missing data from their private libraries, the

libraries of their speleological organizations (especially those in Europe), and their best recollections. Their efforts added vital depth to the book and have been crucial to preserving the history of the UIS.

### Glacier ice-contact speleogenesis

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Relict phreatic caves, in hanging positions within a glacial topography, pose an enigma with respect to the speleogenetic interpretation. A glacier ice mass may provide liquid water and create caves anywhere in the adjacent rock, making glacier ice-contact as well as interglacial, meteoric speleogenesis feasible. The problem is reviewed with relevant glacier rheology, hydrology, and chemistry. The glacial environment was certainly able to overprint and widen already existing caves (*sensu lato speleogenesis*), while the full evolution of caves from tight fractures (*sensu stricto speleogenesis*) was slow and inefficient (about 1/40) as compared to non-glacial condition.

### The bathyphreatic loop of the Plura river, Norway

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The river Plura in Northern Norway has an underground course of 3.5 km, feeding a large karst spring. The total catchment is some 340 km<sup>2</sup>, but the present hydrology is not in its natural state, as most of the headwaters are captured in a hydro-electrical dam and is directed to a hydropower station in an adjacent valley. The dry valley is of relatively large dimensions, carrying two large collapses, both of which can be explored down to the water-table. Hydrological connections are verified by dye tracing from the upstream sink to the main spring. About half of the underground course has been explored and mapped by divers and cavers. Upstream, from the spring, the cave is completely water-filled for almost 1000 m, making a few shallow phreatic loops, up to about 30 m deep, before reaching an almost horizontal, air-filled cave. From here, the water-filled cave dives down into one large, 132 m deep, phreatic loop. The loop is situated beneath a huge collapse doline and reach the water-table in a new airspace upstream of the collapse. The collapse forms a huge breccia pipe where the surface opening is 80 m across and more than 230 m deep. The air-filled cave can then be further explored upstream to an impassable boulder choke, but two pools leads into new phreatic loop that leads upstream. These passages are not surveyed, but rumours will have them to connect to a new airspace in the upstream collapse. Between here and the streamsink, nothing is explored.

The dimensions of the main phreatic loop may place it into the class of "bathyphreatic" loops whose formation (and existence) are controversial. The Plura spring itself is an alluviated spring, suggesting that the deep loop might be a product of aggradation. Closer inspection revealed that the bedrock baselevel is just a few meter below the present spring level, thereby excluding a "per acension" development of the loop. The Plura cave is therefore a "true bathyphreatic" system, which demands other explanations. Accurate underwater cave surveying revealed that most of the cave system is controlled by one single (probably thrust) fault plane, which may offer an explanation on its genesis.

**Large-passage cross-sections: the A-frame lesson**Stein-Erik Lauritzen<sup>1</sup>, Andrej Mihevc<sup>2</sup><sup>1</sup>Department of Earth Sciences, Bergen University, Norway, stein.lauritzen@geo.uib.no<sup>2</sup>Karst Research Institute ZRC SAZU, Titov trg 2, 6230 Postojna, Slovenia, mihevc@zrc-sazu.si

By inspection, large (< 10 m diameter) passages often give the impression of being tubular, with a regular, relatively smooth, vaulted, arch-shaped ceiling. This interpretation is also supported by many photographic records, also showing these arch-shaped, elliptic or semicircular cross-sections. Here, we present a series of laser-based cross-sections from a wide range of "large rooms" in Slovenia, Norway, the US and Mexico. Measurements were done by laser rangefinders mounted on a manual, tri-pod supported clinometer (pre-Disto-X), later by using the Disto-X itself. The lesson to be learnt from this exercise is that geologic structures always dominate, or is at least clearly visible in passage shapes. Theory suggests that a large passage should attain an ellipsoid (or catenary) shape, due to mechanic forces and internal exfoliation, provided the rock mass is homogenous. This requirement is rarely met, in most cases, cross-sections tend to attain a stable A-frame, angular cross-section. Perfect, "mathematical" domes require very large scales, horizontal, thin-bedded material, or sand.

**Results of terrigenous sediments research in the karst caves of Zemo Imereti Plateau**Zaza Lezhava, Kukuri Tsikarishvili, Nana Bolashvili, Lasha Asanidze<sup>1</sup><sup>1</sup> TSU, Vakhushti Bagrationi Institute of Geography, Tamarashvili #6, 177 Tbilisi, Georgia, asanidze.lasha@yahoo.com

Zemo Imereti Plateau covers the easternmost part of the karst zone of western Georgia and is the only platform karst region in the entire Caucasus. By the relief point of view, it is relatively risen central part of the intermountain plain of Georgia.

Litho-bio-stratigraphic/granulometric, mineralogical, petrographic, rentgenostructural and palynological researches of the terrigenous sediments were conducted in the caves developed in the Upper Cretaceous limestones located at different hypsometric levels (400-700 m). During the lithological study of the material the important attention was devoted to the alectonic sediments, which contains the full information for paleogeographic reconstruction due to its sedimentological characteristics. The correlation was done between the obtained results and feeding provinces/petrofunds. The paleogeographic situation of sedimentation was restored in the karst caves, as well as the chronostratigraphy by foreseen of peculiarities of the geological and geomorphological development of the region.

Terraced surfaces are weakly developed in the Zemo Imereti Plateau, and the alluvium of the paleoriver has not been found in the caves yet. Petrographic study of cobblestones proved that the terrigenous sediments are brought by the paleoriver from the southern slope of the Caucasus.

Keywords: karst science, caves

**Speleothem-based reconstruction of the Quaternary environments in Croatia**Robert Lončarić<sup>1</sup>, Maša Surić<sup>1</sup>, Nina Lončar<sup>1</sup>, Nenad Buzjak<sup>2</sup>, Neven Bočić<sup>2</sup><sup>1</sup>Department of Geography, Center for Karst and Coastal Researches, University of Zadar, Croatia<sup>2</sup>Department of Geography, Faculty of Science, University of Zagreb, Croatia

*Reconstruction of Quaternary Environments in Croatia using Isotope Methods* (REQUENCRIM) is scientific project funded by the Croatian Science Foundation (2014–2018) aimed to the estimation of regional response of the environment in Croatia to global changes during the Quaternary. It is based on diverse approaches and different proxies from speleothems, lake sediments, tufa deposits and marine algal rims. Speleothems are considered as valuable high-resolution paleoclimate archives superb to other archives such as deep-sea cores, ice cores etc. Particularly important proxies are stable isotopes ( $^{13}\text{C}/^{12}\text{C}$  and  $^{18}\text{O}/^{16}\text{O}$ ) recorded in speleothems, as they can provide environmental and climatic information from the past, assuming isotopic equilibrium during carbonate precipitation. In the initial phase of the project, speleothems have been taken from three caves, each located in different environmental and climate settings: Nova Grgosova Cave (NW Croatia; continental climate - Cfb), Lokvarka Cave (W Croatia; continental climate - Cfb), and coastal Modrič Cave (S Croatia, submediterranean climate – Cfa). Both drip water from the sites of removed speleothems and rainwater from outside the caves are collected on a monthly basis during the 1-year period in order to characterize the hydrological behavior of drip sites and isotopic variations of the drip water that feeds the stalagmites. Also, microclimate elements (air temperature and relative humidity) are monitored in front and inside the caves. Stable isotopes ratios of radiometric dated (U-Th,  $^{14}\text{C}$ ) speleothems will be analysed in order to determine isotopic variations in the past, which reflects temperature fluctuations and vegetation changes above the caves, both governed by the air mass distribution and climate changes. We assume that the calcite precipitation was uninterrupted at the low altitudes even during the coldest periods while higher mountains were covered by the glaciers rendering calcite precipitation impossible. Final results could prove that the present-day Croatia was border zone between two areas with significantly different response to the global climate changes.

**A follow-up of the use of Panoš holistic principles as a significant factor to overcome speleology development obstacles**

Ivo Lučić

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Half a century of International Union of Speleology (UIS), aiming at „the development of relations between speleologists of all nations and the co-ordination of their activities internationally“, might have been a good opportunity and an incentive to provide competent insight into the global speleological community, to review its history and its current range and obligations. This work has no such ambitions, but played with the idea what kind of problems it might meet fulfilling its task. Even the very attempt to set such requirements encountered a series of insurmountable obstacles. Among biggest is the lack of available information and literature, but also there is no clear and strong desire to achieve such a task. This in turn makes the need of the general public to gain insight into perception of caves and speleology even more distant, as well as it is difficult to decipher feedback from the public as much as it is needed and justified. Unfortunately, the development of speleological organizations at all levels and their vivid interrelations and networking with research institutions are not sufficient to overcome these obstacles. It is crucial to design and implement speleology as a holistic science. Holistic speleology could expand wider range of responsibilities to the understanding of its context to all aspects of the science of underground, regardless of which area of science it belongs to and regardless of the level of its applicability, as well as to all aspects of

the use of the underground. In addition to research the nature of karst, speleology main epistemological interest is a continuous social contextualization of karst nature and study of the relationships between karst and society. Thus, it can accept significantly wider range of its needs. In this respect, speleology might be inspired by the work of Vladimir Panoš (1995) and his integrated karst science system, which unfortunately until now does not have an adequate evaluation among scientists engaged in speleology and its perspectives.

**Keywords:** speleology, history of speleology, science, karstology, holistic speleology

### **The main differences between karst topography of two main zones of Iran: Central Iran (desert region) & Zagros Range**

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This study was carried out in several anticlines at the Zagros range and central Iran in order to identify the main factors that effect on karstic features. The studies at Keino anticline, as representative of the Zagros range, show most of the karstic features such as polje, sinkhole, karren, etc. The Shatte Temi lake depression does appear to be erosional and to be functioning as a hydrologic polje in modern times. The karst landscape at high elevation at Keino anticline is highly oriented so that it looks like a sand dune filed from some angles. We may have a lot of permafrost control here in the past because there are similarities to some of the northern Canadian landscapes. Then it is possible that there has been permafrost (or even some ice cap build up) during Quaternary cold periods. Geomorphology studies show obvious differences between karstic features in Shotori Mountains, central Iran, and the Zagros belt. There are not any advanced morphological karst features such as poljes and sinkholes and other typical features (rill karren, runnel karren, etc.) replace with vespiary features, microspitz karren and similar features. Purity of limestone in Shotori Mountains is the same as Zagros, and then the main reason for morphological differences can be attributed to the type and quantity of precipitations, interbeds of noncarbonate rocks and thickness of carbonate beds.

**Keywords:** karst geomorphology, sinkhole, karren, polje, nival karst

### **Karst - a trap for extraterrestrial debris**

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Karst is a sink for all sorts of sediments. The debris produced by weathering of the exposed rocks is being transported by slope processes, running water, wind, snow, and ice action, and deposited in karst depressions, dolines, poljes and underground cavities. In the subsurface, the external debris is being deposited in shallow parts of caves and ponors where it forms sediment layers commonly interbedded with soils and/or cave sediments sensu stricto (speleothems and collapse debris). This debris compositionally corresponds to the rocks exposed in a particular drainage basin, but karst is

also a trap for wind-blown deposits from far sources (e.g. loess) and cosmogenic debris which rains down on the Earth (e.g. space dust, micrometeorites, microtektites and spherules of various composition and origins). Karst sediments are sometimes fossiliferous, particularly bone-breccias whose fossil content may allow biostratigraphical dating of sediments which would be otherwise difficult, or even impossible.

We have studied sediments from various Dinaric karst areas, including cave and cavern sediments as well as sediments from the karst surface. Usually, the analysed sediments were clays and sands, but also bone breccia and occasionally paleosols. The sediments were decomposed by H<sub>2</sub>O<sub>2</sub>, wet-sieved and studied under microscope in search for microfossils and mineral grains which might indicate their age, and shed more light onto karst evolution. Some of these yielded ostracod fauna, bone splinters or bones of micromammals, and peculiar assemblage of mineral grains. The latter are high-temperature quartz grains, glass shards, microtektites, and glass spherules which occur in discrete horizons.

One of the studied sediments is associated with bone breccia of the Dubci site on the saddle between Omiška Dinara and Biokovo Mts., at 404 m a.s.l. in Croatia. The study site is a road-cut exposure, first opened in 19th century and studied by Malez in 1960s. Malez (1965, 1967) determined the remains of fossil fauna as of the so-called Cromerian complex (ca 890–480 ka) which belongs to the late Early Pleistocene and first half of Middle Pleistocene in Western Europe, and equivalent of Günz Mindel Interglacial in the Alps. During further road works the road-cuts were enlarged and sediments re-sampled in 2007. Marjanac *et al.* (2008) interpreted the facies exposed in the road-cuts; the NW exposure shows: A) Pleistocene lacustrine sediments (Unit 1), B) collapsed cavern filled (Unit 2) with speleothems, collapse rubble, and fragmented bone-rich reddish-brown terra-rossa type soil, locally partly cemented (bone breccia), and C) alluvial sediments (Unit 3). The SE exposure shows: diamicts (debris-flow deposits of Marjanac *et al.* 2008) which are overlain by several diamict-paleosol intervals with a lot of fossil bones locally cemented into bone breccia. The correlation between the NW and SE exposures is impossible because of differences between the exposed sedimentary facies and lack of any direct contact.

During the sediment analyses Lj. M. found glass spherules and several other exotic mineral grain types in lacustrine sediments (Unit 1 of Marjanac *et al.* 2008) which underlie paleocavern deposits (Unit 2) at the NW exposure, and in diamict (DF-1) at the SE exposure. This exotic debris was initially studied for elemental composition on Tescan Vega SEM coupled with EDAX microprobe at the Department of Geology, Faculty of Science in Zagreb. The compositional analysis of the glass spherules was also performed at the Rudjer Bošković Institute Accelerator facility using PIXE Spectroscopy in high vacuum at the ion micro-beam end-station, and the results of both analytical procedures are compared.

The Dubci-site spherules are clear transparent solid glass balls or ellipsoidal bodies, 100-500 microns in diameter. Spherules from other study sites are also clear glass spheres, sometimes fused together (e.g. Middle Permian spherules, Čalogović *et al.* 2015). The Dubci-site spherules are Si-rich (Marjanac *et al.* 2008; Marjanac & Marjanac 2009), similar in composition to the Middle Permian spherules but with higher Na<sup>+</sup> and lower Ca content, and differ from the Split environs Eocene spherules which are Ca-rich and Si-poor (Marjanac *et al.* 2006).

These spherules may have been products of bolide ablation during their flight through the atmosphere, large bolide impacts at the surface of the Earth, and industrial pollution. This last option is eliminated because spherules are discovered at very distinct levels within sediments of various ages and at distant sites (Middle Permian on the central Velebit Mt., Eocene in the Split environs, Pleistocene at the Dubci site on the Biokovo Mt., Novigrad Sea, Kusača site at the foothills of the Southern Velebit Mt., and in recent sediments of the Žečica submarine spring in southern Velebit Channel). In the case of industrial pollution, spherules would occur virtually everywhere around the culprit industry and would compositionally differ as described by Marini and Raukas (2009). The preferred interpretation for the formation of spherules is by condensation in explosion plume(s) caused by terrestrial bolide impact(s). Their occurrence at different stratigraphic levels documents

multiple impact events, and their compositional differences indicate various lithologies of the target rocks. So far, these spherule horizons cannot be associated to any of the known terrestrial impact craters.

This extraterrestrial debris provides good correlation horizon(s) as suggested already by Raukas (2000) and should be looked after in the coeval sediments elsewhere in karst areas.

**Keywords:** Pleistocene, Dinarides, bone-breccia, spherules

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### Giving Meaning to Darkness – Approaches to a Cultural and Social History of Caves and Speleology

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By going underground, early cave visitors opened windows to the past. In quarries, mines or caves, the history of earth became alive and received spatial presence through the finds of fossils, speleothems or layers of rock strata. Regarded as a part of the cultural landscape, caves were of interest for natural historians, travellers and artists as well.

Looking back to the efforts and discoveries of early explorers, we have to consider that dealing with speleological knowledge, practices, media and technical terms is based on contemporary cultural and social implications like images of gender and body, religious thoughts or social hierarchies. Under this aspect, the act of discovery can be recognized as a form of distribution of meaning and significance. Therefore, narratives of speleological activities often teach us more about the author rather than the newly discovered cave areas.

Today, as well as hundred years ago, caves functioned as a projection screen for desires, dreams and the explorer's claims of interpretation and possession. Social communities as speleological research groups and organizations legitimized and controlled this process of attributing meaning to previously undefined areas.

Providing an overview of the current state of research in speleology's history, the lecture examines the significance of narratives for the self-image of speleology and their relevance especially

for historical jubilees like the 50<sup>th</sup> anniversary of the International Union of Speleology. Using historical paintings, maps and photographs as sources, the talk will give a broad outlook towards new cultural and social approaches to the history of speleology, containing theories, methods and main research questions.

Keywords: history, speleology, theories, methods

### **CO<sub>2</sub> and speleogenesis: suggestions from hypogene karst of Italy**

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The CO<sub>2</sub> driving the main karst processes needs to be considerate from different sources. The carbon dioxide produced in the soil and dissolved in the percolation water is considered as the main agent for karstification in the carbonate rocks. Superficial morphologies and underground caves are product of the corrosion of the limestone, while carbonate speleothems is the other end member of the process.

Hypogene speleogenesis driven by deep seated fluids is the cave formation processes for the main karst systems in the Apennines of Italy. Hydrogen sulfide and endogenic carbon dioxide are the main agents for underground karst corrosion and the soil carbon dioxide plays a secondary rule. The limestone corrosion driven by hydrogen sulfide produces gypsum deposits in caves that could be assumed as the indicator of the hypogene speleogenesis. The action of endogenic carbon dioxide in the cave formation, especially if it operates at lower temperature, is not easy to detect and the resulting cave morphology is not helpful to recognize the cave formation process.

The main sources of carbon dioxide in the underground karst system in the Apennines of Italy can be related to different processes driven by the endogenic fluids emissions. The crustal regional degassing seems to be the prevalent source for carbon dioxide in the karst massifs with the main release in the groundwater. Hydrogen sulfide and methane oxidation, possibly mediated by bacteria activity, are other sources in the buried Cenozoic sediments. Releasing of carbon dioxide along the faults and in the fractures occurring in the carbonate rocks is an important source, especially in the seismically active area. Finally, thermogenic reactions with carbonate rocks are well known as one of the main production mechanism of carbon dioxide released in the atmosphere. Data from carbon dioxide monitoring in several caves show a relevant contribution of the endogenic carbon dioxide (about 75 %) in the karst system which drives the speleogenesis reactions and shapes the underground morphologies.

Keywords: speleogenesis, hypogene, Italy

## **Occurrence and significance of Karstic Paleosols in the Stratigraphic Sequence of the Classic Karst near Trieste and their role in the explanation of the Paleogeography in the region.**

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Commissione Grotte "E. Boegan", Società Alpina delle Giulie, Sez. C.A.I. Trieste.

Karstic paleosols are made up of levels of rocks which have undergone an intense action of weathering and pedogenesis in a different climate compared to the current one. They formed in an ancient "landscape".

In classic Karst in Trieste, between Rupingrande (Repent) and Duino (Devin), are detectable at least three levels of paleosols linked to as many episodes of emersions occurred between the Upper Albian and the Cenomanian. They extend regularly and are included between limestones and dolomitic limestones. As well as on the surface, they were also detected during explorations and openings of new underground cavities. Karstic paleosols of the Albian - Cenomanian period are also recorded in the Slovenian Karst, in the Balkans and in the central Apennines. The study of these rocks occurs through different methodologies: XRD (X-ray diffractometry), thin sections, ESEM (environmental scanning electron microscopy), polished cuttings, chemical analysis.

These rocks show intense phenomena of tectonic breccias, differentiations in mineralogy, and accumulations of residual clay.

They consist of calcite and dolomite, as well as of oxides and hydroxides of Al, Mn and Fe, that give the rock the colors ranging from beige to dark red, and of traces of phyllosilicates. These karstic paleosols play an important role for the interpretation of the geological and paleogeographic evolution of the area and surrounding regions.

## **Speleology and Caves of Classical Karst**

Andrej Mihevc

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The term Classical Karst is marking the time and the area where important early observations and scientific studies of karst and caves were done. They started in 17. century, but most of them were done in 19. and first decade of 20. century. Researchers of the area contributed many new data, explanations of phenomena, ideas and terms, together with the word karst, but we can notice that most of them are related to karst surface and hydrology.

Less was done to scientific understanding of principals of cave development in spite of the fact that during 19. century enormous number of deep and long caves have been explored, which gave important insight into the karst underground. Even more, the contribution of researchers of Classical Karst to explanations of cave formation was rather small. So there is a question whether is this a result of the century which was not very friendly to the area or Classical karst is on the field of speleology only historical category and has nothing more to reveal.

Today we are aware of the fact that speleological and geomorphological evolution of the area was long and very complex, which made caves difficult to understand or to extract basic knowledge of cave evolution from them. But we also understand that Classical karst is extremely important because it contains paleo environmental data in surface and cave morphology and infillings. They will contribute to our understanding of general landform evolution in tectonically active terrains.

In this contribution I would like to show on examples of: surface karst features, unroofed caves, collapse dolines and cave entrances that Classical karst can offer us many new information for better understanding of evolution of karst and can also help to related sciences like geology and biology.

## Dolines of Dinaric Karst, Case Study of Menišija, Slovenia

Rok Mihevc

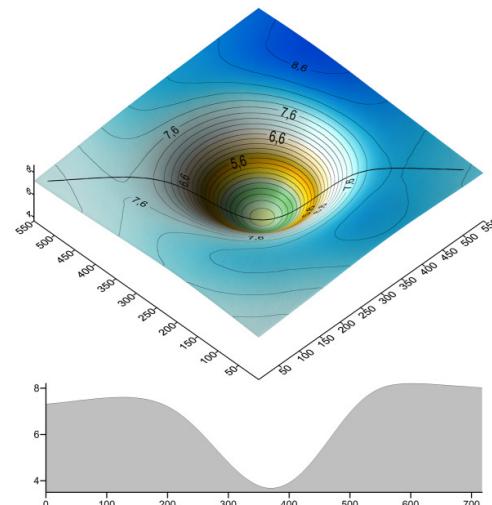
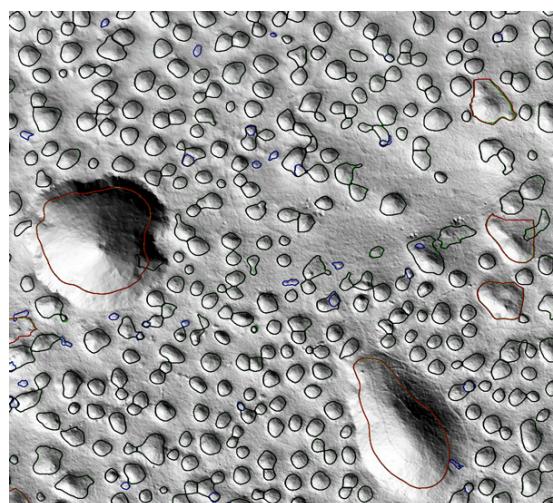
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Dolines are a frequent karst feature. Their shape, genesis and dynamics are conceptually described by various models. However, to the author's knowledge there was no data about exact shape and size of a larger set of karst dolines that could be used for statistical analysis.

We developed and used a numerical method to analyze 60 km<sup>2</sup> of 1 m grid resolution lidar data of digital relief model of Menišija, an levelled karst surface, former polje near Postojna, Slovenia. We identified 8.700 dolines (about 145 dolines/1 m<sup>2</sup>). We then used numerical tools to calculate the average shape of the identified dolines and proposed a function to describe this shape.

Due to the geological history of Menišija and similarity of dolines in the area we propose that they were shaped by the same geomorphological processes, that ultimately lead to a common geomorphologically stable form of doline which is already reached in this area.

Using this hypothesis we propose two possible dynamical models for dolines that would lead to the shape of relief that we observe in Menišija today.



## New exploration in underwater cave systems in Riviera Maya, Mexico

Zdenek Motycka

Czech Speleological Society

During two expeditions in 2014 and 2015 the members of Czech Speleological Society continued their project for exploration and documentation of underwater cave systems on the Yucatán Peninsula, who has been running since 2003. They discovered three new cenotes in the NW and SW from the known parts of the K'oox Baal Cave system, which is now the fourth longest underwater caves in the world 75 km long. In the new cenote Shoot's Hool they discovered 589 m of new passages and in the cenote Wa Ba'ax Yan total of 1,176 m of new corridors. During an inspection dive in cenote Chak Ha, they discovered 354 m of new passages and connected Chak Ha in to the cenote Zebra, which reached the total length of 2443 meters. In new area located about 4 km NE of the K'oox Baal Cave system they discovered 8 new cenotes and 4 of them conected to one cave system Paachil Nah, which is now 5,271 meters long.

Keywords: exploration, caves, underwater cave system, Riviera Maya, Mexico

## Caves exploration in Bosnia and Herzegovina during the AH Monarchy

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The tradition of caves research in Bosnia and Herzegovina dates back to the 16<sup>th</sup> century which document the works of scientist from Dubrovnik, Jakov Sorkočević and Nikola Gučetić. However, just after Bosnia and Herzegovina became a part of AU Monarchy there is significant progress in caves exploration. After the establishment of Administration, the Military Geographical Institute in Vienna became with cartographic recording of the entire territory of Bosnia and Herzegovina. During these recordings, it has been observed many karst phenomena (abyss, pits, caves, estavels, and icicles). The first research and descriptions of karst phenomena, and therefore the cave, to a substantial extent, we found in the works which were published in 1884 in the second issue of Speleological Section of the Austrian Tourist Club.

At the end of the 19<sup>th</sup> century in Sarajevo is established the National Museum, which raises major field research. Viktor Apfelbeck and Franjo Fiala, curators at the museum, and Vaclav Radimsky as an external associate start searching caves, the first such underground fauna habitats, and the other two as pre-historic sites. Apfelbeck in his first paper on insects cavers from 1889 states that he visited twenty caves in Bosnia and Fiala carried out the first archaeological excavations in the caves of Megara on Bjelašnica and Marin's cave at Rogoušić. It is also an incentive to the "non-professionals" to start with research including Christopher Mihajlovic (1889, 1890) who provides the first descriptions of the interior of the Vjetrenica cave and made the first sketch of the interior of a cave. Exceptional findings of endemic underground fauna in the caves of Bosnia and Herzegovina initiated numerous caves studies for collection. Among them, a particularly noteworthy is Leo Weirather who spent the rest of his life researching the fauna in over 500 caves and Lucijan Matulić who was the founder of the first Speleological Society in BiH in Trebinje 1911. One of the greatest explorers of fauna is a Czech Karel Absolon, who found himself in the cave Vjetrenica at the moment of declaration of the World War I. Only in the cave Vjetrenica he was 27 times. It was, at that time, the biggest cave research on a world scale after passing the so-called (later called) "Absolonov canal".

AU authority launches and major infrastructural projects (water supply, construction of roads and railways), which requires intensive geological and hydrological surveys of karst areas. It should be noted works of J. Karlinski, Ph. Baliff, F. Riedl, E. Dolezal, and later, in the early 20<sup>th</sup> century F. Katzer, A. Penck, A. Grund and V. Havelka.

Many "tourists" and hikers exploring caves which was evidenced by numerous signatures of visitors. From this period there are mainly names from other parts of the Monarchy. The names of the local people are very rare.

The number and significance of caves and other natural monuments in Bosnia and Herzegovina are encouraged but then the question of their protection. The World War I prevented this initiative, but in February 23<sup>rd</sup> 1914 the Provincial Government for Bosnia and Herzegovina has brought a Command on the protection of Bosnia and Herzegovina's caves.

Number of caves have motivated Austro-Hungarian military authorities that during World War I formed a special military department that will deal with the research of caves "K. u. K. Höhlenforschungs Detachement". As a member of one such department worked Jirži Daneš, who in the 1917 and 1918 explored the caves in the canyon of the Prača and Glasinačko polje.

Keywords: Bosnia and Herzegovina, karst, cave research, biospeleology

**The Jaj Plateau (Lebanon): a typical high altitude Mediterranean karst  
(International Expedition 2014)**  
Fadi H. Nader & the ISEL 2014 Team

UIS - Speleo-Club du Liban

The high Plateau of Jaj in Mount Lebanon displays an excellent open-air museum for a typical Mediterranean Karst landscape. It exposes the Jurassic carbonate rocks (limestone and hydrothermal dolomites), over a relief ranging from about 1,300 to 1,955m above sea level. Structurally speaking, this area is part of the Qartaba folded (asymmetrical) structure with relatively gentle dipping towards the west and steep limbs towards the east. The Jurassic rocks were covered by volcanic deposits that were eroded later on upon the emergence of Mount Lebanon. This could explain not finding deep caves – most of them are filled by volcanic weathered material.

Such a high elevated Jurassic landscape, with well evolved karstified weathered surface cannot be overlooked by speleologists and cave explorers! Even if, the plateau is bounded by major karst features like the Bala'a sinkholes (three potholes with average depth of 200m), undertaking field search for caves at altitudes averaging 1,700m, with no water sources or enough shades (except the few majestic cedars trees) and on rough terrain has proven to be less attractive. Recent systematic exploration has started again and was planned together with the 3<sup>rd</sup> Middle East Speleology Symposium (2011). Particularly, an international speleological expedition took place in August/September 2014 and revealed some 70 cavities.

This presentation will expose some geomorphological peculiarities of the Jaj Plateau, and the exploration work that is undergoing with its first results. It will also highlight the need to protect this special karstic area."

Keywords: Mount Lebanon, sinkholes, exploration, cave maps, protection

**The highs, lows, and stability of marine isotope stage 5 sea-level in the western Mediterranean**

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Sea level behavior during marine isotope stage (MIS) 5e of the last interglacial (LIG) is of great interest because it serves as an analog for Holocene sea level behavior. Unlike the stable Holocene, significant rises of several meters have been reported during MIS-5e. New and independent records are needed to test what is reported to be a more dynamic sea level highstand during MIS-5e. Phreatic overgrowths on speleothems (POS) from coastal caves of Mallorca Island (Spain) are deposited <40 cm below the brackish water/air interface (water table) at elevations equivalent to sea-level. Thus, stable sea-level stands result in POS that have grown large enough to be used as accurate sea-level markers. Like reefs, the POS are also discontinuous in their coverage of sea level through time, but the method potentially locate both the position and the age of a particular past sea-level stand with very high precision. Uranium-series dating of 18 POS samples from ten caves reveals a stable sea level in the Mediterranean during the entirety of MIS-5e. Our new LIG sea level record from Mallorca indicates that for ~11,000 years (between  $127.4 \pm 0.5$  and  $116.3 \pm 1.3$  ky) the sea-level was remarkably stable at  $2.25 \pm 0.75$  m above the present one. With no evidence of sea-level drop or rise of several meters during this time in the Mallorcan record, the question is, was sea-level more stable globally than shown by results of other far field sites, or is Mallorca different from other sea-level sites for reasons beyond the scope of this presentation? Also indicated by our record

is a fast 5 mm yr<sup>-1</sup> decline in sea-level during the transition from MIS-5e to -5d. Similarly, from MIS-5b to -5a, sea-level rose at ~18 mm yr<sup>-1</sup>, peaked for ~1000 years, then fell rapidly at 5-10 mm yr<sup>-1</sup> at the onset of MIS 4. In all, these changes roughly follow Northern Hemisphere summer insolation. Regardless, Mallorca is a vital location that has a crucial importance in elucidating this part of the global sea-level record.

Keywords: littoral caves, speleothems, sea-level, Mallorca

### **Physical and geological processes in Caves of Dinaric Karst: Mt. Velebit, Croatia**

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We provide an overview of scientific research in caves of Mt. Velebit, Croatia. These activities were initiated in last decades by discoveries of many vertical and deep caves, including the deepest and longest caves in Dinaric karst, 1,431 m deep Lukina jama and 27.8 km long and 737 m deep Kita Gaćešina cave system. Those caves provide excellent way of gathering new insights on the processes connected with geology, hydrology and climate of Mt.Velebit, 145 km long mountain in Croatian Dinaric Karst. It is characterized by the deep karst developed in thick carbonate deposits. Deep karstification of the massif is result of complex geological structures with entirely carbonate deposits thicker than 2,000 meters in the Northern Velebit area. Owing to the position between Adriatic and continental Lika region and altitudes up to 1,757 m, it is also an important climatological border with high precipitation (>3,500 mm/y). Those factors are important for physical and geomorphological processes observed in caves. Access to locations and scientific research in these caves is a complex; it must be coordinated with caving activities, and climate and hydrological situation (vertical dynamics of water and ice). We are using various instrumental techniques, in situ measurements, sampling and laboratory analysis. Parts of research include geochemical and structural analysis of cave sediments, <sup>14</sup>C dating, chemical and isotopic analysis of water, water level monitoring, investigation of microclimate parameters, ice dynamics, radon and carbon dioxide. Special attention in further research will be focused on the collection and analysis of physical data and their role in modeling the physical and geological processes through numerical models of speleogenesis and morphogenesis, heat flow and cave microclimate. In addition, geological and geographical research will contribute to the interpretation of the observed processes.

Part of this work was done under projects Physical Research of Active and Paleoenvironmental processes in Caves of Dinaric Karst (SLO-CRO, PMF ZG-IZRK SAZU) and Exploration of deep pits of Northern Velebit (Northern Velebit National Park and Croatian Environmental protection and energy efficiency Fund).

Keywords: caves, physical and geological processes, Dinaric karst, Mt. Velebit, Croatia

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## Quantifying the value and degradation of caves in selected karst area of Dinarides – example of Ozalj hills

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The particularity of karst landscape is reflected in the specific interconnectedness between the surface and the underground. Caves represent an important feature of karst studies due to their high sensitivity to surface and subterranean changes conditioned by natural and anthropogenic factors. The aim of this paper is to try to determine the value and the disturbance of 39 caves of the Ozalj hills. The method of two modified indices has been applied: the Index of value of caves (IVS) and the Index of disturbance of caves (IUS) whose categories have been modified in order to adjust to the observed area. The index values are based on a number of indicators (geomorphology, hydrology, biodiversity, proximity of towns, proximity of roads, etc.) that were collected from the archives of years-long studies carried out by various speleological associations. Using the correlation of both indices it has been concluded that the caves with the highest level of value have likewise the highest level of disturbance. The most disturbed caves are those with a high level of accessibility and attractiveness of the entrance since that is what increases uncontrolled visits, which reflects negatively on the condition of its interior. The caves with the highest IUS are located in the vicinity of major towns and roads and the caves with the lowest IUS are located in the south-western part of the observed area where there is a higher altitude, a lower level of urbanization and a low density road network.

Keywords: index of value, index of disturbance, karst area, the Ozalj hills, caves

## Ice caves – history of research, present status and prospects for future

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Perennial accumulations of ice in caves are found in places where peculiar combinations of cave morphology, hydrologic and climatic conditions concur. Cave morphologic conditions are a sine qua non provision for their occurrence, while changes in climate (and partly associated hydrologic

conditions) are controlling the persistence and long and short term dynamics of ice. Ice in caves forms either by the diagenesis of snow or freezing of water, and these genetic conditions and resulting morphologies led to some uncertainties on the status of ice accumulations in caves: are they speleothems, piles of sediment(s) or glaciers? Whatever their designation, ice caves are an important (but often neglected) component of the cryosphere: apart from the intrinsic value for understanding natural processes, they hold important clues on past climatic and environmental conditions, harbor peculiar life forms and could provide clues for life on other planets than Earth.

In this review, we will address a series of aspects of ice cave research, ranging from a proposal for definition of ice in caves, through history of research and present status, as well as a proposal for future cooperation.

Keywords: ice caves

### **Geochemistry of solid specimens from caves and hydrochemistry of water samples from wells and springs in the Rovte region (W Slovenia) for the assessment of dedolomitisation**

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Speleological and geological research in the area of Rovte (W Slovenia) revealed that some of the caves, which are developed in *Lower and Middle Triassic* dolostone, may be of hypogenic origin. Among other processes, dedolomitisation could have played an important role in their speleogenesis. To assess if dedolomitisation is still occurring, we sampled and analysed solid specimens from the cave Mravljetovo brezno and water samples from three deep wells and two springs in the Rovte region. The wells penetrate gypsum strata at a depth of several hundred meters. Therefore samples from wells Z and R show high  $\text{SO}_4^{2-}$ -concentrations and  $\text{Mg}^{2+}/\text{Ca}^{2+}$ -ratios less than 1. Water samples from surface springs show very low  $\text{SO}_4^{2-}$ - but high  $\text{NO}_3^-$ - and  $\text{Cl}^-$ -concentrations in contrast. These are clearly impacted anthropogenically. The  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  values of the wells Z and R are in the same range suggesting that the waters from Z and R derive from the same aquifer system. Saturation indexes show that most samples from the wells were supersaturated with respect to calcite and mostly undersaturated with respect to dolomite. Furthermore, pH and  $\text{SO}_4^{2-}$ -concentration are positively correlated. Analysis of the solid specimens show high percentage of  $\text{Ca}^{2+}$  and low percentage of  $\text{Sr}^{2+}$ . The dedolomite specimens have low percentage of  $\text{Mg}^{2+}$  and high percentage of  $\text{Fe}^{2+/3+}$ . The dolomite specimens have higher  $\text{Mg}^{2+}$  percentage than the dedolomite and almost no  $\text{Fe}^{2+/3+}$ . Thus the preferential removal of  $\text{Mg}^{2+}$  as suggested by the molar  $\text{Mg}^{2+}/\text{Ca}^{2+}$ -ratio of < 1 indicates that dedolomitisation may still be occurring.

Keywords: dedolomitisation, dedolomite chemistry, hypogenic speleogenesis, Slovenia

**"The Blanches-Fontaines" karst system (Switzerland): between science and exploration.**  
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The Blanches-Fontaines karst spring is located in the Jura moutains, in the northwest of Switzerland. The annual average flow rate of this spring is 1.3 m<sup>3</sup>/s. However, during extrem rain event, the discharge may reach 15 m<sup>3</sup>/s. That is why this karstic spring is known as one of the biggest spring of the Swiss Jura mountains. It is linked to an aquifer, located in the limestones from the Upper Jurassic (Malm), and its watershed represents a surface of 56 km<sup>2</sup>, with an average altitude of 1000 meters above sea level.

The Blanches-Fontaines karst spring has recently been the subject of a multidisciplinary approach study: Tracer tests, hydrochemical and microbiological analyses, and a monitoring of the physico-chemicals parameters of the spring have been performed, in order to modelize the variation of the water level and the flow of water into the karstic system. Moreover, some flood events have also been monitored to understand the behavior of the karstic system during important rain events. Tracer tests highlighted verys heterogeneous water velocity within the aquifer (from 5 to 200 m/h) regarding of the hydrologic conditions. The monitoring of the water level variations in the conduits revealed a spectacular water level rise (0.5 cm/s) during a flood event. Finaly, the hydrochemical analysis proved the good quality of the water and confirmed the absence of any industrial contamination. However, the microbiological analysis showed that important rain events during spring or summer resulted of a high contamination of the groundwater by fecal bacteria (more than 400 *Eschierichia Coli* into 100 ml of water).

Speleologists have been fascinated by The "Blanches-Fontaines" karst system for more than sixty years. There are a lot of variable size sinkholes and caves in the spring's catchment areas resulting in an important flow rate. This led speleologists and scientists to think that there might be an important network of caves and conduits (approximately 20km long) to discover. Every part of the catchment area of the spring was explored by the speleologist with the hope of discovering the entry to this fabulous cave network. The bottom of each sinkhole has beed dug with the aim to find an entry to reach the karst system. The most important excavation began thirty years ago in the "Rocher Bacon" sinkhole which is located near to the outfall of the "Blanches- Fontaines" karst system. 2,000 m<sup>3</sup> of mud, gravel and rock have been removed from the hole thanks to an awesome excavation system. Today, researches continue in five holes, but the fabulous cave network remains hidden.

After 65 years of exploration only a few hundred meters of galleries have been found (about 40 km could be found) but a lot of friendship was shared... Which is probably for the best!

Keywords: karst spring, Switzerland, exploration, microbiology, modelisation, dye tracing

**History and significance of the cave beetle studies in Classical Karst for the development of Biopeleontology**  
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Caves were not considered as a proper habitat for animals until 1831, when the first cave troglobiotic beetle was discovered in Postojnska jama. This troglomoprhic beetle originally found by Luka Čeč, has been soon recognized as a true cave adapted beetle and scientifically described under the name of *Letodirus hochenwartii* by Ferdinand Schmidt, an entomologist from Ljubljana. Schmidt later discovered additional cave beetles and other cave adapted invertebrates in caves from Classical Karst. Those discoveries triggered the interest in studying cave animals among several European

naturalists, who visited Postojna and the surrounding caves in search for such extraordinary new cave specimens. The first among them were H. C. Schiødte, V. Motschoulsky, H. Schaum, J. Sturm, G. Joseph, R. Khevenhüller and J. H. Schinner, who later found and described the first troglobiotic representatives of the most significant animal groups living in the Dinaric Karst. Cave adapted species of beetles, spiders, pseudoscorpions, millipedes, crustaceans and mollusks described in the years to come, were called Carniolian cave fauna at first. Later, cave adapted animals were found in other karst areas from Europe and other continents as well.

The interest for discovering and describing the new cave beetle species in the Classical Karst never declined, but real systematic investigations started at turn from 19<sup>th</sup> to 20<sup>th</sup> century with fruitful studies and comprehensive publications of J. G. Müller (Trieste) and R. Jeannel (Paris). Some of those studies are considered as the fundaments of a new science, Biospeleology. Extensive knowledge on cave beetle taxonomy and distributions have been used for one of the first zoogeographic and consequently paleogeographic models. Müllers' student Egon Pretner and his junior colleagues systematically mapped the Slovene subterranean beetle fauna in the 20<sup>th</sup> century. This knowledge is a fundamental base for the modern zoogeographical and modern molecular phylogenetic studies carried out in a recent time.

Keywords: cave beetles, Leptodirus, history, entomologists, Classical Karst

### **Climate-driven soil CO<sub>2</sub> concentration, hardness of water and flux of inorganic carbon – quantitative data from southern Alpine and northern Dinaric karst**

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Comparison of inflow (precipitation) and outflow from karst massifs indicates important changes in chemical composition of water – general increase in pCO<sub>2</sub> concentration, hardness and alkalinity are usually observed. Such changes are the result of well-known reaction with soil CO<sub>2</sub> and limestone/dolomite where water acts as reagent and media/solvent for CO<sub>2</sub> and Ca/Mg transport. However, changes are generally lower in cold/dry karst in comparison with karst in warm humid climate; this shows significant role of climate on CO<sub>2</sub> production followed by different carbonate dissolution.

To quantify rate of CO<sub>2</sub> and carbonate uptake, water at the surface, caves and springs was sampled from high Alpine karst (2,257 m a.s.l.; depth up to -1,240 m) to coastal Dinaric karst (50 m a.s.l.) in Slovenia. Calcium and magnesium hardness, alkalinity, water temperature and pH were further used in PHREEQ chemical software to get calcite/dolomite saturation index (SICal/SIDol) and equilibrium CO<sub>2</sub> concentration. Up to May 2015, results of 214 samplings have been available. Results show abrupt increase in equilibrium CO<sub>2</sub> concentration from 0.4 % (Renetovo brezno, 2,257 m a.s.l. in depth -250 m) to 4.2 % in case of Škocjanske jame (425 m a.s.l.) as a result of soil CO<sub>2</sub> production. Higher CO<sup>2</sup> concentrations were found in low submediterranean limestone karst (4.2 %) as well as in lowland temperate subcontinental dolomite karst (3.5 %). Hardness of water can be paralleled to CO<sub>2</sub> concentration. SICal value is much more complex parameter; taking into account only karst springs, water can be from slightly undersaturated usually in high Alpine karst (up to -0.29) to oversaturated (up to 0.85 where important CO<sub>2</sub> outgassing take place) in low Dinaric karst (overall arithmetic mean 0.08 and median 0.05). Percolation water intercepted at the tip of stalactites at low to middle altitude caves is saturated with respect to calcite with values from -0.08 to 0.23 (arithmetic mean at 0.10). While approaching cave floors, outgassing of CO<sub>2</sub> raises SICal value that is followed by sinter deposition. Results show undoubtedly strong climatic effect important for various scientific

disciplines dealing with speleogenesis, speleothem deposition, CO<sub>2</sub> production and sequestration, and catchment area delineation.

**Keywords:** carbon dioxide, CO<sub>2</sub>, Alpine karst, Dinaric karst, calcite saturation index, climate, epikarst, springs

**Karstification and speleogenesis in Olympus Mountain, Central Macedonia, Greece**  
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"Olympus, the highest mountain in Greece, forms a continuous rock series of Cretaceous-Eocene carbonates and the overlying flysch with an Eocene age. These rocks are presently exposed in the form of a tectonic window through a number of thrust sheets. The Olympus massif is also characterized by rapid tectonic uplift. The present paper focuses in the study of Olympus karstic formations. The mountain's karstic area covers over 50 km<sup>2</sup> with the significant presence of vertical formations and several superficial karstic features. Especially vertical caves do not exceed 50 m depth in altitudes above 2,000 m.

Surface and underground karstic formations were mapped during this study in order to define the karstification process in the whole area of Olympus Mountain. Underground karstic features commonly formed along the intersection of joints, faults and bedding planes, sub-parallel to the dip. Speleogenesis and underground karstification in Olympus area occurs along the tectonic and stratigraphical discontinuities from the upper Miocene till present. The scarcity of large caves in the mass of Olympus shows that Pleistocene glaciers have played a key role in the karstification magnitude and the underground water movement.

**Keywords:** Olympus Mountain, karstification, caves, glaciers, Greece

**Geoturistic inventory of natural cavities in the Province of Napo (Ecuador): Documentation of orality and related strategic resources**  
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The Ecuadorian Amazon is commonly known for its natural attractions and transcendent biodiversity, and these biological characteristics is supported and linked for the variability of geoforms, piedmont features and the eastern plains to the east of the Andes. Significant rock formations packages with age base bordering the Upper Jurassic until alluvial and pyroclastic deposits, appear in this sector, giving evidence of a variety e imposing geodiversity. The morphological complexity in the province of Napo (Ecuadorian northeastern), occur some natural cavities of various sizes, but all with an implicit potential for geoeducation. This project consists of a geological characterization and detailed systematic inventory, from approximately 15 caverns previously identified, and lifting of affine information to the caverns: orality (legends and myths), biological inventory and supply watersheds. This information will be use as input for geoturismo strategies in the territory, and the basis for the management of futures projects and the formation of an Amazonian Geopark.

**Keywords:** Amazon, caves, geoeducation, geoparks, Province of Napo

## The roles of exploration, mapping, science, and artistry in "seeing" caves

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Caves are probably the most challenging landforms to quantify and visualize. This is due to their "negative" configuration as well as potentially harsh field conditions. The 50<sup>th</sup> anniversary of the UIS is an appropriate occasion to reflect upon the synergies existing between exploration, cartography, and science in the visualization of caves, and also to examine changes that have occurred with new technologies and approaches. The vast majority of cave maps (or visualizations) make use of human interpretation, as well as dimensional measurements. As such, what the surveyor/cartographer perceives in the field is critical to creating a useful rendering, to fulfill the overall purpose: transmission of information. Three hundred plus years of cave mapping have seen major advances in everything from illumination methods, traverse techniques, measurement protocols, data reduction, cartographic tools, display, printing, and digital visualization. Recent trends are towards collection of denser data, faster surveys, and 3d visualization. Increased data density (e.g. terrestrial lidar scans) can improve understanding of caves and karst systems by providing the ability to discern features that would otherwise be obscured. However, dataset sizes and structures require robust hardware and smart algorithms to provide human-useable outcomes. Further, a fast survey may not prove best for characterizing a feature. Examination of cave maps from the 1800's shows that profound insights were obtained under the harshest settings, and with very basic equipment – the most important tools were the observant eyes of the surveyor.

Keywords: history, surveying, science

## Scientific researches and explorations in quartzite and quartz-sandstone caves

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"Quartz is considered one of the less soluble minerals of the Earth's crust, and thus hardly affected by chemical weathering. Despite this, since more than forty years, it's clear that the formation of caves and peculiar surface weathering morphologies in quartz-rich lithologies is common and very similar to the well-known karstic ones in carbonate rocks.

The first attempt to explain the processes responsible for these formations was given in the late seventies with the Arenisation theory by J.J. Martini. Later an ever increasing number of evidences of these weathering mechanisms were reported from several areas of the world. Arenization implies a slow but pervasive dissolution of the quartz grain/mineral boundaries increasing the general porosity until the rock becomes incohesive and can be easily eroded by running waters. The loose sands produced by the weathering processes are then evacuated to the surface through processes of piping due to the infiltration of waters from the fracture network or the bedding planes.

The range, volume, and availability of information to geomorphologists on this topic are now much greater than twenty years ago. Thus, our understanding of the distribution, morphology, chemistry and evolution of karstified quartz-sandstones and quartzites has improved substantially in the past few decades. The exploration of some giant maze cave systems in the quartz-sandstones in

the tepuis of the Guyana Shield in Venezuela, as well as peculiar caves and landforms in Australia, Brazil and Europe has led to an urging need of new studies and theories on these processes.

Quartz-sandstone and quartzite landforms have begun to be recognised as more than just a curiosity, and accepted as being important in their own right. This has even developed to the extent of several geomorphologists reassessing the definition of the term 'karst', and its application to these peculiar lithologies.

Since 2000, more than fifty research papers were published on this topic, supporting new ideas or presenting new quantitative data about the arenization process. Substantial progresses were obtained in the fields of silica chemistry, modelling, petrography, geomicrobiology and secondary caves minerals in these environments. In addition, the study of hypogenic speleogenesis in quartzites has made an important breakthrough which will have several implications not only in the field of karstology.

In this lecture the state of knowledge on the relevant chemical processes, weathering mechanisms and speleogenesis involved in the surface and underground karstification of highly siliceous sandstones and quartzites will be outlined. Following this, the range of solutional landforms on these rock types will be presented together with their global distribution. Finally we'll discuss the ongoing significance of solutional weathering processes and landforms in quartz-sandstones and quartzites, and suggest several avenues where questions and blank spaces remain and where additional research is necessary."

**Keywords:** quartzite, quartz-sandstone, arenization, weathering, karst, pseudokarst

### **Human adventures in a karst environment: the case of the Monti Lessini (Venetian Prealps, Italy)**

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The Monti Lessini, a mountain group located north of the town of Verona, has been the scenery, since from prehistoric times, of many different human adventures some of which related with the local karst environment. In particular, during the late Middle Age, the Renaissance and the Modern Age, interesting adventures, linked with natural monuments and peculiarities of the karst environment, have involved famous people, members of the culture of the time and local inhabitants.

So, regarding the celebrities there are clues that: 1) during the XIV century Dante Alighieri visited some karst cavities in the mountains, 2) during the XV century the famous painter Andrea Mantegna represented in the Camera degli Sposi of the Ducal Palace of Mantua a natural karst monument of Lessini known as Ponte di Veja.

Regarding the members of the culture of the time: 1) in the XVI century the pharmacist Francesco Calceolari realized in Verona one of the first Wunderkammer of the World consisting in an exhibition of curious objects collected for the most part in the mountains (both Monti Lessini and Monte Baldo), 2) the local priest Gregorio Piccoli, in 1736, starting from the description of the paleontological fillings of a cave proposed the interpretation that the limestone in which the cave is developed has been deposited in the bottom of a sea much before the diluvium universalis. He also argued that, because many limestone beds have a constant thickness, in that time the bottom of the sea was a nearly horizontal plain.

Regarding the local inhabitants of the mountains, they have been able not only to solve some environmental problems, as the scarcity of surface water, but also to exploit some special resources, as the ice trapped in some caves (since the XIV century they were quarrying ice in a deep karst shaft). They have also developed a system to produce ice and to store it in artificial cylindrical warehouses

inspired by the karst shafts. Beside this, they have also understood aspects of the functioning of the karst geo-system, as the underground karst hydrology and the dynamics of the epikarstic zone. So, here the existence of the epikarst has been comprehended by simple people much before than by the modern researchers.

In general, it is fascinating to discover that in the past people living in a karst environment has been able to understand its characters and dynamics much more than it is commonly thought.

Keywords: man and karst environment, history of karst science

### New findings about new discoveries in Zarrin cave

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Zarrin cave is located in zarrin Roud village, Zanjan, Iran. The area is a cold, dry with eroded rock unites. The cave is hosted in Cretaceous tectonized limestones. The study area is a dynamic and faulted zone which is closed to Sanandaj – Sirjan magmatic – metamorphic zone. This zone is famous for its huge and thick magmatic and metamorphic unites which are belong to Paleozoic and specially Mesozoic. Two big show caves like Alisadr and Katale khour caves are close to our case study. These caves make three corner of a triangle on the map. Zarrin cave was explored after an earthquake in 2005. After that cavers mapped the cave. Access to the main chambers of the cave is a bit hard and cavers should descend a steeped crashed way which is filled by muds and surface zone sediments that make the way so dangerous. This entry way is 400 m in length and about 150 m in depth. Cave includes chambers and pools. Chamber morphology and evidences such as notches and old water lines revealed a notching and water table activities and phreatic situation. Zarrin cave contains several kinds of speleothems like big columns, stalagmites, stalactites, spars, rimstones, helectites, anthodites, etc. colorful formation increase the cave attractiveness. All these forms are broken by tectonic movements and structural events which effect on the area therefore detailed microseismic and tectonic studies are necessary to find accurate results. Zarrin cave has complete sets of clastic and weathered sediments which are significant and show different phase which were happened in the cave spelogenesis development. Compare the data from Zarrin cave with to other caves which are in the neighbour of it can give useful information about spelogenesis processes which cause to form these caves in the area.

Keywords: findings, discoveries, Zarrin cave, spelogenesis, tectonic caves

## History of cave science

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To cover the history of cave science in 30 minutes is impossible. What I aim to do, therefore, is to consider what it was like to be a cave scientist in previous centuries. What were their starting points? What were the beliefs accepted at the time as facts? And what happened that made their task easier?

While today we might start from Ford and Williams, they had two authorities to guide them: the Greek and Roman classics and the Bible, especially the Bible for it provided useful facts about the (young) age of the earth and the historical fact of the great universal flood. Before the 1660s there was little direct communication between scientists of any sort; but from then on the new learned societies produced regular journals so that a person publishing his ideas knew that they would be read by his peers.

Then follow four case studies that illustrate how contemporary beliefs could lead logically to rather strange conclusions. I emphasize that I have not recorded these cases just as quaint or comic theories but as relatively logical conclusions from false premises:

- The flooding of the intermittent lake at Cerknica was so rapid that it could only be explained by the action of siphons.
- Knowledge of Noah's Flood led a priest, who was also a cave explorer in the 1750s, to regard dolines and caves as being eroded by the retreating water of the Flood.
- Just as plants are a lower form of life than animals, so minerals were a lower form of life than plants. Metallic ores regrew in mines and speleothems grew in a similar manner.
- Bones found in caves were those of animals washed away by the great Flood when the earth was young and the rock had not yet become hard. As the carcasses rotted the resulting gases pushed back the soft rock to form cavities and caves.

## Classical karst: high biodiversity of its underground, its importance for the birth of speleobiology

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Classical karst is a part of Dinaric karst, where first specialized cave animals (troglobionts) were found for science. J.N. Laurenti (1768) described the salamander *Proteus anguinus*, F. Schmidt (1832) described the beetle *Leptodirus hochenwartii* and started the search for cave animals; this might be the birth of speleobiology, a new research field. Close to Dinaric karst is also the Vardar valley, where S. Karaman found and described (1932) the first interstitial troglobionts, e.g. *Microparasellus* species.

Recent studies confirmed the globally highest known biodiversity in the same area. The richest aquatic group are crustaceans, the richest terrestrial are beetles; they alone may exceed 20 troglobiotic species in 20x20 km quadrat. Virtually all species and many genera of Dinaric coleopteran troglobionts are endemic within the area, 84% of species with distribution ranges less than 50 km.

Two among the largest cave systems in Dinarides are with ca 100 troglobiotic species each the richest known in the world. Beside the animal groups rich in troglobionts, the Dinaric fauna harbours unique troglobiotic species of some groups, like: clams (Bivalvia, *Mytilopsis kusceri*), cnidarians (Hydrozoa, *Velkovrhia enigmatica*), tube worms (Serpulidae, *Marifugia cavatica*).

The first ecological investigations of anchihaline caves have been done along the Dinaric Adriatic coast. The special habitat 'cave hygropetric' was recognized and described here. Showy, macroscopically perceivable microbial colonies were discovered; such are the aquatic *Troglogloea absoloni* and the colorful, actinobacteria dominated, mixed microbial colonies on cave walls.

Postojna-Planina Cave System in Slovenia served as a polygon for diverse speleobiological investigations. The most important was the evidence of the troglobionts-nontroglobionts equilibrium depending on the food support; this is important for understanding the formation of the subterranean fauna. Some animal species reveal genetic consequences of the recurrent immigration from surface even within one cave system, let alone in continental extents. The isopod crustacean *Asellus aquaticus* is a particularly appropriate model for such studies. And last but not least, here are the type localities of a number of first discovered troglobiotic species and the polygon for first attempts to classify the subterranean fauna.

### **North Dalmatian caves in palaeoenvironmental studies (Croatia)**

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North Dalmatia (Croatia), as a part of Dinaric classical karst, hosts a variety of caves within different climate zones and diverse environments, from the submarine to the highest mountain peaks. In order to reconstruct Quaternary changes, speleothem-based studies have been conducted in 7 of them – three submarine (Cave in Tihovac Bay on Pag Island, Pit near Iški Mrtovnjak Islet and Vrulja Zečica near Rovnjska) and four subaerial caves (Manita peć, Strašna peć, Modrič and Spilja u Zubu Buljme caves). While the submerged speleothems were used for the reconstruction of the sea-level changes, thorough monitoring, sampling and isotope analyses in subaerial caves provided insight in the regional response to the global climate changes from the Late Pleistocene to Holocene, and present-day precipitation conditions. Caves showed different potential for the palaeoclimate researches: Spilja u Zubu Buljme Cave was evaluated as unreliable for palaeoclimate studies, Strašna peć Cave potentially points to a Holocene paleoseismic event, Manita peć Cave provided stalagmites with climate signals from MIS 5 to MIS 1, whilst Modrič Cave's speleothems cover different periods, with previous studies mostly focused on the last two millennia. Ongoing researches are aimed to the comparison of the speleothem records from littoral and continental part of Croatia with the intention of the resolving spatial and temporal shifting of Mediterranean and Atlantic air masses dominance throughout the late Quaternary in this region.

### Sannur Cave as a paleokarst and international heritage site

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Sannur Cave is one of paleokarst sites in Egypt. It is Located in Beni Suef province, Egypt. It is about 70 km southeast of the city at an elevation of 236 m a.s.l. The cave is discovered in an alabaster quarry in 1989 where Egyptian alabaster has been mined since Pharaonic days. Although it has been found in middle Eocene rocks, its approximate age is about 200,000 years. The paleo rain system (pluvial periods) which occurred in Oligocene, Miocene, Pleistocene and Holocene gave good opportunities to the development of paleo karst landforms (Stalactites, Stalagmites, curtains...etc.). The main target of this study is to shade light on one of the world Heritage Sites that tell a complete story about the paleo climate conditions.

Keywords: paleokarst, Beni Suef, Egypt

### Study of cave sediments in Budimirica Cave, Macedonia FYR – Correlation to late pleistocene environmental changes

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The Budimirica Cave is a small cave, located in the central parts of Republic of Macedonia, developed in Cretaceous limestones, in the lower parts of Kamenica River valley. The limestone areas are covered mostly with pyroclastic sediments of Vitachevo Plateau, deposited in a lacustrine to fluvial environments during Pliocene and Early Pleistocene time. The Kamenica River developed its valley after the draining of the lake (starting as late as Middle Pleistocene), cutting first through the pyroclastic deposits, and continuing down to the pre-Cenozoic basement, exposing limestone to karst processes.

An exposed sediment profile within the cave was studied, for its stratigraphy, composition and age of deposition with an attempt to correlate with past environmental changes inferred from sediment record in the Ohrid Lake. The profile starts with flowstone deposits at the bottom, covered with clastic sequence of clay, silt and sand, coarsening upwards to gravel and covered by flowstone deposits on the top. This whole section is then eroded, with the lower parts covered with fossil bearing breccia deposits, on top of which a defecation organic material is deposited. Mineral composition of the finer sediments within the clastic sequence confirms origin from the pyroclastic deposits of Vitachevo Plateau. They were also sampled for paleomagnetic dating, with the sediments containing normal magnetic properties, very close to the present magnetic field for Republic of Macedonia, and being deposited within the Brunhes chron, are younger than 780 ka. This age was later refined based on  $^{234}\text{U}/^{238}\text{U}$  dating of the underlying flowstone deposits as younger than 83 (+16/-14) ka, with the flowstone deposited during the last interstadial of the last interglacial stage in Late Pleistocene (MIS 5a). Comparing the registered events within the studied profile with the environmental data based on the Ohrid Lake sediment core, the upper parts of the profile were attributed to be deposited during the Weichselian Glaciation (MIS 4 to MIS 2), with the clastic

sequence likely during MIS 4, the topmost flowstone deposit during the slightly warmer MIS 3, and the breccia deposits during the last stadial of the Weichselian Glaciation (MIS 2). The organic deposits are likely result of pasturage within the recent (Holocene) time.

Considering the location (central parts of Balkan Peninsula), the cave can have possible future implications on paleoclimate studies from cave deposits and their comparison to the lacustrine environmental record from Ohrid and Prespa lakes, with future dating of the middle and upper parts of the profile refining the age of the sediments.

**Keywords:** Budimirica Cave, cave sediments, magnetostratigraphy, Late Pleistocene, paleoenvironment

### The Future of Cave Exploration and its Contributions to Cave Science

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People have explored caves for thousands of years, with advances and changes occurring with advances in technology. The next 100 years promise the most rapid technological advances in human history, and similarly rapid and major advances in cave exploration and science will also occur. Current and near-future changes involve lighter and superior exploration and scientific equipment. Several people around the world are developing highly portable 3-dimensional mapping systems. Hand-held scanners are identifying minerals in caves. Complex compositions of cave atmospheres are being measured in unprecedented detail. Robotic exploration will soon begin to compliment human exploration, with drones flying into high domes and crawling into passages too small for humans. In the coming decades, as robots become more robust, they will explore and analyze actively-forming volcanic caves and water-filled caves too deep for humans. Cave exploration technology will grow as the testing ground for exploration of other planetary bodies and their caves. Hundreds of cave entrances have been identified on the moon and Mars. The largest cave in the solar system is likely the ice-covered ocean of the Jovian moon Europa. Saturn's largest moon Titan appears covered with a type of methane-based karst, whose exploration will challenge future engineers and scientists. The one constant in the history of cave exploration has been the indomitable human spirit that will continue to lead us into new underground and scientific frontiers.

**Keywords:** exploration, science, future, planetary exploration

### Is the interconnection of Demänová Cave System and Štefanová Cave real or just a dream? (Exploration and speleological issues of the longest cave system in Slovakia)

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The Demänová Cave System with total length 40,453 m and denivelation 196 m represents the longest cave system in Slovakia. It is situated in the Demänová Valley, in central part of the Low Tatra Mts., central Slovakia; more than 65 km of caves have been found in this valley. The Demänová Cave System has been created mostly in dark-grey Gutenstein Limestones along tectonic pattern of SE–NW and NE–SW orientation by two main allochthonous ponor rivers and several autochthonous tributaries, from Pliocene till now. The shape of system shows nine levels of huge horizontal corridors meandering in S–N direction with tight tributaries and few vertical passages up to 90 m

deep; there are 20 siphons known. The cave system consists of 11 formerly independent caves (Pustá Cave, Medvedia Cave, Demänovská Cave of Liberty, Údolná Cave, Cave pod Útesom, Trosiek Cave, Vyvieranie Cave, Demänovská Cave of Peace, Pavúčia Cave, Točište 15 and Demänovská Ice Cave), which were interconnected by cavers' work. In 1921 the Cave of Liberty was found, and the systematic speleological investigation started. The most southern parts of the system belong to the Demänová Ice Cave with permanent ice fill; these parts were known already before 1719. Currently, the Ice Cave and the Cave of Liberty are open for the public as two different show caves. Most of space of the cave system is rich decorated by flowstone and dripstone formations. Due to karst structure the area replenishes water-bearing layers that form part of an underground hydrological system and aquifer providing the most important source of drinking water to Liptov region. The Demänová Cave System was considered as the National Natural Monument within the Nature Reservation and National Park, and together with another caves in the Demänová Valley it was inscribed to the List of Ramsar Sites as underground wetland of European importance.

Štefanová is 14'746 m long cave, which was known from the half of 20<sup>th</sup> century as a small cave, southern from Demänová Cave of Liberty. In 1993 its length reached 1.5 km and after cavers' discoveries in 2007 it rises about 2 km per year. The cave was created by two main allochthonous ponor rivers and few smaller autochthonous tributaries mainly in the Stodôlka massif, which divides the Demänová Valley into two branches – Zadná voda and Lúčanka. Therefore the cave has been formed in two different ways. Tectonics caused the subsidence of the karst area in few meters and the melting glacial moraine of Zadná voda fulfilled significant part of the cave during the Quaternary glacials. In the area of Lúčanka there are horizontal cave corridors situated ca 10–30 m under the level of Demänová Valley, they cross it in few places on the map. There is a nicely decorated dome called Cavers' Dream with adjacent passages, which was created by autochthonous water and reaches +122 m in the chimneys.

Substantial part of water from the Štefanová Cave flows to the Demänová Cave System through Pekelný Siphon, about 100 m long and 32 m deep. Speleodivers have tried to dive there many times, but the results have been not successful. Genetically the caves are considered to be parts of one cave system, but practically they are still two different caves until the siphon is dived through. Nowadays, cavers of "Speleoklub Demänovská dolina" wish to connect Štefanová Cave with the system by digging in several places trying to reach first "50 km of underground" in Slovakia. They also work in many other places which show great potential for new kilometers of Demänová Valley's underground.

**Keywords:** Demänová Cave System, Slovak caves, Demänovská Valley, cave exploration, cave topography

#### **Extreme values of discharge rates on Croatian karst rivers during 2014**

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Extreme values of discharge rates were recorded at numerous Croatian rivers during the year of 2014. as a direct result of two extremely wet years. Although karst areas have thick permeable bedrock with high retention capacity, the Gacka, Slunjčica, Korana and Bregana rivers had new maximal discharges that were recorded at the same day of September 13<sup>th</sup> 2014. Other karst rivers have also followed the trend of high discharge rates.

**Keywords:** extreme discharge rates, Croatia, karst, 2014

## Looking to the future: cave and karst conservation

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### Context and review of progress in conserving caves and karst

The concept of a national park was established in 1872 at Yellowstone. At an international level importance of global conservation was recognised through the UNESCO World Heritage Convention in 1972. To help ensure that geo-conservation values were not overlooked, UNESCO Geoparks were established in 2001.

There are now 25 World Heritage sites with important carbonate karsts, of which nine are in Europe. Important karst areas are also part of at least 29 other World Heritage properties established for other reasons.

### Gaps in coverage

Comparison of the global distribution of carbonate rocks with the location of World Heritage sites shows there to be deficiencies in the formal protection of karst in the Middle East and Central Asia, South America, Africa, central and western Australia, and Oceania.

There is also a total absence of protection of karst in evaporite rocks (not one WH site).

A review of the environmental distribution of protected sites also reveals there to be few World Heritage sites in arid and semi-arid locations, as well as relatively few in periglacial environments.

A major gap in coverage is the global type-site of karst: the Dinaric Karst. Although the region contains three world Heritage sites, two UNESCO MAB sites and one RAMSAR site. These have arisen by an ad hoc process, but ideally there needs to be a collected consideration of what to conserve, using a staged process similar to that followed successfully in the South China Karst.

### UNESCO Geoparks

Geoparks are areas where geological sites are part of a holistic concept of protection, education and sustainable development. They offer an important avenue for conservation by a process outside of the World Heritage Convention. A European Geopark Network and an Asian Geopark Network are already established. Some of the established Geoparks conserve karst and cave areas, and there is huge scope to make further conservation progress around the world by this process.

### What can the UIS do?

Take leadership by developing a conservation action plan for international cave and karst conservation.

Communicate formally with scientific academies of States where we wish to see progress made in the conservation of caves and karst, at the same time offering scientific advice to aid the process.

### Conclusions

There is limited scope for new cave and karst sites on the World Heritage list, but there is unfinished business that had previously received UNESCO support for the establishment of a Dinaric Karst World Heritage property. This needs to be revitalised with UIS playing a part.

There is considerable potential for cave and karst conservation as UNESCO Geoparks. The UIS can assist conservation by this process by developing a conservation action plan in which priority sites are identified and associated State Parties are formally notified.

**Microorganisms in the air of labyrinth hypogenic caves  
(e. g. Zoloushka Cave, Ukraine-Moldova)**

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The presentation presents the results of microclimatic and microbiological research carried in the large labyrinth Zoloushka Cave (Ukraine - Moldova). Microclimatic study were to determine the thermal, humidity and circulation characteristics of the cave microclimate. Microbiological studies aimed to determine the number of microorganisms (bacteria, fungi and actinomycetes) present in the air of the cave in two contrasting seasons, summer and winter. The rules of occurrence of microorganisms in temporal and spatial (within a cave) cross-sections and the relative role of external and internal (cave) factors in shaping of the microbiological "image" of cave air were established.

Keywords: microclimate, microbiology, microorganisms, Zoloushka Cave

**Understanding past climate changes from speleothems**  
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Speleothems have been used as a useful terrestrial proxy for paleoclimatic information due to several advantages such as their common occurrence, wide distribution, precise dating result, and continuous growth intervals for long periods of time as well high resolution records (even down to annual cycles!), compared to other paleoclimate archives (e.g., ice cores, pelagic sediments, tree rings, loess and lake sediments). Numerous results on global and local climate changes in the past have been revealed from all over the world. East Asian monsoon records have been one of the most interesting subjects for the past two decades because they have been considered to be connected to global climate system. The purposes of this lecture are to show basic paleoclimate from speleothems such as methods, proxies and interpretations, and also to show some case studies from textural and geochemical records of speleothems from South Korea to understand the evolutionary changes of East Asian monsoon system in northeast Asia.

More than 1,000 limestone caves are estimated to be extensively developed in South Korea. A potential to use soda straws as regional paleoclimate proxy was investigated. Monsoonal climatic variations can be detected from the soda straw in Seopdong Cave, which grew up to ca. 20 cm for five years (July, 1999 ~ July, 2004). Excess  $^{210}\text{Pb}$  variation coincides well with the amount of precipitation during its growth, and the values are high during rainy summers and low during dry winters. Carbon isotope contents are relatively more depleted from 2000 to 2001, and this was probably due to the smaller amount of precipitation during this interval. Two stalagmites from Gwaneum and Daeya caves revealed that carbon isotopic compositions indicate East Asian Summer monsoon intensities during MIS 5a, Eemian and Middle Holocene. Textural and geochemical investigation was carried out to delineate the paleoclimatic variations from the late Pleistocene stalagmites of the Eden cave. Based on U-series age dating, the stalagmite of Eden Cave started to grow from 537 ka BP and the growth ceased at 96 ka BP. Based on the frequency and density of growth laminae, the stalagmite shows five orders of cycles, and each cycle reflects various climatic changes with different periods of growth intervals. Three stalagmites of the Yongcheon and Dangcheomul lava tube caves in Jeju Island were investigated to delineate paleoclimatic history of the Jeju Island for the past 2,000 years. High resolution carbon isotopic variations clearly show the

period of the Current Warm Period (with global warming), Little Ice Age, Medieval Climate Anomaly, Dark Age Cold Period and Roman Warm Period. Detailed textural data combined with carbon isotope values clearly demonstrate the termination of the Little Ice Age and the transitional period from LIA to Current Warm Period. The data also coincides with the instrumental records of Northern Hemisphere temperature variation during the last 2,000 years. Studies on fine scale variations in the isotopic composition of speleothems along with age control promise a great potential for the reconstruction of climate and environmental changes during the geologic past. Also, it is emphasized here that textural data can provide invaluable information on paleoclimatic history in addition to geochemical data.

Keywords: speleothem, paleoclimate, stable isotope, East Asian monsoon, Korea

**The civilization traces of prehistoric cultural heritage: Rock art cave dwelling in Karst Region of Maros-Pangkep, South Sulawesi, Indonesia**

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Indonesia is rich in cultural resources scattered throughout its territory. One area that contains a lot of cultural resources is the Pangkep and Maros limestone mountains in South Sulawesi Province. In the mountains of limestone (karst) caves are found in the prehistoric times inhabited by humans. Selected cave as a place of living human beings is inseparable from the availability of natural resources found in the environment around the cave. In addition to shelter, the walls of the cave or rockshelter is used as a medium to express their experiences, struggles and hopes of the human life in the form of cave paintings (Stern, 1973 in Linda, 2005). The representation of cave rock art objects are related or influenced by the presence of fauna, environment social-ekonomi life especially food acquisition strategies and elements of religious life (Suprapta, 1996). In Indonesia, the rock arts were the result of human culture of the past and came from prehistoric times is known and developed from the Paleolithic period (period of hunting and gathering of food simple level) to the mesolitik (the hunting and gathering of food advanced) (Kosasih, 1983). According to H.R. Van Hekeren (1972 in Permana, 2008) most likely caves life in South Sulawesi took place from the mid or end of kala Pleistocene and after roughly 50,000 to 30,000 years BCE.

Keywords: rock art, prehistoric, cultural heritage, cave, karst

**The concept of a new interpretative exhibition at Postojnska jama**  
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Cave Postojnska jama is the biggest show cave in Slovenia and in Europe. Parts of the cave were known already in Paleolithic, one of the signatures on the cave walls is known from 13<sup>th</sup> century and its first scientific descriptions are known from 17<sup>th</sup> century.

Its worldwide fame was achieved through almost 200 years of intensive tourist development: guided tours since 1819, railway since 1872, permanent electric lighting since 1884 and another thing of great importance: despite its continuous use for the purposes of tourism the cave remains a natural attraction in excellent condition with over 500,000 visitors per year.

In 2012, new authorities decided to invest in an interpretation of the Postojnska jama cave story. Prior to that, Postojnska jama was a historically well-known show cave with a large number of visitors, including many famous ones, from all over the world, but without any permanent exhibition or interpretation of the cave.

It was decided to use science in partnership with Karst Research Institute ZRC SAZU to present the cave's natural and tourist developments as a tourism product, because of an ever-increasing challenge to find a competitive edge or a development that gives a point of difference and visibility in the present day as well.

The main idea was to present cave Postojnska jama in terms of its natural evolution and tourist development and its significance in space and time with the use of innovative technologies and interpretation. Management and science were combined to produce a display that it is as scientifically accurate as the current knowledge allows, but is nevertheless exciting for visitors of all ages and educational backgrounds.

There were many great stories to tell, which will help visitors understand the wealth of Postojnska jama cave: its geological and Classical karst background, speleogenesis, growth of various speleothems, the importance of the first cave fauna in the world discovered in it and consequently the development of biospeleology as a science, as well as long-term and sustainable development for tourism.

Evidence for all these facts are on display in the new gallery; individual themes are presented separately: the karst surface, the cave, nonliving and living cave contents, karst and cave pollution, the great discovery of inner cave parts, cave explorations, preparations for guided tours, lighting, transport, the underground post office, management, advertising, events, arts, etc.

The big challenge in setting up the exhibition was how to provide sufficient information for average visitors, without over-simplifying or giving visitors an information overload. A multi-level exhibition has been set up, which ensures that on the first level the main subjects and significant terms are always well defined and explained and that visitors can get all additional information individually by exploring the sub-levels.

It was crucial to keep the focus on the presentation of the cave and to make sure that individual stories related to the overall topic were not explained in too much detail, but to nevertheless emphasize enough of everything that has made cave Postojnska jama unique among other show caves of the world.

I hope that the new exhibition will well present the cave Postojnska jama, which is still the biggest attraction by itself.

Keywords: exhibition, scenario, nature, tourist development, tourist cave, Postojnska jama

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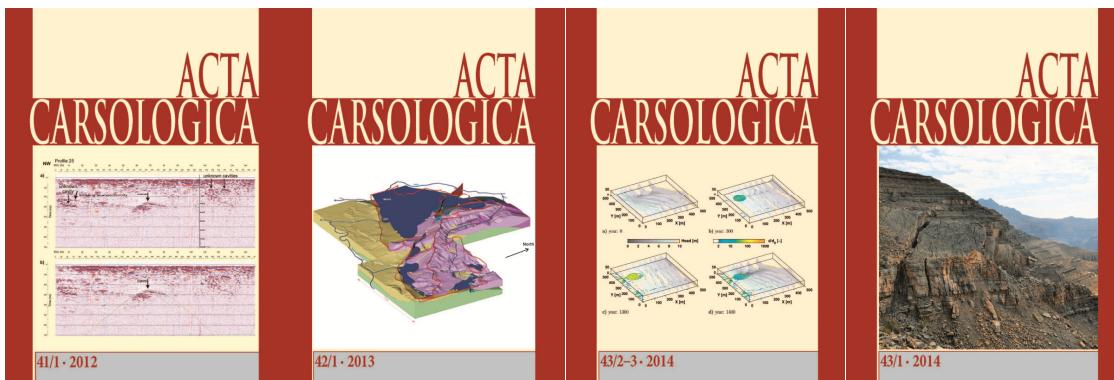
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