Issued for the purpose of 17th Congress of the International Union of Speleology, Sydney 2017

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of the Slovak Speleological Society

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Photo: Ján Šmoll

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Foreword

The International Congress of Speleology is an important event not only for the participating speleologists, but also for those who are awaiting news about underground explorations which are published after the Congress. Australian underground is almost unknown for Slovak cavers, however, the problems which cave explorers face are perhaps the same everywhere.

We all ask questions such as 'How to find a continuation of existing passages?' or 'Which secrets are hidden inside?'. In Australia as well as in the Europe caves are one of the last places on our planet which are not penetrated by our civilisation and still remain unconquered. There is no cell phone signal or any means of transport which could carry us through rugged corridors. Every visit in a wild cave allows people to touch the vast space of original, real world, unspoilt by the modern age. Present is an authentic microcosm shaped only by nature. The underground environment brings to speleologists tough, but meaningful obstacles, similar to those James Cook was facing on his voyage to Australia.

Cavers explore and learn about the underground spaces where immense natural and cultural treasures are hidden. Many discoveries which may be of a great significance for scientific research are still waiting for us.

On the other hand, even the most careful research causes irreversible changes in caves. Biotope, geotope or even archaeological findings can be easily damaged and in Australia you surely share the same worries.

How far can we go in speleological research? Is it justifiable to open new corridors at the expense of devastation of the original caves? Where is the threshold of what is acceptable during underground exploration? Should we not sometimes give up our ambitions and leave the questions unanswered for the next generations? Slovak cavers hope that the discussions during the Congress will also touch these questions.

Slovakia has a total area of 49 036 km² out of which 2 700 km² correspond to Karst regions mainly consisting of quaternary limestone and dolomite. In the central register of Slovak caves, maintained in accordance with the Nature Conservation Act by the Slovak Museum of Nature Protection and Speleology (founded in 1930 as a speleology institution), there are 7,283 caves and abysses with total length of approximately 500 km.

Karst areas in Slovakia are researched predominantly by members of the Slovak Speleological Society, who are organized in smaller local units covering the whole area of Slovakia. Our cavers collaborate extraordinarily well on underground exploration with Czech, Polish and Hungarian colleagues, with whom we share borders as well as karst areas.

The history of the Slovak Speleological Society dates back to 1943 when it was founded as a section of Society of Slovak Hikers. As a founding member of The International Union of Speleology, Slovak Speleological Society can offer to the world of speleology not only natural beauties, but also scientific knowledge and the experience of our members from caves exploration, which has been developing in our region ever since the Middle Ages. As early as the 19th century, extraordinary caves formed by burnt and decayed trees previously engulfed in lava were explored and documented.

Nowadays, more than 500,000 tourists a year visit one of the 20 caves in Slovakia which are open to the public. A significant number of these caves is operated by the Slovak Caves Administration, managed by the government, with four of the caves being administered by members of the Slovak Speleological Society.

I wish all participants of the Speleological Congress in Australia to enjoy a pleasant stay and to gain a lot of new information and inspiration.

Peter Holúbek chairman of the SSS

List of the longest caves of Slovakia (May 1, 2017)

Ján Tencer

1. DEMÄNOVÁ CAVE SYSTEM
Low Tatra Mts., Demänovské Hills
Length: **41,463 m**
Depth: 196 m

2. MESAČNÝ TIEŇ CAVE
Tatra Mts., High Tatra
Length: **31,840 m**
Depth: 451 m

3. STRATENSKÁ CAVE SYSTEM
Spiš-Gemer Ore-mountains, Slovak Paradise
Length: **23,670 m**
Depth: 194 m

4. JASKYŇA MŔTVYCH NETOPIEROV (Cave of Dead Bats)
Low Tatra Mts., Ďumbier
Length: **21,042 m**
Depth: 324 m

5. ŠTEFANOVÁ CAVE
Low Tatra Mts., Demänovské Hills
Length: **16,720 m**
Depth: 123 m

6. JAVORINKA CAVE
Tatra Mts., High Tatra
Length: **11,936 m**
Depth: 480 m

7. JASKYŇA ZLOMÍSK CAVE
Low Tatra Mts., Demänovské Hills
Length: **11,248 m**
Depth: 148 m

8. SKALISTÝ POTOK CAVE
Slovak Karst, Jasovská Plateau
Length: **8,215 m**
Depth: 376 m

9. HIPMAN'S CAVES
Low Tatra Mts., Demänovské Hills
Length: **7,567 m**
Depth: 499 m

10. DOMICA – ČERTOVA DIERA CAVE SYSTEM (a part of Domica – Baradla Cave System, 25,868 m long)
Slovak Karst, Silická Plateau
Length: **6,603 m**
Depth: 70 m

Jaskyňa zlomísk Cave. Photo: L. Vlček

List of the deepest caves of Slovakia (May 1, 2017)

Ján Tencer

1. HIPMAN'S CAVES
Low Tatra Mts., Demänovské Hills
Length: 7,554 m
Depth: **499 m**

2. JAVORINKA CAVE
Tatra Mts., High Tatra
Length: 11,936 m
Depth: **480 m**

3. MESAČNÝ TIEŇ CAVE
Tatra Mts., High Tatra
Length: 31,840 m
Depth: **451 m**

4. SKALISTÝ POTOK CAVE
Slovak Karst, Jasovská Plateau
Length: 8,215 m
Depth: **376 m**

5. JASKYŇA MŔTVYCH NETOPIEROV (Cave of Dead Bats)
Low Tatra Mts., Ďumbier
Length: 21,042 m
Depth: **324 m**

6. JAVOROVÁ ABYSS
Low Tatra Mts., Demänovské Hills
Length: 2,322 m
Depth: **313 m**

7. JASKYŇA V ZÁSKOČÍ – Na Predných Cave System
Low Tatra Mts., Demänovské Hills
Length: 5,034 m
Depth: **284 m**

8. ČIERNOHORSKÝ CAVE SYSTEM
Tatra Mts., High Tatra
Length: 2,360 m
Depth: **232 m**

9. KUNIA ABYSS
Slovak Karst, Jasovská Plateau
Length: 933 m
Depth: **203 m**

10. TRISTARSKÁ ABYSS
Tatra Mts., Belianske Tatra
Length: 600 m
Depth: **201 m**

Mesačný tieň Cave. Photo: I. Pap

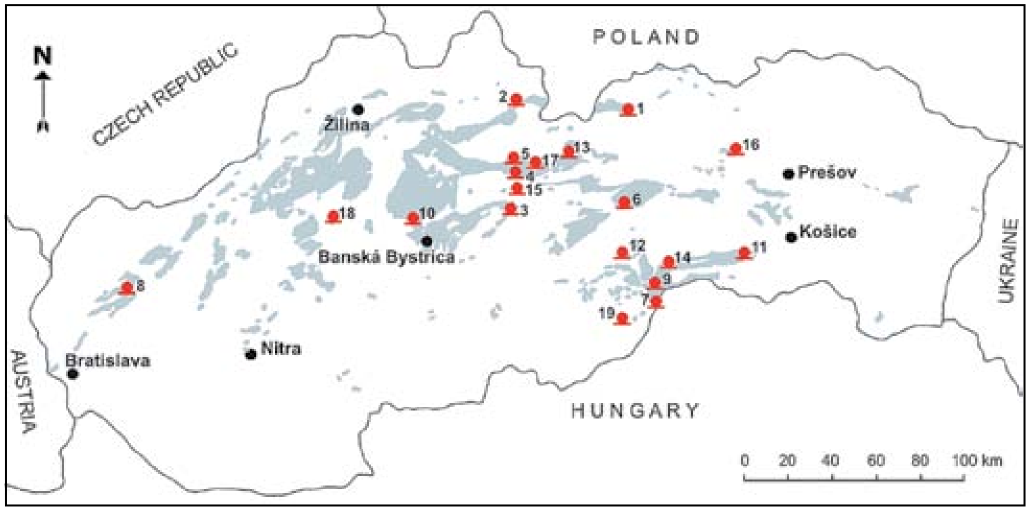
SHOW CAVES OF SLOVAKIA

Pavel Bella – Lukáš Vlček

Slovak Caves Administration– Slovak Speleological Society

Today, around 7,200 caves are registered in Slovakia, of which only 40 reach a length of about 1 km. The others are significantly shorter. All the caves were discovered and documented by volunteer cavers. Each cave is a property of the state and protected by the Nature and Landscape Protection Act. The administrative organization of all caves in Slovakia is the governmental organization State Nature Protection of the Slovak Republic – Slovak Caves Administration (SCA). The SCA also manages 13 show caves and oversees the others. 13 show caves are open to the public in the classical way: Belianska Cave in Belianske Tatry, Brestovská Cave in Western Tatras, Bystrianska Cave in Hron Basin, Demänovská Ice Cave and Demänovská Cave of Liberty in Low Tatra Mts. (Both of them are parts of the Demänová Cave System), Dobšinská Ice Cave in Slovak Raj Mts., Domica Cave in Slovak Karst, Driny Cave in Mala Carpathians, Gombasecká Cave in Slovak Karst, Harmanecká Cave in Veľká Fatra Mts. Jasovská Cave in Slovak Karst, Ochtinská Aragonite Cave in Revúcka Highland and Važecká Cave in Liptov basin, Brestovská Cave is the newest cave show of Slovakia, it was opened to the public at the end of 2016.

The Bojnická Hradná Cave is accessible as a part of a sightseeing tour of the Bojnice Castle. Another five caves are in the hands of private owners who rent them from the government. These are: Jaskyňa mŕtvych netopierov (Cave of Dead Bats) and Malá Stanišovská Cave, both in the Low Tatra Mts., Krásnohorská Cave in the Slovak Karst, the Bad Cave in Branisko Mts, and one speleodivers' locality – a flooded shaft Morské Oko (the Sea Eye Cave) in Rimava basin. The thermal cave Parenica in the Štiavnické vrchy Mts. is open to the public within the spa treatment area, and at the entrance of the Prepoštská Cave near Bojnice Castle there is an archaeological site with an exhibition open to the public. A few smaller caves are open for visitors only for a few days in the year, for special occasions, e.g. Pružinská Dúpna Cave in Strážovské Mts.



Show caves in Slovakia: 1 – Belianska jaskyňa Cave, 2 – Brestovská jaskyňa Cave, 3 – Bystrianska jaskyňa Cave, 4 – Demänovská jaskyňa slobody Cave (Demänovská Cave of Liberty), 5 – Demänovská ľadová jaskyňa Cave (Demänovská Ice Cave), 6 – Dobšinská ľadová jaskyňa Cave (Dobšinská Ice Cave), 7 – Domica Cave, 8 – Driny Cave, 9 – Gombasecká jaskyňa Cave, 10 – Harmanecká jaskyňa Cave, 11 – Jasovská jaskyňa Cave, 12 – Ochtinská aragonitová jaskyňa Cave (Ochtinská Aragonite Cave), 13 – Važecká jaskyňa Cave, 14 – Krásnohorská jaskyňa Cave, 15 – Jaskyňa mŕtvych netopierov Cave (Cave of Dead Bats), 16 – Zlá diera Cave (Bad Hole), 17 – Malá Stanišovská jaskyňa Cave (Small Stanišovská Cave), 18 – Bojnická hradná jaskyňa (Bojnice Castle Cave), 19 – Morské oko Abyss (Sea Eye)

BRESTOVSKÁ JASKYŇA – ANOTHER SHOW CAVE IN SLOVAKIA

Pavel Bella – Lukáš Vlček – Dagmar Haviarová – Zuzana Višňovská – Ján Zelinka

Slovak Caves Administration– Slovak Speleological Society

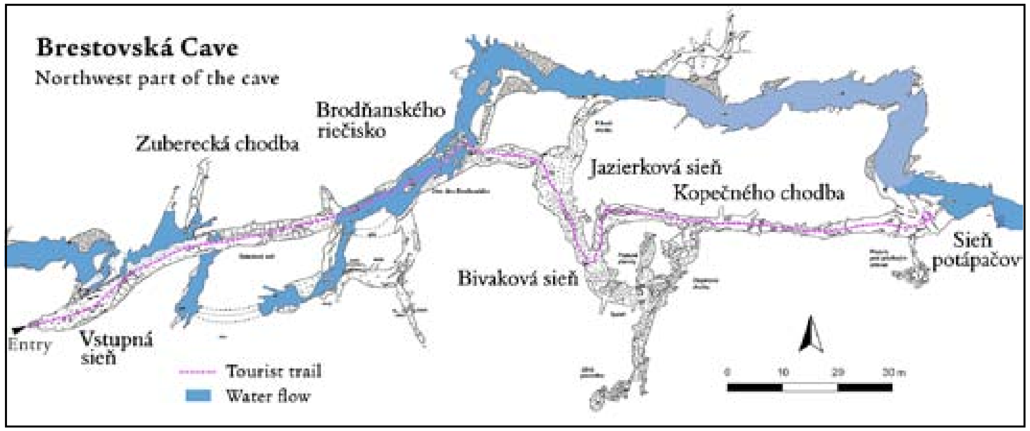
The Brestovská Cave is one of the most remarkable natural sights of the Western Tatras (Northern Slovakia). It is located near the village of Zuberec, on the northwestern foothills of the Western Tatras, on the left side of the mouth of the valley of Studený potok Brook. The cave entrance is located at an altitude of 867 m a.s.l.

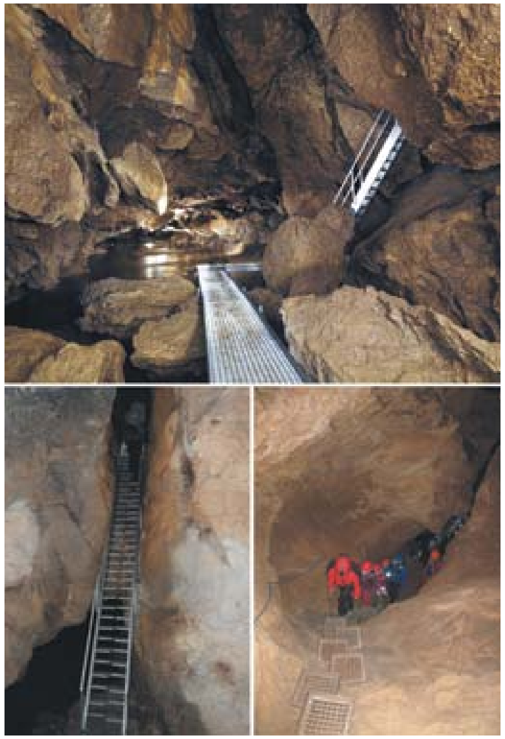
The Brestovská Cave was created by an underground water flow in the Triassic light--colored Ramsaus dolomite with inserts of darker Gutenstein-type limestone, predominantly along tectonic faults. Dark gray Reiflin limestone are also visible locally. The ceiling in the highest part of the cave is controlled by the contact of Triassic carbonates with Paleogene dolomite and limestone-dolomite breccias (the base of the Borovian Formation). The cave was formed in the Middle and Late Quaternary in relation to the incision of the valley of Studený potok Brook.

The cave has been surveyed to a length of 1,890 m. An underground stream flows through its bottom part and then appears on the surface, west of the cave, by the Brestovská Resurgence (Resurgence of the Števkovský Brook). It originates from the waters of the Studený potok brook and its tributary on the side of Volariská Valley, which flow from the main mountain ridge of the Western Tatras. On the permeable limestone and dolomites the waters are lost to the underground through the cracks under the aggraded river bed and open sinks. Granite pebble and sand, deposited on the underground river bed, were transported into the cave from the non-karstic area of the main mountain ridge of the Western Tatras. The eastern part of the cave behind the siphon, which leads under the side Volariská Valley, is accessible only for divers.

The passages of the upper floor are 5 to 10 m above the underground stream. The sculpturing of cave passages by running water in the phreatic zone is evidenced by numerous ceiling pockets, rock holes and windows. With the incision of the river bed of Studený potok Brook on the surface, the groundwater level in the cave declined. The precipitation of dripstone and flowstone from seeping rain-fall waters was started in dry upper parts. The upper parts of the cave were occasionally flooded, probably at the time of the melting of mountain glaciers from the last glacial, which occured in the upper part of the valley of Studený potok Brook.

A series of sinkholes have been created above the underground stream between the Brestovská Cave and the resurgence. These funnel-shaped depressions formed after the





Accessible parts of the Brestovská cave.
Photo: P. Bella, P. Gažík

deposition of a large glacifluvial cone from glacial sediments redeponed from the former glaciated part of the valley.

Cave passages and halls are decorated by small stalactites and stalagmites, and flowstones. Microcrystalline forms of aragonite were also found in the cave. The average annual air temperature in the entrance hall and in the passages along the underground stream is 4.9 °C, and at the upper floor up to 5.4 °C.

Diverse and rich communities of aquatic invertebrates inhabit the underground riverbed of Brestovská Cave as well as the adjacent resurgence. *Diacyclops languidoides* (Copepoda), *Niphargus tatrensis* (Amphipoda) and *Bathynella natans* (Syncarida) are typical relic aquatic species found in caves in the Tatras. Of the terrestrial invertebrates, the most remarkable are *Mesoniscus graniger* and *Ischiposalis manicata,* which are Carpathian endemites. *Protaphorus janosik* is considered to be a glacial relic and endemic to the Western Carpathians. Altogether, nine bat species have been found to hibernate in the passages of Brestovská Cave and in the vicinity of its entrance. Of these, *Myotis myotis* is the most common. It is worth mentioning that the Brestovská Cave is one of the northernmost hibernacula of *Rhinolophus ferrumequinum* both in Slovakia and Europe.

The first mention of Stefkówka cave, (today's Brestovská Cave), and the nearby resurgence is from 1886 by the Polish botanist and Tatra explorer T. Chałubiński. In 1887, the pioneer of Tatra caving J. G. Pawlikowski wrote about his considerations of the cave's accessibility for tourists. In the years 1923 – 1925, within the Club of Czechoslovak Tourists Cave, the cave was investigated by captain Kopečný and a group of soldiers from the Dolný Kubín military crew. After the founding of the Slovak Speleological Society in 1949, J. Brodňanský, the founder of organized caving in Orava, was involved in the cave exploration. The first speleodiver action in the Brestovská Cave took place in 1968. In 1979, the divers J. Kucharovič and V. Sláčik overcame the siphon and discovered new parts of the cave. In 1981, these cave parts were measured by Z. Hochmuth, J. Kucharovič, P. Marek and V. Sláčik to the length of ca 900 m. Up to now, speleodivers have overcome seven siphons against the stream to a total length of 220 m. During the last decades, speleological research of the cave has been performed mainly by cavers from the Orava speleological group. Speleodivers continue to explore the connection of the resurgence with the cave.

The first intention to develop the Brestovská Cave for tourism purposes was included in the strategy of the development of Slovak caves in the years 1971 – 1985. The project for the tourist development of the cave was elaborated based on the results of the complex cave research realized by the Slovak Caves Administration in 2006 – 2007. Technical works in the cave started in 2015. The cave was open to the public on 31 August 2016. The tourist trail is 434 m long. The cave is open from 2 January to 31 December, each day except Monday and the off-seasonal technical break. As the cave is not lit electrically, every visitor must have a helmet and headlamp provided by the operator – State Nature Conservancy of the Slovak Republic, Slovak Caves Administration.

LASER SCANNING AND DIGITAL 3D MODELING OF THE UNESCO HERITAGE CAVE – DOMICA

Zdenko Hochmuth – Michal Gallay – Ján Kaňuk – Jaroslav Hofierka – Vladimír Sedlák – Alena Gessert – Dušan Barabas – Jozef Šupinský – Ján Šašak

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Introduction

Mapping and modelling the complicated geometry of caves is an extremely challenging task that has traditionally been undertaken by tacheometric surveying with a mining compass / clinometer and laser measure or with a total station. These methods are excellent for capturing the general shape of a cave system but they are not suitable for high-speed, high-resolution mapping of complex surfaces found in this environment. Terrestrial laser scanning (TLS) technology is capable of acquiring millions of points represented by 3-D coordinates, at very high spatial densities on complex multifaceted surfaces within minutes (Fig. 1A). In the last few years, advances in measurement speed, reduction in size / cost and increased portability of this technology has revolutionised the collection of 3-D data.

Fig. 1. The Domica cave was mapped with a light weight FARO Focus 3D scanner even in narrow passages (A). Some parts of the cave were not accessible for TLS and therefore they were remapped with traditional mine compass/inclinometer (B) or laser distance meter on a tripod (C) to correct and extend the old surveys from 1950 – 60s (B).

After four years of research (2013 – 2017) within the nationally funded scientific project SPATIAL3D (spatial3d.science.upjs.sk), we present results of highly detailed mapping and monitoring of a precious area of the Domica cave in Slovak Karst (Fig. 2). The cave is an UNESCO Natural World Heritage site and is part of the largest karst region in the West Carpathians. The total length

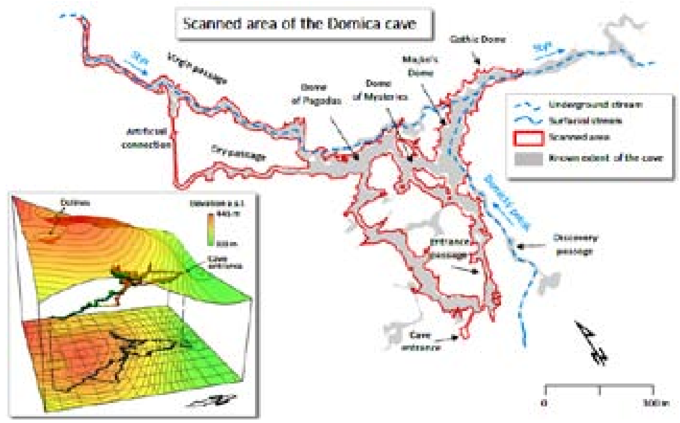

Fig. 2. The part of the Domica show cave scanned by terrestrial laser scanning and perspective 3D view of the cave models with the digital model of the above terrain. The cave entrance coordinates in WGS84: 48.477806° N, 20.469927° E, 339 m a. s. l. The figure is adopted from Gallay et al. (2016).

of the cave system is circa 5,400 metres, however, it does continue into the Aggtelek Karst region in Hungary as the Baradla cave with a combined length of 26,065 metres (Caverbob, 2016). The Domica cave was formed by corrosive-erosive processes caused by surface fluvial water and temporary streams which sank underground at the contact of the Middle Triassic white limestones and the Pontian fluvial-lacustrine gravel-sand-clay sediments (Bella, 2001).

Research methods and data

The aim of the SPATIAL3D project supervised by prof. Jaroslav Hofierka was in generating a complex and highly detailed 3D model of a karst landscape where surficial and subsurface processes strongly interact. The purpose of the model was in dynamic modelling of environmental phenomena such as infiltration of water, floods, air temperature in high resolution in a geographic information system (GIS). For this reason, a wider area of Domica was flown with an airborne lidar (67 km^2) and 1,600 metres of the Domica cave system were mapped by terrestrial laser scanning (TLS) (Fig. 2).

The collected ALS point cloud for the terrain data contains almost 2 billion of measured 3D point coordinates and the cave lidar dataset comprises over 11.9 billion of 3D points capturing fine details of the cave morphology at a millimetre scale (Gallay, et al., 2015; Hofierka et al., 2017a). The cave was surveyed with TLS in 5 days from 328 individual scanning positions. Semi-automatic registration of these scans was carried out using reference spheres placed in each scene and this method archived an overall registration error of 4 – 5 mm (1σ). Transformation of the final registered point cloud from its local coordinate system to the national cartographic system, with an accuracy of 12 mm, was achieved by surveying four chequer board targets captured in the terrestrial laser scan survey with a GNSS receiver and using the stabilized control points from 1967 still preserved in the cave (Gallay et al., 2015). Some parts of the cave between Čertova diera and Domica show cave were surveyed with traditional methods (Fig. 1B) and also laser distance meter (Šupinský and Hochmuth, 2016) (Fig. 1C). By this means, old surveys from 1950s – 60s were made more precise and new corridors were also discovered (Hochmuth, 2016). The final TLS point cloud was used to derive a 3D surface model (Fig. 3) allowing for volumetric and morphometric analysis of the cave surface.

Results

Processing and modelling of the massive ALS and TLS data sets required distributed computing for which we modified the existing tools such as DEM surface interpolation, water flow

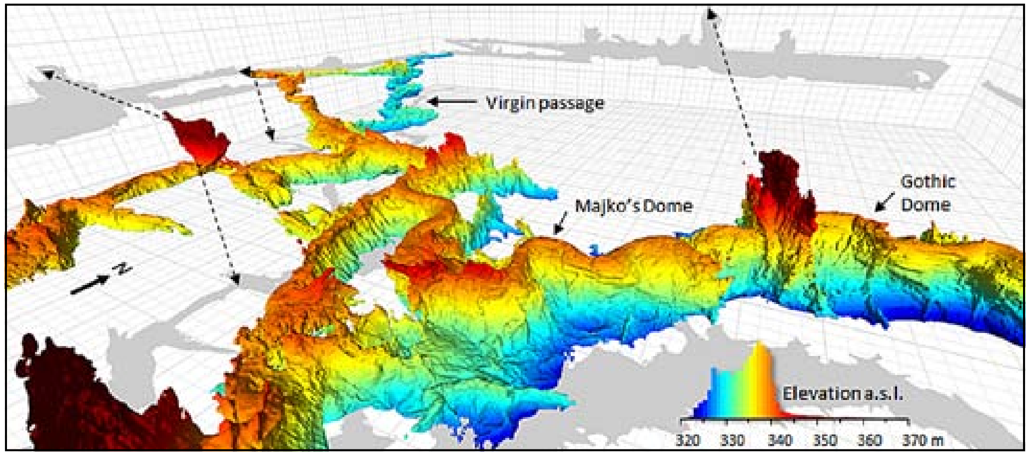

Fig. 3. Domica cave 3D surface model viewed in 3D perspective showing the surface from outside. The view well depicits the morphology of a meandering ceiling channel. The model is coloured by the value of altitude above mean sea level which distribution is shown by the histogram. The 3-D geometry is orthogonally projected on the XY, YZ, and XZ planes. The size of the major and minor cells in the background grid is 20 and 5 m along all three axes, respectively. Note the flat, horizontal ceiling levels projected on the vertical XZ and YZ planes. The figure is modified after Gallay et al. (2016).

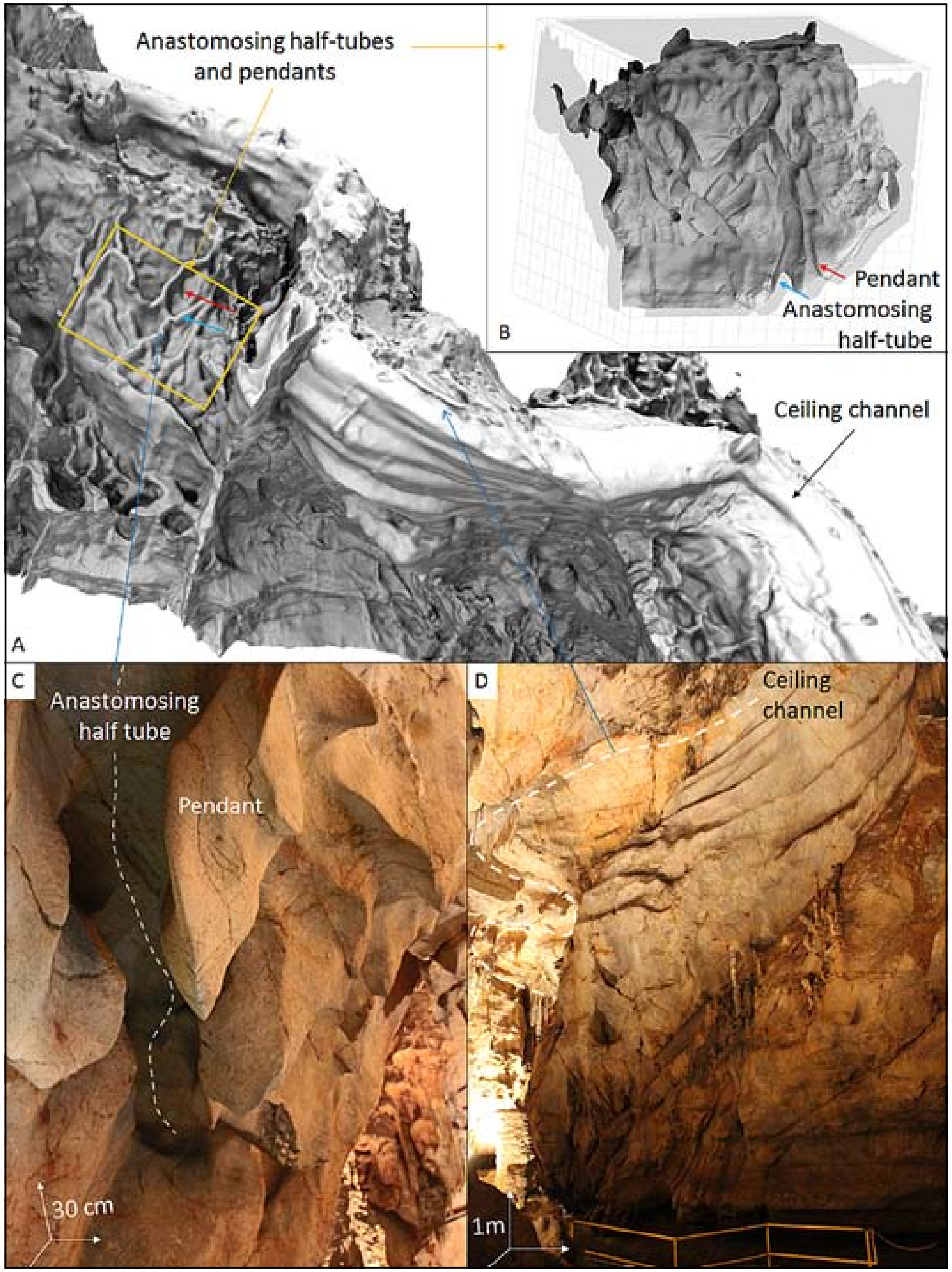

Fig. 4. The Gothic Dome in Domica displayed as a 3D cave surface model viewed from a 3D perspective from outside (A) and from inside in detail (B). The model is rendered with grey tones of ambient occlusion which enhances perception of the cave surface morphology including ceiling channels, pendants and anastomosing half tubes associated with the phreatic regime. The forms are shown in real in photographs (C) and (D). Presence of the speleoforms in the ceiling and walls of the Gothic Dome indicate paragenetic (antigravitational) development. The highest parts of the channels can be situated as high as 16 m (C, D) from the cave floor. The figure is adopted from Gallay et al. (2016).

simulation or solar irradiation (Hofierka et al., 2017c). The new tools are to be implemented in the open-source GRASS GIS (Neteler and Mitasova, 2008). These very detailed ALS and TLS data sets enabled studying cave morphology across a multitude of scales (cm to km), including the interaction of the land surface with the cave below and the related geomorphological and environmental processes (Gallay et al., 2016; Hofierka et al., 2017b, 2017d).

Domica has a complex genesis during which several phases of corrosion, accumulation and erosion altered it. In some parts the cave evolution resulted in formation of ceiling channels, anastomosing half tubes, or speleothems organised vertically in different levels. Studying such complex environments traditionally requires tedious mapping, however, this is being replaced with terrestrial laser scanning technology. Laser scanning overcomes the problem of reaching high ceilings providing new options to map underground landscapes with unprecedented level of detail and accuracy (Fig. 4A, 4B). In Gallay et al. (2016), we adopted traditional geomorphometric methods in a unique manner and also new methods used in 3D computer graphics to better understand the palaeohydrography exploiting the benefits of high resolution cave mapping and 3-D modelling of the Domica. By this means, we were able to study the hardly accessible speleoforms to support the theory of paragenetic (antigravitational) formation of Domica (Fig. 4C, 4D). Continuous monitoring of water depth and air and water temperature on several profiles in the Domica cave by automated data loggers coupled with meteorological monitoring around the cave enabled linking the overland flow with underground hydrology (Hochmuth and Gessert 2016). The results will be analysed in the future to explain the response of the underground water stream of Styx which drains the cave to the overland flow around the cave. Several times in recent years, major rainfall and snow thaw events have caused flooding in the cave (Fig. 5) and periods of drought have also caused the disappearance of Styx from the cave.

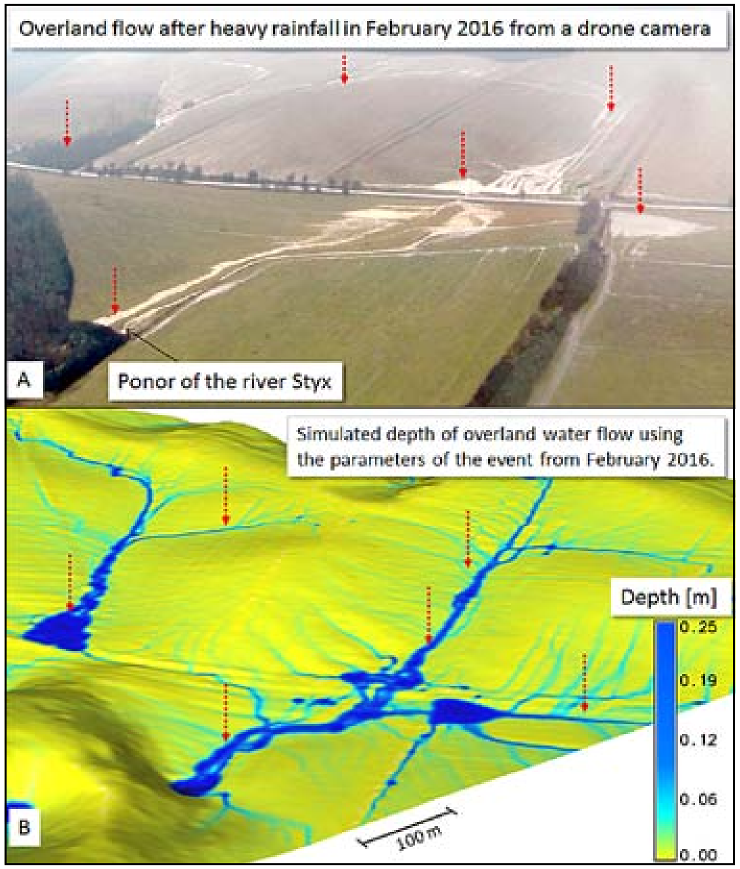

Fig. 5. Heavy rainfall in February 2016 caused major flooding in the Domica show cave (A). The event was simulated (B) using the parallelized version of the r.sim.water module (Hofierka et al. 2017c) which enabled calculation of the water volume entering the cave and comparison with the records of hydrological monitoring (Hochmuth and Gesserrt, 2016).

Conclusions

The results of the presented research demonstrate that the acquired airborne and terrestrial

lidar data sets open new dimension for speleology and karst geomorphology by providing highly detailed and accurate 3D point data. 3D point clouds themselves are useful for basic analysis such as measuring distances, creating profiles, visualization. Meshed 3D surface models bring more benefits when analyses of cave morphology or volumes are the main concern. Also the meshed 3D cave surface models or raster-based digital elevation models are useful for simulating processes such as water flow. Integrating the georeferenced 3D models into a GIS database enabled us exploration of complex spatial interactions between landscape components and the cave system. The complexity of karst landscape can be studied across multitudes of scale in future research. For example, one can infer cave genesis from parametrizing detailed morphology of speleothems and large-scale forms such as anastomosing ceiling channels. The simplified cave 3D models are available via a web-interface of SPATIAL3D (2016).

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DOMICA-BARADLA CAVE SYSTEM ON THE SLOVAK – HUNGARIAN BORDER

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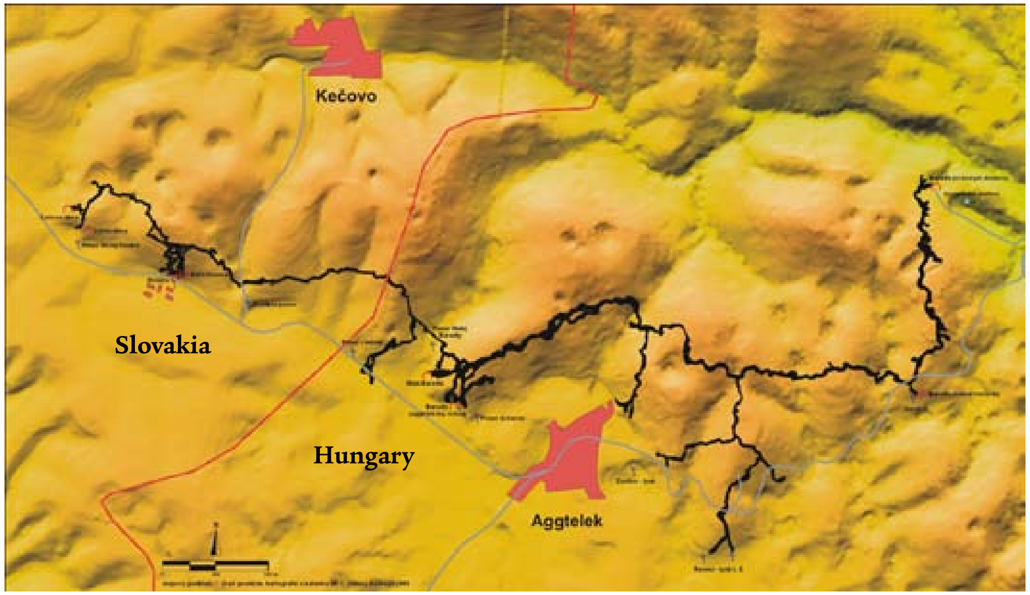
New investigations were made in the Domica-Baradla Cave system in 2013 – 2014. The new researches were oriented mainly to the tectonic and geomorphological development of the cave system and to the acquirement of biological and microbiological knowledge of cave life. The Domica-Baradla Cave system traverses from Slovakia to Hungary, and in both states belongs to the most significant caves. The results of these researches were published in the monography (Ľ. Gaál and P. Gruber, eds., 2014, Jósvafő, 512 pages).



An overview of the Domica-Baradla cave system (black line)

The Domica-Baradla Cave system cuts through almost the whole bed sequence of the Triassic age from East to West. Near to the eastern entrance in Hungary, the Lower Triassic marly shale is found in a little tectonic wedge. In the underlying shale, there are uncovered beds of dark grey Gutenstein limestone, dolomite, and a mass of light Steinalm limestone. The dominant part of the cave system is developed in light grey Wetterstein limestone, which sporadically includes fossils such as ammonites, crinoids and green algae. These limestones are chemically pure and considerably karstified. The cave system was affected by the fault system oriented NE–SW and NW–SE, but in Domica Cave the fault system markedly appears in the direction of WNW–ESE. These tectonic faults controlled the main drainage channels of the cave system.

Three development levels are known in the cave system. The oldest was developed in the Pliocene period about 3 – 4 mil. years ago, which possibly correlates with the large Pliocene pediment preserved on both sides of the Jósva River valley in Hungary. The Quaternary development of the cave system was markedly influenced by uplifts during the Pleistocene age, with amplitude of more than 60 m. The medium level was probably formed at this time. The erosional poten-

Flowston den in the Domica Cave. Photo: P. Staník

tial of the underground stream named Styx and its lateral allochtonous branches were certainly influenced by quartz gravels of the Pliocene period cover near the cave system, however, the corrosive potential of the underground stream also increased, mainly in the Pleistocene cold period when the water kept its ability to chemically dissolve for a longer time. Stagnation took place in the Middle Pleistocene for a while after the distinct deepening of the cave riverbed and during relative tectonic calmness. The main riverbed was widening at the sides. Sporadic vegetation during glacial times could not prevent the erosion, therefore gravels and sands from the Pliocene cover of the accumulation platform were washed down to the underground spaces, which were filled up to the roof. This caused paragenetic modelling of spaces, with the formation of ceiling channels. Underground spaces were emptied again only after the new uplift of the territory. Deepening water flow abandoned the old channel, and by cutting deeper, formed a new vadose passage. The formation of the lower level of the cave began. The presently known riverbed was probably coarsely formed in the Middle Pleistocene Age. Ponors were also functioning on the accumulation platform, with side branches such as the branches from the Smradľavé Lake, Domický Brook, from the Demikov Ponor, and on the Hungarian side, the Csernai branch from the Csernai Ponor, Rubikon branch from Kis-Baradla Ponor, and the main entrance to Baradla with the branch of Acheron, etc. These new ponors already enabled the entrance of larger amounts of torrential waters into cave spaces.

The age of the main part of the rich cave speleothems is calculated as 100 000 – 130 000 years.

The youngest third level of the cave system is known as Long Lower Cave (in Hungarian *Hosszú-alsó-barlang*) with the depth of 40 m under the present riverbed of Baradla Cave. The lower caves are linked up by epiphreatic and vadose zones, connecting ducts that sharply descend or run vertically along the main branch. The cave system was filled by collapses resulting in autochthonous processes, in places where there was originally great space. Such events are rather typical in the Baradla.

During these researches, several new cave species of invertebrates were discovered in the cave system. The overall number of determined species increased to 500. The cave system is locus typicus for numerous rare species like *Mesoniscus graniger*, *Duvalius hungaricus*, *Niphargus aggtelekiensis* and *Pygmarrhopalites slovacicus* Also of significant value is the worm species *Helodrilus mozsaryorum*, which lives constantly in water covered mud and has been found only in Baradla's Short Lower cave. The cave system represents important biotope for 16 species of bats; dominant is the Mediterranean horseshoe bat (*Rhinolophus euryale*), which forms colonies of 1000 – 2000 units.

Underground river of the Domica – Baradla Cave System. Photo: P. Staník

The Domica-Baradla cave system is an important part of the Slovak--Aggtelek Karst caves, which were listed as UNESCO World Heritage sites in 1995. Currently, 1184 caves are known in the Slovak Karst, and 280 caves are known in the Aggtelek Karst. The most prevalent are fluviokarstic (flowing water origin) caves such as Krásnohorská Cave, Hrušovská Cave, Gombasecká Cave, Kossuth Cave and Béke Cave. There are also vertical corrosion shafts in this karst area, which reach to 100 – 200 m deep. This can be well observed in the Almási, Szabó-pallag or Vecsembükk shafts in Hungary, as well as in the Malá Žomboj, Zvonivá jama and Obrovská Shaft in Slovakia.

Less frequent are also phreatic-corrosion caves (Ochtinská Aragonitová Cave) as well as the fault or crevasse type of caves. The World Heritage caves are extraordinarily rich with various types of speleothems. The Domica-Baradla cave system belongs to the richest occurrence of cave drums, which evolved through the hydrostatic pressure of water, some of which grow upwards from their base as well.

In more than 30 of the Slovak and Aggtelek Karst caves, the presence of prehistoric man has been detected. These findings point to at least 35,000 years of prehistoric culture.

NEWLY DISCOVERED PASSAGES IN THE GOMBASECKÁ CAVE

Tomáš Suchý – Ľuboš Suchý – Jozef Hetesi – Miroslav Šichula

Arachnos Slovenský kras

Introduction

Slovak Karst, part of the inner Western Carpathians, lies at the south-eastern border of the Slovak Republic. In 2002, because of this area's valuable natural heritage, it was classified as a National Park. Over 1300 caves and abysses are hidden beneath its surface, while visitors can admire beauties of nature in three of them. The attention of cavers is focused on undiscovered places, which this territory still offers.

Gombasecká Cave is one of the most important caves of the Slovak Karst national park. It is known mostly for the occurrence of thin straw stalactites. The cave was discovered on November 21 1951 by volunteer cavers – members of the Slovak Speleogical Society (SSS). In 1955, 285 m out of 1525 m were opened to the public. The cave is also used for speleotherapy as a sanatorium, focused on airway diseases. In June 2016, volunteer speleologists discovered new underground spaces, and they revealed beautiful speleothem passage fills.

The hydrological system of Gombasecká Cave and Silická Ľadnica Cave

The Gombasecká cave and Silická ľadnica (ice) cave are parts of the Silica-Gombasek underground hydrological system. Both caves are separated by, to date, an unknown section of the Black Brook.

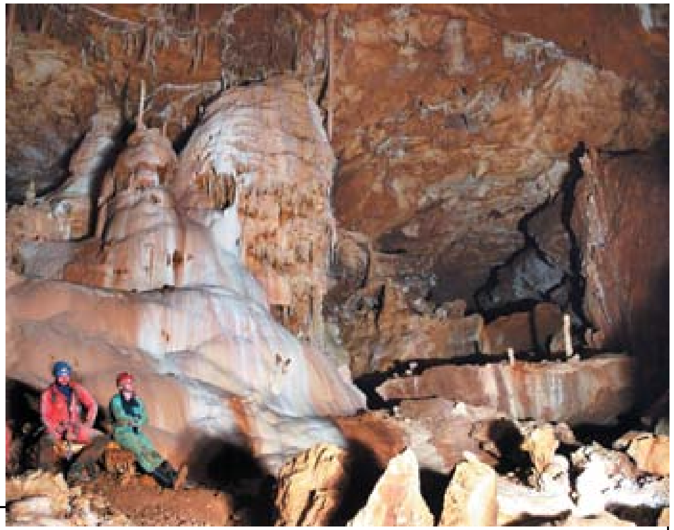
Silická ľadnica cave lies in the Silická Plateau at an elevation of 503 m. It is one of the most important natural phenomena in the Slovak Karst, because the glaciation at the entrance persists throughout the year. A faint flow (few $l.s^{-1}$) of the Black Brook emerges in the huge spaces of the cave; the hydrological connection with Gombasecká Cave was confirmed using the water color experiment. The huge spaces are probably remnants of water flow in the paleolithic age.

The first cavers entered the Gombasecká Cave through the Black water spring, which lies on the edge of the Silická plateau at an elevation of 250 m. The members of SSS discov-

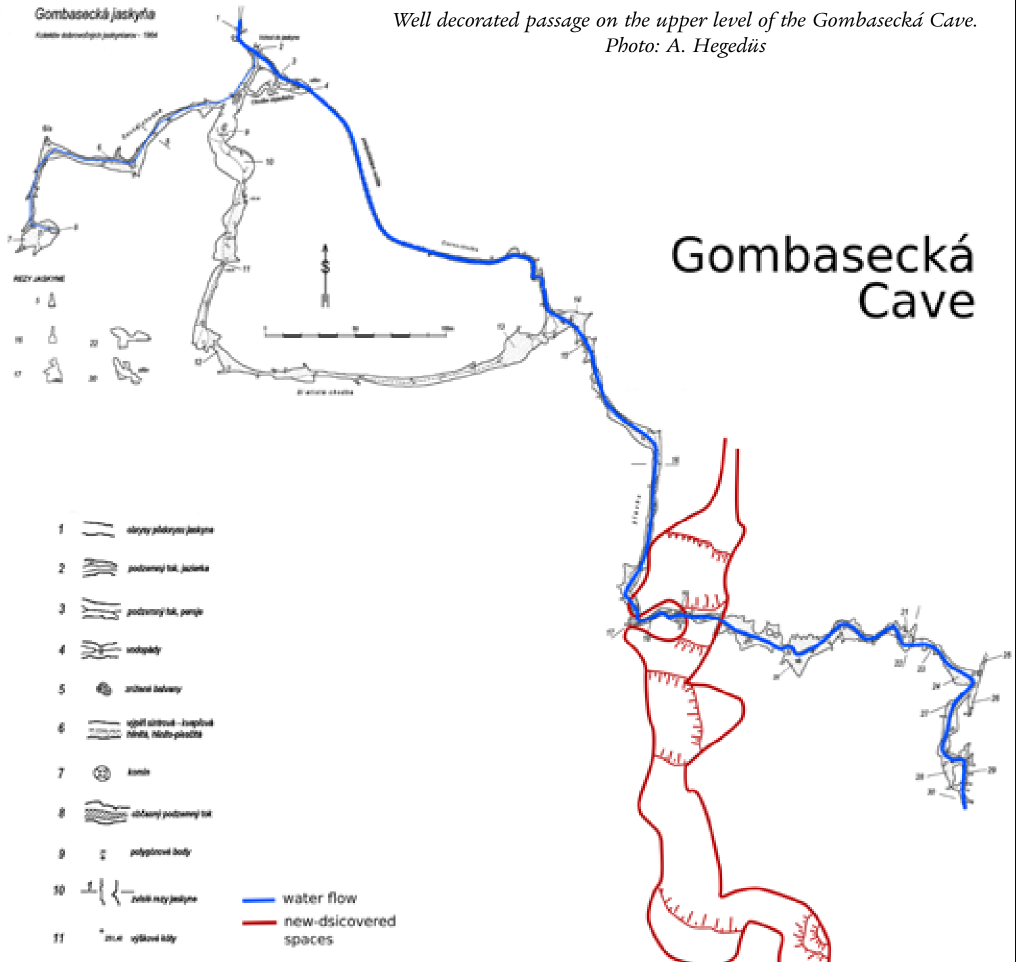
Location of the Slovak Karst in Slovakia ered underground river-shaped spaces, which in places are widened by collapses into domes and halls. Despite the effort of speleologists, the 1525 m length of the cave has remained unchanged for 65 years.

New discovery

There was a hypothesis that there should be the older development levels in the Slovak Karst, which should be the remnants of the paleolithic water flow. This level should be 50 – 80 m above the



Well decorated passage on the upper level of the Gombasecká Cave. Photo: A. Hegedüs



Map of the Gombasecká Cave – sketch of new spaces

Huge passages of newly discovered space. Photo: A. Hegedüs

present active watercourse, which was confirmed in other caves of the Slovak Karst (e.g. Drieňovská Cave). This level was a subject of our exploration.

A few years before, speleologists from Rožňava, with the intense cooperation of Jozef Hetesi, began researching the vertical fissures in Black Brook Canyon. On June 18, 2016, brothers Tomáš and Ľuboš Suchý climbed up to the older development level, which is approximately 45 – 50 m over the Black Brook, and discovered the system of the bigger halls. The newly discovered inactive level includes a great number of remarkable forms of flowstone fill. As well as traditional stalagmites and stalactites, there are flowstone shields and drums, and helictite speleothems, which are rarely found as fill in caves. Last but not least, the thin and fragile straw stalactites, typical for the Gombasecká Cave, also occur here.

Currently, the mapping and documentation process is in progress. Even now, it is certain that the new spaces will exceed 500 meters in length. The total length of the cave should exceed 2000 meters, and Gombasecká Cave should rank among the top 25 longest caves in Slovakia. A sketch of the newly discovered spaces on Gombasecká Cave map is attached.

Conclusion

The Gombasecká Cave and Silická ľadnica Cave consist of one hydrological system, but they are separated by a so far unknown flow of the Black Brook. The air distance between known spaces is still about 3 km in a horizontal direction and about 100 meters in a vertical direction. This fact invites further discoveries.

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KARST AND CAVES OF THE TATRA Mts.

Pavel Bella – Lukáš Vlček

The Tatry Mts., the highest mountains of not only Slovakia, but also of the whole Carpathian's range, are well-known for their high and sharp rocky peaks, trog valleys and cystal-clear glacial mountain lakes. Karst areas are located here on both sides of the border between Slovakia and Poland. Several caves of the Tatry Mts. are important from many points of view. The well-known Belianska Cave is open to the public. There is still potential for discoveries in several other cave systems.

From the geological point of view, the Tatry Mts. belong to the core Western Carpathian mountain range, with main ridges composed of granite rocks and crystalline shales. Mostly in the northern part of the mountains, lies a belt of folded and partly removed Mesosoic limestones, dolomites and other sedimentary rocks. Karst phenomena are connected mainly with good dissolvable limestones of the Belianske Tatry and Vysoké Tatry Mts., Červené vrchy Mts., group of Sivý vrch and the slopes of Roháče and Osobitá groups. The highest area above the upper limit of forest belongs to the high-mountain karst. The largest continual area of 74 km^2 of karstic rocks is located in the Belianske Tatry Mts.

However, the Tatry Mts. are divided by deep valleys; exokarst is represented only by karren and a few sinkholes in lower positions of the terrain. More abundant are endokarst phenomena – caves. To date, more than 350 caves have been discovered and documented in the Tatra Mts. Almost 2/3 of the caves are located in the Belianske and Vysoké Tatry Mts. Three of the caves were declared national natural monuments – Belianska Cave, Brestovská Cave and Cave Javorinka. In higher altitudes the caves are only sparsely filled with dripstones, in some places the walls are completely bare. Ice fill in caves is common; in a few caves it remains for the whole year.

Belianske Tatry Mts.

In this part of the Tatras, the Belianska Cave, with its length of 3829 m and depth of 168 m, is the longest cave. The occurrence of many cupolas in ceilings of halls and corridors makes this cave unique. The initial space of the cave was formed in the Lower Tertiary period, just before the main uplifting of the Tatras. The pressurised water flowed along a fault between the central and marginal parts of the mountains. On the NE slope of the Bujačí vrch (1947 m a. s. l.) there is the long-known 300 m long Alabastrová Cave, where the oldest inscription on the rocky wall is dated 1768. The next important cave of this area is Ľadová pivnica. Tristarská Abyss developed on the northern side of Havran Mt. (2151 m a. s. l.) with a length of 600 m and depth of 201 m. Located in the western part of Belianske Tatry Mts. is Nová éra Cave (267 m long and 121 m deep), as well as the caves in Nový vrch Mt. (the biggest one is 674 m long and 53 m deep), Muránska and Muránske okno caves.

Behind sharp peaks of Vysoké Tatry Mts. stands the softly modelled surface of the central ridge of Belianske Tatry Mts. Photo: L. Vlček

At the rocky ridge of Belianske Tatry Mts. Photo: P. Bella

Vysoké Tatry Mts.

In the Javorinská Široká massif (2210 m a. s. l.) between Bielovodská and Javorová valleys, cavers discovered in 2004 an enormous cave, Mesačný tieň (Moon Shadow Cave), with many deep shafts. It's length currently reaches about 32 km and it is the longest cave in the Tatras and second longest cave in Slovakia. Another very important cave is Javorinka Cave in the Úplaz massif (1784 m a. s. l.) between Javorová and Kolová valleys, which exceeds 12 km in length. Water from sinkholes in the Kolová valley ran in the lower level of the cave. In higher parts of the western slopes of Úplaz Mt. there is a 2.4 km long Čiernohorský Cave System, which consists of three caves (Kamenné oči, Nižná

Shaft called "Sun Rain" in the Moon Shadow Cave. Photo: M. Audy

Dissolutional forms of rocky surface could indicate the hypogene speleogenesis of Belianska Cave. Photo: L. Vlček

Čiernohorská Cave and Veterná Cave) that were interconnected in 1994 and 1997. In 2002 Jaskyňa verných (870 m long) was discovered in the same massif; Sedlákova diera Cave, last year's discovery, reaches 1034 m in legth. In Javorová valley, cavers interconnected the caves Suchá and Mokrá diera, reaching a length of more than 1.7 km.

Červené vrchy Mts.

Although the karst of Červené vrchy in the Western Tatras extends only over an area of 3.5 km^2, 63 caves have been discovered there to date. The biggest one – Nová Kresanica Abyss – is 820 m long and 194 m deep. The next important caves are Zadný úplaz (550 m long and 165 m deep), Vyšná Kresanica (300 m long and 50 m deep), Kresanica (70 m deep), Ľadová priepasť (60 m deep) and Občasná vyvieračka (450 m long). In 2010 Tichá Cave was discovered with a length of 632 m and depth of 69 m, the waters of which probably led to the Bystra Valley on the Polish side of the state border. Bigger caves were discovered in Poland, where the Wielka Śnieżna Cave reaches the length of 23.6 km and the depth of 824 m. Our highest lying caves are located In Červené vrchy Mts., at an altitude of 2080 m a. s. l. (Vyšná Kresanica Cave and other caves). Besides caves, the karren and karren fields are well developed here.

Sivý vrch Mt.

The highest part of Sivý vrch Mt. (1805 m a. s. l.) in the Western Tatras is known for its bizarre rocky formations. Among the rocky towers lies the entrance to Priepasť v Sivom vrchu – an abyss 93 m deep. It is a rock fissure created by gravity movement of the mountain slope, because the fragile dolomites lie on plastic claystone substrata. Abysses on Mních Mt. are up to 51 m deep. More caves are located in Suchá valley; the most important is Med-

Dolomite ridge of Sivý vrch group. Photo: L. Vlček

vedia Cave with its unique palaeontological finds. Other caves such as Biela, Košiarec and Dúpnica are spacious.

The deepest caves of Tatra Mts. (1. 1. 2017)			
1.	Javorinka	Vysoké Tatry	480 m
2.	Mesačný tieň (Moon Shadow Cave)	Vysoké Tatry	451 m
3.	Čiernohorský Cave System	Vysoké Tatry	232 m
4.	Tristarská priepasť	Belianske Tatry	201 m
5.	Nová Kresanica	Červené vrchy	194 m
6.	Belianska jaskyňa	Belianske Tatry	168 m
7.	Zadný Úplaz	Červené vrchy	165 m
8.	Nová éra	Belianske Tatry	121 m
9.	Bezodná priepasť	Osobitá	120 m
10.	Priepasť v Okolíku / Sedlákova diera Cave	Osobitá / Vysoké Tatry	106 m

The longest caves of Tatra Mts. (1. 1. 2017)			
1.	Mesačný tieň (Moon Shadow Cave)	Vysoké Tatry	31 840 m
2.	Javorinka	Vysoké Tatry	11 936 m
3.	Belianska jaskyňa	Belianske Tatry	3 829 m
4.	Čiernohorský Cave System	Vysoké Tatry	2 360 m
5.	Brestovská jaskyňa	Roháče	1 890 m
6.	Systém Suchej a Mokrej diery	Vysoké Tatry	1 764 m
7.	Sedlákova diera	Vysoké Tatry	1 034 m
8.	Jaskyňa verných	Vysoké Tatry	870 m
9.	Nová Kresanica	Červené vrchy	820 m
10.	Jaskyňa vo vrchu Nový 3	Belianske Tatry	674 m

Roháče group

The well-known Brestovská jaskyňa in Dolina Studeného Potoka Valley is the latest cave open to the public in Slovakia. An active underground river flow originates from three ponors in the Suchá, Múčnica and Volarisko valleys. Approximately half of the cave passages is accessible for speleodivers only. The length of the cave is 1890 m. An underground river leaves the cave through Brestovská Resurgence. There are many sinkholes and breakdown caves (Zrútená Cave) between the cave and the resurgence.

Osobitá group

In the northern part of Western Tatra Mts., the Juráňový brook hollowed out a gorge with rocky walls and potholes. In the Osobitá massif (1687 m a. s. l.), cavers discovered the 120 m deep Bezodná Abyss. Priepasť v Okolíku Abyss reaches the depth of 106 m; in it's underground the remains of mining activities were found. Ľadová jaskyňa v Okolíku Abyss contains ice fills.

Erosional corridor inside the Brestovská Cave in Roháče group. Photo: P. Staník

MESAČNÝ TIEŇ (MOON SHADOW CAVE), HIGH TATRA Mts.

Igor Pap – Štefan Šuster – Peter Šuster – Michal Sabovčík

Speleoclub UK Bratislava – Speleoclub Cassovia

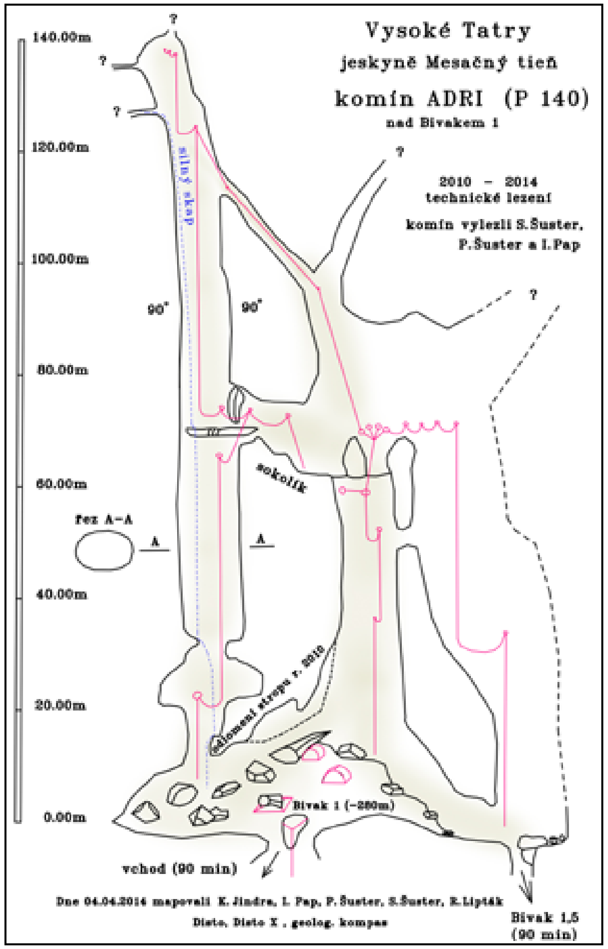
Nature can surprise you any time. We are frequently flabbergasted when looking at natural sceneries or interesting geological phenomena. Trying to understand the laws of Mother Earth gets us closer to the depths of our being itself. Everything is related to everything, so the answers to many questions which we, mere mortals, ask, may be found in places where common man cannot get easily... One of these places is our caves. Those who live near to the High Tatras can easily reach places where nobody put foot before. Here it becomes obvious that the underground of the Tatras is still a big unknown. This has been proved by a relatively recent discovery of the Moon Shadow Cave system by me and my friend Branislav Šmída in 2004, in the Bielovodská Valley on the northern part of the Tatras.

The discovery of this cave changed our lives, literally.

It's a typical Tatras' high-mountain, cold deep pit, dozens of kilometers long. Full of pitfalls and bad bivouacs that break or strengthen the personalities of the surveyors. We realized very soon that further discoveries in this monstrous pit would be closely related to our lives on the surface. The pit didn't forgive us for anything, and what's worse, is that this was also valid conversely; frequently our families suffered by our failures underground.

The Moon Shadow is currently the longest and probably also the most complicated cave system of the High Tatras. The only entrance is located at an altitude of 1767 m a. s. l. and to access it requires undertaking a medium Tatra hike. Just for comparison, the length of the cave is roughly equal to the length of all marked hiking trails in the High Tatras.

A view of Moon Shadow Cave and neighbouring digs marked yellow



A profile view of the chimney Adri

Chimney Adri. Photo I. Pap

Steady progress in discovering new parts of the cave is hampered by a fundamental logistic problem: transportation through the cave. Team members are getting older and their strength is decreasing, therefore it is really desirable to open a new entrance for easier access to the remote parts of the cave. Most of us are experienced mountaineers or workers at heights. Moon Shadow, 35 km long, also provides opportunities for climbing to the upper floors of the cave, some of which are explored, while we presume the existence of others. The underground system is drained by 3 underground rivers originating in one place. These rivers also drain four valleys, either partially or fully. In two of those valleys we expect soon to discover connections of the cave to the surface. The valleys were shaped by two of the hugest Tatras' glaciers (12 km long, 380 m thick) in the last ice age. The glaciers substantially determined the present shape of the cave as well. The distance of the nearest cave passage to the surface in that part of the cave is 73 m according to radio measurements; it takes 9 hours from the cave entrance to get there underground.

There are about 300 different shafts or pits in the cave. It's clear that 90 % of them end too narrow to climb, but our desire to alleviate the suffering of transportation is much stronger. So we are gradually climbing into all possible places, mostly along the main route through the cave. The main factor when choosing which unsurveyed chimney to climb is the reach of the beam of our most powerful headlamp. In the bivouacs we are inventing tricks with hot-air balloons which illuminate the whole profile of the chimney; wonderfully contrasting with the wild shapes of the cave. We are as happy as little kids if we don't get just a burnt wreck of the balloon at the end. There are no limits to the fantasy, as can be seen when

Vertical parts of the Mesačný tieň Cave. Photo I. Pap

considering the names of the shafts: "Outer Space Shaft", "Moon Creature", "Adri" (a nick-name of one surveyor's wife). We have counted hundreds of meters climbed; the first vertical kilometer climbed was only a matter of time. We survey and rig the shafts. We make movies inside the huge caverns. Proxy bivouacs are built near more difficult chimneys; currently there are seven of them. To climb a verti-cal takes 5 to 6 days. It's impossible for us to climb more than 50 meters a day on that unpleasant and frequently fragile rock. The pictures of unending abysses went viral in Slovakia. Expert Tatra mountaineers just don't understand how we've achieved this. Everything done without a serious injury. We leave kilometers of static ropes and hundreds of bolts and other rigging material in the cave. The cave is growing... We alternate underground trips with surface ones, in about 1 to 15 ratio. New, complicated but interesting digs are in progress in two other valleys, under which Moon Shadow is located. But that's a topic of a future article...

Maybe it will take a lot of effort and time to open the second entrance we are dreaming of... or maybe not. Well, what is life about? It always gets you there, where you are aiming.

Outer Space Shaft. Photo I. Pap

DEMÄNOVÁ CAVES
The most extensive underground karst phenomenon in Slovakia

Pavel Herich

Speleological club Demänovská dolina

Intensive speleological works during the last years have brought significant results in the knowledge of unexplored underground spaces, findings in geomorphology, paleontology and archeology, as well as partial understanding of cultural aspects of the history of human activities. In addition, modern, detailed numerical cave maps have significantly contributed to attaining these results, and highlight once again the importance of precise documentation of underground spaces.

Fig. 1. The Demänová canyon one century ago. SMOPaJ archive

About Demänová caves

Allogenic karst of monoclinal folds in the Demänová valley have already been mentioned many times in international journals, principally in reference to its typical evolution of a horizontal multi-level cave system along a base-level (D. C. Ford et al.). New important discoveries during the past years certainly confirm the hypothesis about the evolution of similar cave systems, but bring some new unanswered questions too.

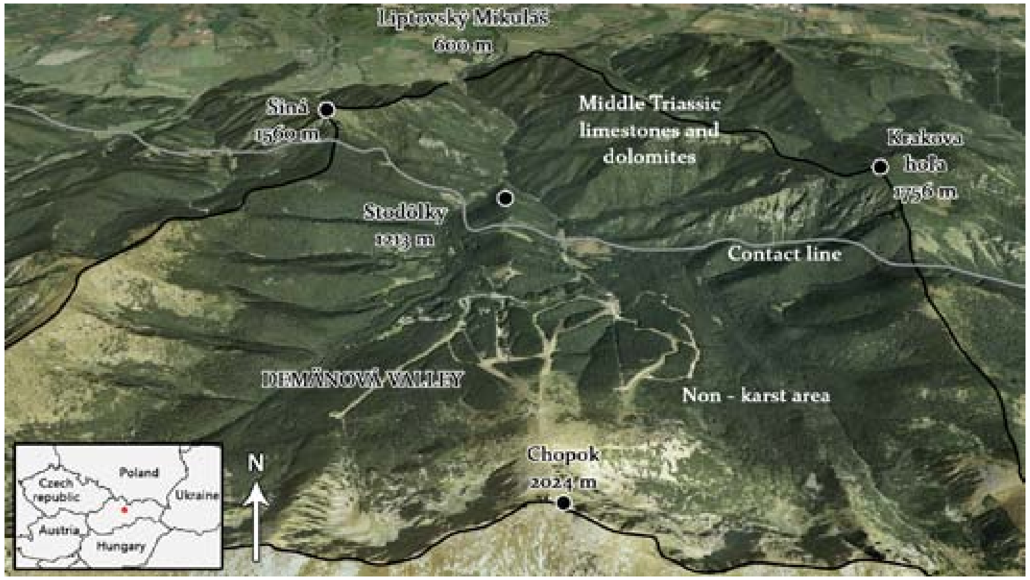


Fig. 2. Orthophoto of the Demänová valley

Tab. 1 List of the caves in the Demänová valley (longer than 100 m), situation in May 2017

No.	Cave name	Lenght [m]	Denivelation [m]
1.	Demänová Cave System (DCS): Dem. Cave of Peace, Temple of Liberty, Pustá Cave, Dem. Ice Cave, Dem. Bear Cave, Vyvieranie, Cave no. 27, Údolná Cave, Pavúčia Cave, Cave under Cliff, Cave no. 15	41 348*	196
2	Štefanová	17 020*	123
3	Okno (Window)	2 676	110
4	Suchá (Dry) Cave	1 536	33
5	Beníková	787	27
6	Chladivý dych	589	46
7	Cave by Kamenná chata	424	10
8	Kosienky	350	97
9	Cave in Veľký Sokol	265	41
10	Studňa v Okne	211	36
11	Kľukatý kanál	202	10
12	Uhlište	201	27
13	Cave under Stodôlky	182	11
14	Štefanová 2	178	32
15	Tri Okná	168	27
16	Jaskyňa nad Vyvieraním 2	165	20
17	Strieborná cave	159	31
18	New cave under Bašta	153	23
19	Dvere	151	13
20	Zbojnícka cave	151	9
21	Jaskyňa nad Vyvieraním 1	146	10
22	Sheep cave	136	17
23	Cave in Kostolce	123	31
24	Small cave under Bašta	108	18
25	Skautská cave	108	4
26	Cave in Malý Sokol	106	8
27	Portal cave	106	5
Total		**67 749**	

** The length of unsurveyed passages reaches hundreds of meters. Overall, there are 300 caves in Demänová valley longer than 2 m*

In spite of the major importance of Demanova, the karstified part of the valley, which is characterized by a narrow canyon, covers only 16.5 km^2; a half of this surface is composed of dolomites. The allochtonous water courses, which are concentrated over a crystalline basement with a surface area of 31 km^2 and divided into two roughly similar valleys, Demänovka and Zadná voda, are crucial to the development of caves. Glaciers accumulated in the two valleys during glacial periods, then, during warmer periods, the melted water contributed to the streams with erosive materials and cold unsaturated water This water, which has a highly corrosive influence on carbonates, disappeared underground through a dozen sinkholes of different sizes. Thus, during the last 2.5 million years, the most extensive cave system of the Carpathian Mountains, with a known length of 70 m, has developed in that area. Currently, we have principally explored the 42 km long Demänová Cave System (DCS), by joining different caves, and the nearby Štefanová cave with 17 km (tab. 1). They are only separated by 55 m as the crow flies. Exploration still goes on, however, the eventual joining will not necessarily be an easy task (fig. 2).

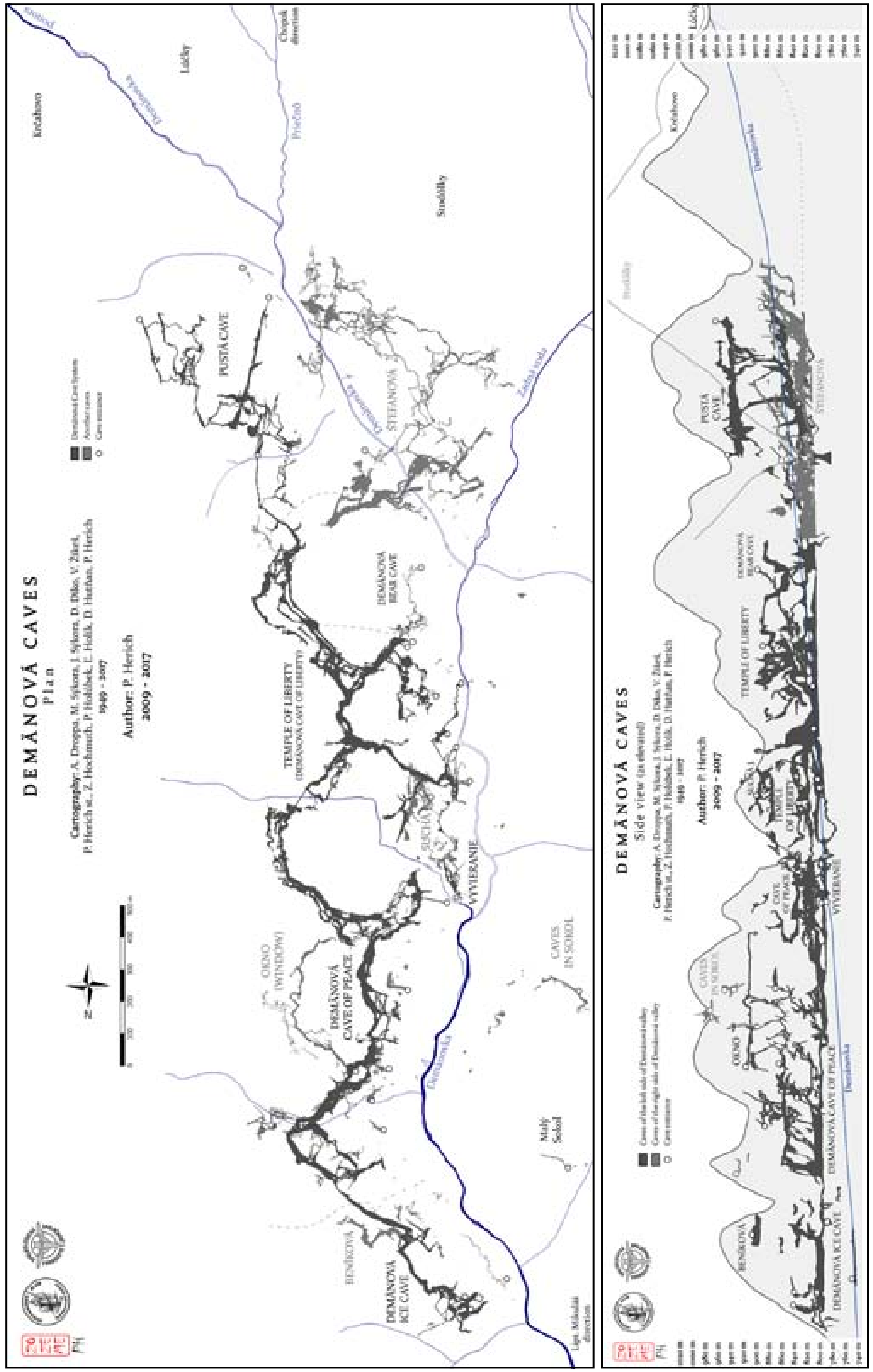


Fig. 3 Demänová Caves

Prolongation efforts during the last years

In Slovakia, there is a rather strong tradition of digging in the caves in order to discover new galleries. In comparison to other countries, our karst localities are not very extended and their detailed exploration began relatively early, thus the caves with free continuation have been explored before. The first map (scheme) of cave galleries in Slovakia is from 1670 and it is one of the oldest cave maps in Europe. The Demänová valley had already witnessed the first scientific research by the end of the 17th century, and a few years later in 1719, G. Buchholtz jr. created a beautiful detailed map of Čierna (Black) cave (today's Demänová Ice Cave) (fig. 4).

Nowadays cave exploration still goes on in Slovakia, but it is rare that a new cave could be discovered without digging its entrance, or digging underground. In comparison to the caves in Great Britain (that often do not have any sediments), or enormous underground spaces in Vietnam or China, caves in the Carpathian Mountains, and particularly the Demänová caves, are characterized by middle dimensions (galleries 30 m high and wide), and an important volume of underground spaces is filled with sediments. In Demänová valley, cave endings are often channels completely filled with allochtonous sands and pebbles, which is the case even for big galleries. Choke stones and important concretion accumulations also interrupt what our knowledge of the karst tells us should otherwise be a continuation of the caves. Important horizontal galleries rarely stop without continuation in the massif; their interruption is likely be due to downcutting of the lateral or main valley, or by reaching a karst spring.

It is very hard to estimate, if possible at all, the dimensions of choke stones, or the amount of sediments, separating free galleries. That is why, so often, in the past as well as nowadays, after dozens of digging sessions, cavers have left the discovered place, even though they have opened 20 – 30 m of sediment filled gallery. For example, after 3 years of work (2015 – today) and 20 sessions, we have progressed 25 m in Okno cave; the digging in dry, loose sand, is not difficult, although there is no air circulation We did not have big hopes, we simply wanted to join cave Okno (Window) with DCS and in the process explain the question of their common evolution... In the past, digging activity was often unsuccessful, because without proper orientation in the space (without maps), diggings were directed in a wrong direction, or they went towards known parts of the cave.

How to join two big caves

Since 2007, when we passed through a constriction at the end of the 1.5 km long Štefanová cave, we have been exploring new galleries. At

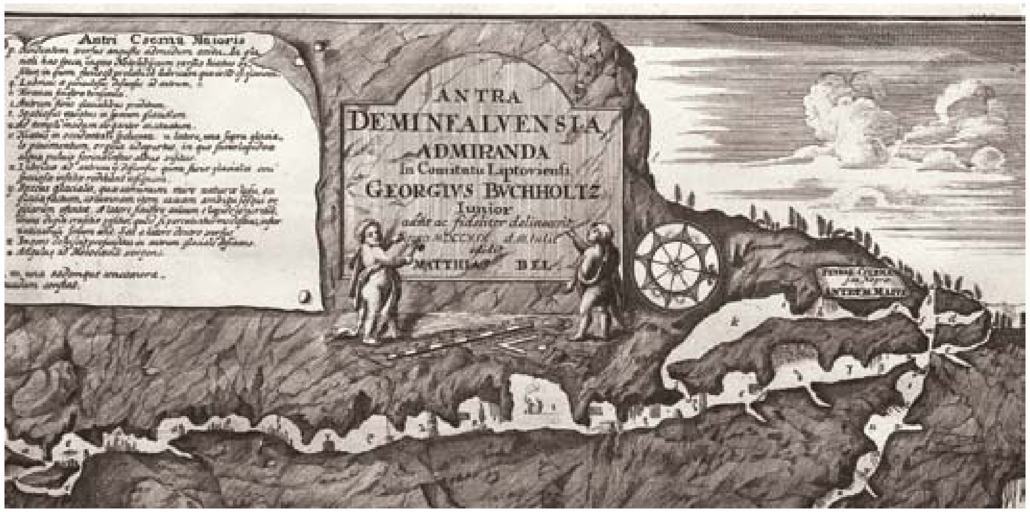


Fig. 4. Section of G. Buchholtz' 1719 map

the moment, Štefanová is likely to be the only cave in Slovakia that has free continuation, which means that we have not yet come to the ends of its galleries; we have just to explore and carry on with documentation. During the discovery of new passages, we almost reached DCS; 55 m or 100 m did not seem like impassable distances. Thus, we had the idea to join these caves, which would create a 60-km long cave system if successful. However, it depended on which obstacle separated the caves. The expectation of free galleries and air circulation between the caves (from Eldorado in Štefanová cave), gave us hope that it was possible. Between 2012 – 2016, during 30 working sessions at two places, we moved forward 18 m and 15 m, but the air draft disappeared inside a crack and transport of excavated material became too complicated. As forces and time are limited, and it is necessary to finely consider options, we moved away from these digs.

Today we encourage experienced divers, trained principally in flooded caves of the Yucatán, to systematically explore the possibilities of joining the caves by diving in siphons. According to the latest results, immersed passages are only 55 m distant and the connection by water has been proven for several years. However, from the side of the Chrám slobody cave (Temple of Liberty), there is a dangerously narrow siphon with moving sand inside a steeply descending gallery, 35 m deep. Its exploration is at the limit of acceptable risks, perhaps even beyond. In 1984, Vlado Žikeš, an excellent diver and founder of our cave group in the Demänová valley perished there. In Jazerny dóm (Lake hall) in Štefanová cave, there is a siphon that was only explored in 2013 for the first time. The relatively spacious, immersed gallery (6 × 3 m) finishes in a narrowing in fine silts at a depth of 17 m. The silts stir during diving through the passage and decrease the visibility practically to zero. However, in December last year, we discovered that gallery continues on freely, but it is necessary for a diver, while following the current in the siphon, to swim faster than the water flow, so that the water isn't muddied by silt. Thus, after a narrow opening it is possible to see a spacious gallery. It took 30 years from their discovery to connect the two big caves (Pustá Cave and Cave of Peace) in the Demänová valley to the Temple of Liberty Cave. Štefanová cave has only been known in its full splendor for 10 years, and who knows how long we will have to wait for the feast given the 30 years required for finding connections in the past?

Diving discoveries

Diving techniques have improved, but experience is still most important as is, perhaps the courage to take the risks. The first and most important discoveries using diving techniques occurred in 1981 – 1984. Principally, the solo dives of V. Žikeš, without a spare regulator and with only one tank, brought about the joining of Vyvieranie with Temple of Liberty caves through the so-called Water Way by passing 6 siphons, that foreign div-

Fig. 5. Lake Hall in Štefanová cave. Photo: P. Herich

ers had previously considered impassable. Almost all the other siphons of the underground Demänovka river were systematically explored, until, as mentioned before, the caves took Vlado with them.

For the conquering of the next siphon, we had to wait till 2011, when R. Husák, an exceptionally experienced diver who has explored caves everywhere in the world, literally dug through a constriction at the bottom of the siphon in Pustá cave. Gravels at the bottom of the narrow gallery at the depth of 13 m were virtually boiling from the pressure of the water. He passed through at the third attempt, though he had to leave one of his two oxygen tanks in front of the constriction. He emerged in a vast gallery that continued further... After many tries at different places, the year 2014 brought the next vanquished siphon; the other siphons still offer future challenges. Altogether, 200 m of new galleries have been thus explored, but the principal exploring possibilities in the Demänová valley have not yet been solved.

New cave entrances

With new discoveries in the Štefanová cave, we have started to set up bivvies, because a one--day working session took 12 or more hours and ceased to be effective (only one third of the time was spent by actual exploring). In comparison to vertical caves, where a slow-down in progression is due to the increasing depth and complicated transfers using ropes, Štefanová cave is specific with plenty of large, but low galleries, which require crawling or wearisome low walking. Though there are not too important distances, to get to some explored parts of the cave takes something like 4 hours. After constructing the third bivvy, where even bringing the material involved strenuous efforts, we started to search for a new entrance. Not all of us agreed on its necessity, looking at it from the point of view of having a few days of adventurous expedition, as a new entrance would mean a step backwards. However arguments including exploration, safety and the possibilities of scientific research finally prevailed.

After 15 working sessions, we eventually reached the surface. However, it was at the limit of all acceptable risks, we were opening through a vertical 16-m long chimney filled with gravel and rocks, which narrowed to the bottom and it was larger in an upward direction. With long metallic bars, we were beating at the ceiling above and then immediately had to try to avoid the falling rocks from an ever increasing height. However, during the last working session, the ceiling was too far away and it was bulging a little, so after a short consideration, we tried to climb in the middle of its height and from a nearer position to throw the material above our heads. In unconsolidated rocks, we dug a small shelter. One person could almost horizontally enter in, and from this position, it was possible to work by hitting the graveled ceiling with a bar and to advance upwards. At that moment, we could hear the noises made by friends at the surface, but they were still too far away. Soon, rocks began falling spontaneously, they were thundering down only a few centimeters in front of the face. The person inside the narrow shelter curled up, covering his face with an assistance rope as a protection against impacts. We could only hope that there wouldn't be a bigger boulder hiding in the gravel that would choke the constriction below, without opening the passage to the surface. In the last seemingly never-ending hour, when it was obvious that we were approaching the surface, we found it was impossible to get back under the chimney to safety; the ceiling was slowly collapsing and its total crash was imminent. During the following intense bombardment, a big stone crashed down and it choked the bottom of the chimney... Fortunately, smaller stones could fall down alongside the stone, thus the volume of the chimney was not stuffed and at last, after an overwhelming 12 h spent underground, we reached the surface through a new opening of the cave system. Dreadful images were overtaken by happiness and relief, that natural forces had allowed us, on 1st May 2015, to return without any physical affliction to the terrestrial surface.

With the new entrance to Pustá cave, opened in the same year, we have avoided a 90 m long sandy siphon that was dug through between 1991 – 2001, which, during higher water levels, quickly flooded and took a long time to dry.. Both of these results, but principally the new entrance to Štefanová cave, proved to be key

achievements for initiating the next explorations and discoveries, and significant new results followed very soon (see below).

Discoveries in Štefanová cave

From 1956 the cave was known to have a length of 205 m, but at the beginning of the 90s new discoveries of 1.5 km long galleries exceptionally rich with concretions was added. In 2007, after roughly 8 digging sessions in a low constriction with a pulsating air circulation, we entered into a huge labyrinth of galleries, that freely continues even today (tab. Stef) reaching an actual length of 17 km (5th longest cave in Slovakia). After opening the new entrance our efficiency has considerably improved, and during all exploring-mapping expeditions in 2016 (and so far in 2017), we have been simultaneously discovering new galleries at different places. These previously very distant places are closer today by 2 h. We have been exploring the cave step by step for many years, together with its mapping and documentation, in order to avoid useless, repeated visits of the parts that may thus stay without human presence for a long time. Map drawing helps a lot for orientation in the space, and often we come across new, shorter and more comfortable passages to the known galleries. At the moment, the cave still has enormous potential (principally in the vertical range), though we assume that the principal corridors have been more or less already recognized.

Geomorphologic observations New discoveries have brought an interesting point of view on the speleogenesis of depressed and invasive vadose zones. The cave crosses 3 times under an active riverbed of the Demänová valley, at the nearest point perhaps only 5 – 8 m below its bottom. Older cave levels are remodeled by younger vertical grades and shafts (invasive vadose zone), whose ceilings in some cases have collapsed and thus even reach the surface. An-

Tab. 2 Progress of explorations and mapping in the cave since its discovery in 1953 to 2016

Date	Measured distance [m]	difference [m]	number of explorations	Notes
1953	205	205	2	Discovery of the cave
...				
1991	300	95	10	
1992	846	546	6	
1993	1 521	675	15	
...				
2007	4 092	2 571	23	Discovery of Titan dome 20. 1. 2007
2008	4 766	674	12	
2009	8 050	3 284	34	Discovery behind Difuzor 10. 3. 2009
2010	11 144	3 094	15	
2011	13 105	1 961	9	
2012	14 105	1 000	17	
2013	14 746	641	12	
2014	-II-	0	9	Diging for new entrance
2015	14 840	94	16	1. 5. 2015 new entrance of the cave
2016	16 651	1 811	12	Comeback to the explorations

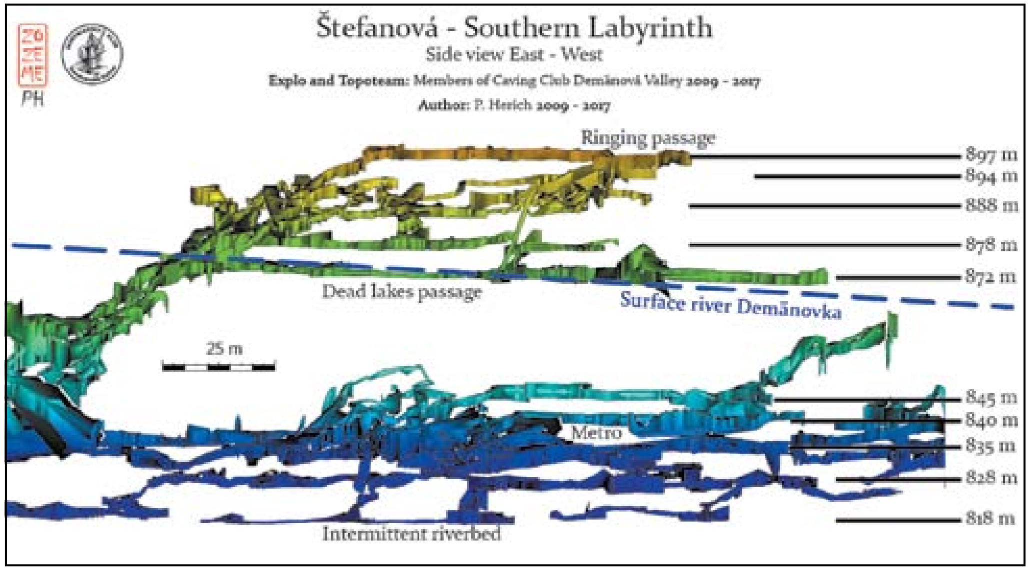


Fig. 6. Horizontal galleries in Štefanová cave

other interesting observation is a dense stratification of horizontal galleries in these zones, being integrally connected with diagonally descending flooding labyrinths (fig. 6). Apparently horizontal galleries are roughly 3 times more present in vertical density than the galleries in lower cave levels in Štefanová cave and especially compared to the DCS. Because these galleries are closer to the contact with the crystalline basement, they could be interpreted as the consequences of aggradation events during interglacial periods along with classical cave level evolution.

Fig. 7. From new discoveries in Štefanová cave. Photo: P. Herich

Big digging works at Krčahovo

With the discoveries in Štefanová cave, it might seem that the explorative potential in the Demänová valley has been drained out. The places around today's karst spring, fossil levels along the main drainage, along with older karst spring localities are well-known. Štefanová cave has brought us directly to sinkholes, that means, with all that concurring theories believe belong there – meanders, cascades, shafts, flooded labyrinths, an anastamosous system of descending channels, pressure flow tubes... Sinkholes are so near, that boulders in the cave reach the dimensions of more than 2 m! However, sinkholes were formed by waters of the Zadna voda river and also the Demänovka river, but other ones sink even higher, under the massif called Krčahovo.

This vast empty space is a terra incognita. We are pretty sure that there is a cave of similar dimension like Štefanová cave. However, in comparison, the Krcahovo massif is quite large and it goes a few kilometers higher, up to Krakova hola with the deepest caves in Slovakia. At one side of the massif the waters of the Demänovka disappear underground, and on the other side, 130 m deeper, they traverse the Machnatô valley and reappear in Pustá cave. In 1952, the highest sinkhole collapsed during spring flooding as it caught the whole downpouring of the Demänovka river. The problem was that high water level flooded the Temple of Liberty cave, which was open for tourist visits, so the sinkhole had to be artificially closed. Today, we would consider the situation differently and we would likely avoid sending a couple of trucks filled with gravels for stuffing the sinkhole. Consequently, with this action, we have perhaps missed a rare opportunity to get to the underground of Krčahovo. During a detailed surface exploration of the massif, we have found only one place where fluviokarst caves occur. The big issue is the structure of the massif, which consists of the contact of crystalline basement with the sedimentary series and a strong gradient between surface drain-

Fig. 8. A new cave in Demänová valley – Chladivý dych. Photo: P. Herich

age and the base of the underground water level. Seven alluvial channels of small dimensions (up to 1 m in height and width), with an exception of a wider meander (5 × 2.5 m) filled up to the roof with allochtonous sands, have been discovered near a minor cliff at Krčahovo. But they are too high, DJS is below 1000 m a. s. l.; there we are 250 m higher and the caves would likely be one generation older (Pliocene) – their connection is thus very questionable.

However, we completed 58 digging sessions over 2 years. From two 9 m long caves, there is now one 100 m long cave, that follows down the stratification (aligned with surface topography and only 4 – 5 m below it). Some portion was dug, the rest was free. There is no air circulation and very little chance of success. Considering the enormous potential, we still hope, that we will make a breakthrough and today's objective is "100 digging sessions and then we will see".

Complementary discoveries in the Demänová valley

As previously stated, in cave systems similar to Demänová caves it is sometimes fairly easy to forecast the next continuation of gallery levels. Theoretically it works, sometimes even practically, but the most important factor behind these theories is to find the motivation for the next work. That is why we work on several different localities; occasionally some of them offer new discoveries and we can find ourselves exploring hundreds of meters of new galleries. After 3 working sessions in 2014, we discovered 600 m of galleries in Cave of Peace; the surprise was huge, as we found a labyrinth like karst in ramsaus dolomites. In spring 2017, after 7 working sessions in a well-known Pustie massif, we passed into a completely new cave, called Chladivý dych. After further work, it now reaches the length of almost 600 m. It has a special, very quickly changing pulsating air circulation and it corresponds to a missing fragment of an important level of Demänová caves. We once again acknowledged, that it's not quantitative parameters like the length or depth of the cave, number of stalactites or dimensions of the domes, that are important for a human being, but the expectation, curiosity and happiness from a result shared together with friends or fellow companions. During the last 10 years, I have personally participated in exploring more than 20 km of new cave galleries, mainly at home in the Demänová valley, but in other places in Slovakia and Balkans too. However, the discovery of Chladivý dych, a short, but surprising cave, is one of the most precious experiences.

Protection of Discovered Galleries

As discussed earlier, all discoveries are documented alongside the exploration, which means that we visit some places only once. The places are mapped, perhaps photographed, casually documented (fauna, morphology, drainage, sediments, minerals, possibility of

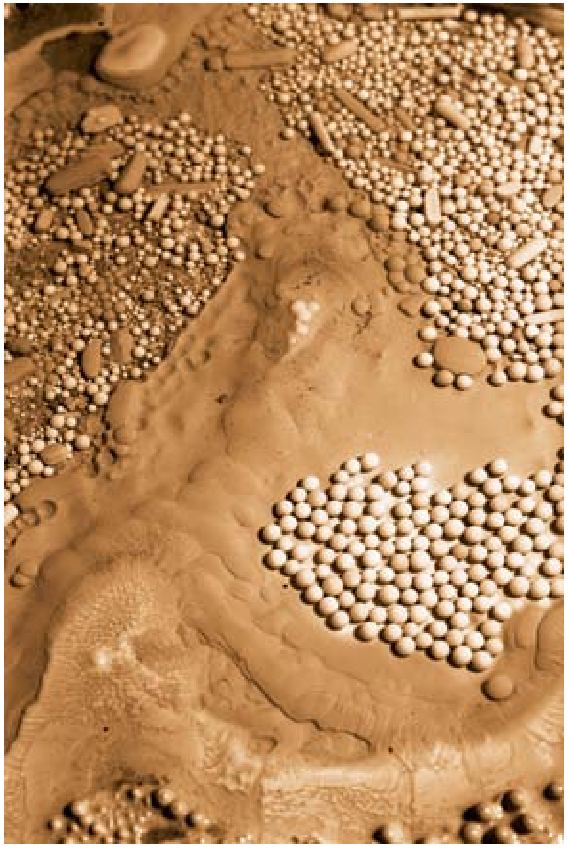


Fig. 9. Cave pearls in the cave Temple of Liberty. SMOPaJ archive

continuation etc.) and if it is not necessary, we don't return. Thus, the cave rests for the future relatively undisturbed.

In the past, cave explorations were less sensitive to the protection of underground environments, which was probably linked with the purpose of their use (tourist visit, deposit zone, shelter etc.). From the outset, in Chladivý dych, the latest discovery in the Demänová valley, we have been very careful and we have established a route using a thread, which should be taken by an explorer in order that all the other places will not be disturbed. Over time, it appears that this carefulness is justified; in many caves we have, for example, identified cryogenic calcites (CCC), which have only been described very recently, despite the fact that they have often lain for thousands of years in the middle of wide galleries. These white powders have been trodden by many cavers and visitors. Chladivý dych conceals traces of an important cryogenic destruction of speleothems and we intend soon to analyze the spatial and directional organization of these fragments. Data obtained from broken individual concretions lying in their original position and undisturbed, will give a very realistic image about their organization. Speleological techniques and new surprising data collection methods about the caves continue to develop. The recent news about the possibility to extract DNA samples of prehistoric animals (even humans) from cave sediments, and thus to determine their presence at the locality, means that we have to be careful during our progress and work in the caves.

Topographic project

By the end of 2009, intensive work began on a complex map of all Demänová caves. We reviewed all measured data (from 1949) and we completed them with new data. In the locality of the valley with superficies of 16.5 km^2, 300 caves have been documented, with a total length of 75 km, as well as many sinkholes, karst springs, depressions. Most of them are genetically linked with the cave system, which is why we have established as a goal to map and describe in detail all karst manifestation in the Demänová valley, to obtain the most complex view possible of the locality, its evolution and structure. In the cave atlas under preparation, all the caves, even the smallest, have a plan, a profile, with some cases profile sections, entrance photography and a precise geolocation coordinates based on a stabilized point in the entrance of the cave. Text description includes all the relevant information about the cave. One result of this work is a 3D cave model depicting the topographic surface and cave galleries, which makes it possible to analyze spatial organization during scientific research and it can be used for presentations and education. Currently, we train mobile 3D scanners in speleology practice, and employ them.

Archeology

The Liptov region, where the Demänová valley is situated, has a very interesting and rich history. The central part consists of a rather wide basin (up to 20 km) in altitudes 550 – 700 m above sea level, and it is encircled by mountains as high as 2300 m. From our point of view, there was an interesting *refugium* of Lusatian culture at the border of the Demänová valley situated on the karst plateau at an elevation of 1450 m, that probably disappeared around 500 BC. There are dozens of similar refuges in the Liptov region. They were fortified with stone and wooden ramparts and they were used as places of safety against enemies. After their permanently settled hillforts on the middle elevation were conquered, inhabitants, with their livestock and personal property, found shelter in the refuge. Today, we know, that the disappearance of these refugia happened at approximately the same time throughout the Liptov region, as well as in nearby localities. We do not know exactly what happened, but rare Scythian-type arrowheads in the walls of ancient fortifications give us a hint.

Refugium Na jame is interesting, since in the upper part of a fortified and hardly accessible karst plateau, there is a 12-m deep shaft which is surrounded by an artificial sandstone rampart, the same sandstone that was used for fortification and had to be carried from where it naturally occurred 700 m below. Since the discovery of the refugium in the middle of the 20th century, there has been debate about

Fig. 10. View at the summit of Na jame ridge with the acropolis of an ancient refuge

whether or not the shaft is of a natural origin or if it was excavated by inhabitants of the fortification, perhaps for the water or for ritual reasons. A caver would recognize evidence of a natural origin of the shaft, and so we have decided to organize annual expeditions to the area, with the goal of excavating the fallen matter at the bottom of the shaft (dimensions of the bottom 2x 2.5 m) and trying to reach the layer with cultural artefacts of ancient inhabitants. The violent disappearance of the hillfort, or the possibility of the existence of the shaft as a ritual object, give us hope to make compelling discoveries. During a demanding 5-day long expedition, we dug 4.5 m deeper through the young clay sediments containing gravel. We excavated many animal bones of several smaller and bigger vertebrates. But a big surprise was a complete human skeleton at a depth of 3 m. For an archeologically untrained person, it was a weird sensation to clean human bones from clay and gravel in a 15-m deep dark, wet shaft, trying to make a drawing of its initial position, accompanied by the thunder of a severe storm at the surface, which for a few days had circled around the summit of our hill without hitting it... We realized, that the shaft does not necessarily contain only the messages from 2500 years ago, but that it is an archive of all ancient periods, as it is a part of the country's culture today, as it was in the past. The search for the life story of the human being that was till recently at the bottom of the shaft goes on, and we hope to decipher his story. We would like to go further back in time in this shaft, to find something – no one knows what.

PALEONTOLOGY

Discovery of the oldest vertebrate in Slovakia

In 2016, after opening a new entrance to Štefanová cave, we revisited many distant places that had not been visited in a while. During one such trip, we finally took time to look around us in the galleries, and thus we found in the ceiling of a gallery a few centimeters long fossil. As described in the next article, it was finally considered to be an important finding of Pachypleurosaur, a middle Triassic Slovakian quadruped. So far, only the findings of dinosaurs' tracks from the Late Triassic in Západné Tatry are comparable in age.

DOBŠINSKO-STRATENSKÝ CAVE SYSTEM

Ján Tulis

Speleological club Slovenský raj

1. Geography, nature, geology and geomorphology

Slovenský raj (Slovak Paradise) represents an area with high natural, landscape and aesthetic value, and high concentration of natural monuments. The varied morphological structure gives the country a special character. The landscape is distinguished by its biotic and abiotic components. The territory has irreplaceable scientific significance and belongs to the cultural heritage of the Slovak nation.

The territory is developed on a geological basement of carbonate rocks with a good predisposition to karstification. As a result of the karst processes, special surface karst forms (gorges with waterfalls, varied forms of rock relief, uvalas, sinkholes, karren) and underground karst forms (caves and abysses) were created.

Slovenský raj lies in eastern Slovakia, west to southwest of Spišská Nová Ves, in an area of 178 km^2. The dimensions of the area are: E–W 25 km, width N–S 15 km. The area is situated between 20°11´03˝ and 20°31´51˝ north and between 48°50´30˝ and 48°58´57˝ east. According to Kolektív (1980) the Slovenský raj area is a part of Spišsko-gemerský Karst within the Slovenské Rudohorie Mts.

From a geological point of view, the area is built predominantly of Mesozoic rocks: limestones and dolomites (Mello a kol., 2000). North from the Hornád river, Paleogene conglomerates and sandstones occur (Podtatranská group).

In relief, Slovak Paradise is dominated by two basic geomorphological forms, which are the cause of the attractiveness of the territory – karst plateaux and river valleys. Slovak Paradise consists of plateaux, which are divided by a network of canyons, gorges, river valleys, massive ridges and smaller basins on the edge of the territory. Caves and abysses occur in the plateaux' underground.

The territory of Slovak Paradise belongs to a temperate climate zone with a predominantly western air flow. The area is at the interface between the oceanic and continental climates.

Limestone and dolomite rock predominate, and its karst formation and special development are connected with specific elements of flora and fauna. The territory is characterized by the occurrence of Carpathian plant and animal species, in many cases endemic and endangered. According to the typological classification (Mazúr – Jakál, 1969), a part of the Slovak Paradise is a complete karst plateau comprised of semi-massive structures. The karst plateaux are: Glac, Geravy, Duča, Pelc and Skala.

There are typical karst forms on the surfaces of the plateaux: uvalas, valley-uvalas, sink-holes and ponor sink-holes, hums, isolated platforms etc. Karren are common on the sides of uvalas and karst ridges, and exceptionally, bogaz. Several shallow senile river valleys are pre-

Karst plateau Duča, Slovenský Raj. Photo: J. Tulis served on the periphery of some platforms, which are a relic of Pre-Upper Eocene fluviokarst relief., Between the top of the plateaux and their basins, gorges divide the slopes.

2. Karstic plateau Duča

The area of Duča plateau is 6.07 km^2, and the area of the platform is 2.07 km^2. The plateau is in the south-east and north and is bounded by the allochthonous flows of Tiesňavy and Hnilec brooks. The Tiesňavy brook forms the border of the Pelc plateau. The northern boundary is very ragged. The plateau is is predominantly comprised of Wetterstein Limestones.

Rozprávkový dóm – the most voluminous space in the cave system. Photo: J. Tulis

2.1. Endokarst phenomena of Duča plateau

From the point of view of the expansion, development and importance of endokarst, the Duča karst plateau has an extraordinary position. So far, 58 caves with a total length of 24,940 m have been explored, registered, documented and mapped. The most significant of them will be described in detail.

2.1.1. Dobšinsko-stratenský Cave System

The Dobšinsko-stratenský Cave System (in the following text DSCS) is one of the most important cave systems within the Western Carpathians. It spreads out in the Duča karst plateau. Previous research has confirmed that Duča is the most prospective area for further discoveries within the whole area of Slovensky Raj in terms of the occurrence of endokarst phenomena.

The DSCS consists of the following separate caves:

1. Dobšinská ľadová Cave (DLC) 1 483 m,
2. Stratenská Cave (SC) 19 317 m + Psie diery (PD) + 2 670 m + Duča Cave (DC) 1 248 = 23 670 m is the 3rd longest cave in Slovakia,

Relic of older flat ceiling in the Stratenská Cave. Photo: J. Tulis

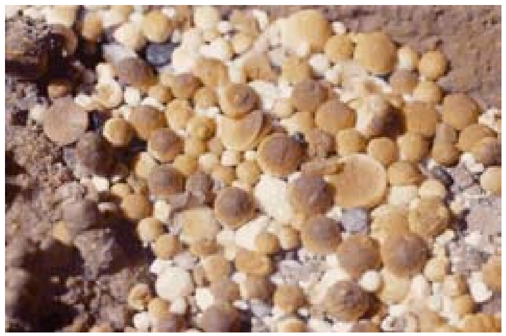
3. Vojenská Cave 53 m,
4. Zelená Cave 31 m,
5. Sintrová Cave 17 m.

2.1.1.1. Stratenská Cave

SC was discovered by members of the Slovak Speleological Society, Speleological Club Slovenský Raj (SKSR SSS, the "Oblastná skupina Spišská Nová Ves" before) – V. Košel and J. Volek on December 1, 1972. The exploration

Variegated chemogene filling in the Stratenská Cave. Photo: J. Tulis

White dripstone decoration and flat ceiling in the Stratenská Cave. Photo: J. Tulis



Hemispheroides in the Stratenská Cave. Photo: J. Tulis

and documentation of the cave was the main focus for SKSR's members; the results were presented by J. Tulis (1974, 1975, 1976, 1979, 1983, 1984) and L. Novotný (1984, 1990, 1992, 1993, 1995, 1998 as well as monographies Jaskynný systém Stratenskej jaskyne (Stratenská Cave System; Tulis – Novotný, 1989) and Kras Slovenského raja (Karst of Slovak Paradise; Novotný – Tulis, 2005). Here is a selection of the main findings gained during the entire 45 years of survey and research of the Stratenská Cave.

Many years of speleological work followed the discovery of Stratenska Cave. As the cave system was explored, many questions concerning the speleogenesis and evolution of the underground spaces were raised. Using sw. Therion, a comprehensive map was created.

The cave spaces originated in Steinalm (Upper Anisian) and Wetterstein Limestones (Ladinian). The dominant directions of the rock layers are: a) E-W with dip direction to the SE and b) NE-SW with dip direction to the SE. Steinalm and Wetterstein Limestones are chemically pure (content of CaO 53,91 to 54,7 %; in comparison to the content in calcite crystals: CaO = 55,01 %) and have good predisposition for karstification (Tulis – Novotný, 1989).

The whole cave system is situated in the wide "Nižná Slaná" fault-zone in a NNW – SSE direction. The faults and fissures inside the cave system have correspondent orientation. The four most important faults inside are: Lake, Well, Straight and Kopský faults; they are mostly steeply inclined. The orientation of cave corridors are underpinned not only by tectonic features, but also by folded limestone layers.

Variegated stalagmites in the Stratenská Cave. Photo: J. Tulis

Passage to the Reprezentantov Corridor in the Stratenská Cave.Photo: J. Tulis

In general, there is a lack of water in SC: we can distinguish underground streams, lakes, infiltration water from the ceiling and walls, and condensation moisture. Except for two autochthonous flows, all underground flows are periodic; lakes are corrosive-erosive, weired and in the sinks of the cave bottom. The "Stalagmite Lake", with an area of 320 m^2, is the biggest in the cave. The water temperature is stable and close to the surrounding cave air (4.6 – 6.0 °C). All observed waters are cold, alkaline and moderately mineralized (301.89 – 387.395 $mg.l^{-1}$); they belong to the basic Calcium-bicarbonate type. Cave parts below 850 to 855 m a. s. l. are flooded with water permanently.

The average cave temperature is 4.94 °C (min 3.91 °C, max 5.61 °C). The low temperature gradient in the NW part of Duča is reflected in the microclimate of the Dobšinská Ice Cave. The temperature changes in the cave are affected also by an exogenous factor – solar energy. Relative humidity in the cave is very stable and ranges from 95 to 100%. There is a characteristic pulsing air draught with variable flow direction, prevailing in one direction. Observations show that Stratenská Cave is a dynamic cave.

SC is a large maze of underground spaces. The width of corridors is from 0.6 to 86 m, height from 0.6 to 27 m. The largest underground space is the "Fairy Dome", with a volume of 79,017 m^3, which is also the largest cave space in Slovakia. The largest elevation in the corridors reaches 58 m. The bottom floor is rugged for no more than 15 m. The largest sump has a length of 60 m and a depth of 12 m. The deepest abyss, with a depth of 47 m, is called Šikmá.

In accordance with the direction of the underground spaces, the corridors can be defined as (Tulis – Novotný, 1989):

1. NW – SE corridors are horizontal with flattened ceilings and rugged bottoms – the spaces of the 4th level of the cave, which were created by a Palaeo-Hnilec brook.

2. SE – NW to N – S corridors are horizontal with flat ceilings divided by ceiling meanders with variegated morphology and morphometry. Corridors were modelled by Palaeo-Tiesňavy and Palaeo-Hnilec brooks, as were autochthonous flows, although in a smaller range.

3. NE – EW to E – W corridors represent tight and high meander passages sloped along tectonic features to NE – E.

There are five genetical levels and two horizons in SC (Tulis – Novotný, 1989) in a vertical span of 140 m (the depth of the cave is 194 m):

Underground camp in the Stratenská Cave. Photo: L. Novotný

B horizon in 995 to 977 m a. s. l.
V. genetical level in 970 to 960 m a. s. l.
IV. genetical level in 950 to 930 m a. s. l.
III. genetical level in 925 to 912 m a. s. l.
II. genetical level in 907 to 890 m a. s. l.
A horizon in 886 to 876 m a. s. l.
I. genetical level in 868 to 855 m a. s. l.

The largest and most important genetical level is the 4th one. The cave rock surface is modelled into the shape of karren, flattened ceilings, ceiling and lateral meanders and pots, facetten, anastomosis, pendants, bottom meanders etc.

Ponorný sump is the deepest point in the cave system. Photo: J. Tulis

Cave sediments are of various genetical types: A. aquaeous chemogene sediments (a, flowstones and dripstones: gravity formations – stalagmites, stalactites and anomal formations – helictites, excentriques, calcite crystals, b, calcite aggregates from water solution: bottom flowstones, flowstone dams, pisoides, hemispheroides, cave pearls, calcite crystals, c, aragonite and gypsum crystals), B. water mechanic sediments (pebbles, sands), C. restits (fossil breccia, clays), D. gravitational sediments, E. organogenic sediments, F. kryogene sediments

The cave is an important site of the occurrence of calcite hemispheroides. They were described as the first occurrence of this type of cave sediment in the world (Novotný – Tulis, 1974). Formations were created 21.15 ± 2.66 to 23.43 ± 1.05 ka ago, during the last ice age, from a slow freezing water solution (Žák et al., 2003). Hemispheroides from SC are also published in Cave Minerals of the World (Hill – Forti, 1997).

Aquaeous mechanic sediments represent the deposits of autochthonous and alochthonous flows. There are 3 types of alochthonous pebbles here: Hnilec type, Tiesňavy type, mixed type. The palaeoflow reconstructions show that Palaeo-Hnilec brought sediments to the cave from the NW direction and Palaeo-Tiesňavy from S-SE direction.

2.1.1.2. Psie Diery Cave

PDC is the second longest cave of the DSCS cave system; it has been known from time immemorial. SKSR cavers started exploration of the cave in 1974, when they surveyed the Entrance hall and Direct Corridor. During the mapping of the cave's 320 m length, they discovered intensive air draught flowing through the break-down. In 1988 cavers extended the cave to 2,670 m, and in 1994 interconnected PDC with SC (Miháľová, 1994). PDC is important for its dripstone and flowstone decorati-

Cave bear's skull in the Psie Diery Cave.
Photo: L. Novotný

Cave bear's scratches at the wall of the Psie Diery Cave,
Photo: L. Novotný

on; the area of dripstone pools is about 100 m^2. Spaces below 880 m a. s. l. are permanently flooded. The cave has a dynamic air draught.

The cave was created in grey Wetterstein Limestones dissected by tectonic structures of a NNW – SSE and NW – SE direction with dip direction of ENE – NE (58° – 70°) as well as NNE – SSW to NE – SW with dip direction of ESE to SE (46° – 88°). Cave passages follow the tectonics. In ground-plan, the passages are arranged in the shape of an "X". A branch of the NNE – SSW direction represents the most important space in the cave: passages with a slight decline run SSW to NNE. 4th and 2nd genetical levels occur in the cave (as in Stratenská Cave), the vertical parts are less abundant. Passages of the 4th level of the NNE – SSW and NNW – SSE branches were created by Palaeo-Tiesňavy brooks at the same time as the creation of the surface "mid mountain level".

The dimensions of the corridors range from crawlings to corridors with widths of up to 10 m (max. 27 m) and heights up to 15 (usually 3 – 7 m). A wide variety of cross sections with ceiling and wall karren (anastomoses, pendants) is a result of the development of passageways in the phreatic and epiphreatic zone (mainly sloping tubular chimneys), often remodelled in a vadous zone (bottom meanders). Wall and ceiling meanders point to the phreatic development.

Cave sediments represent: A. aquaeous chemogene sediments (stalagmites, stalactites, flowstones, excentriqes, calcite crystals, flowstone dams; the richest dripstone and flowstone decoration is in the northern part of the cave: white to brownish coloured stalagmites up to 3 m high covered by calcite crystals), B. aquaeous mechanic sediments (alochthonous pebbles of Tiesňavy type), C. restits (clay), D. gravitational and E. organogenic sediments. Organogenic sediments contain a rich deposition of cave bears' bones with an age of 15 490 (± 780) to 17 530 (± 900) years (Pomorský, 1993). Bears have lived in the cave for at least 2,000 years.

The Neo-Alpine karstic period, the period of "mid mountain level" creation, was the most important period in the creation and development of underground spaces in the PDC. The 2nd genetical level was mainly developed during the Quaternary period, when the 4th level also continued to develop. The phases of destruction, flowstone and dripstone creation are described by Tulis – Novotný, 1989.

2.1.1.3. Duča Cave

The part of DSCS with an entrance in 996 m a. s. l. has been known from time immemorial. Members of SKSR explored and mapped the cave in 1986.

The DC was developed in Steinalm Limestones. The direction of underground spaces determine NW – SE diaclases crossed with E – W diaclases. The spaces are mostly between fallen boulders and blocks of limestone. The main cave space is oriented in the direction of N – S, with widths of 15 – 20 m and heights of 1 – 10 m. In the spring months (e.g. in April) the bottom of the cave is covered by a number of ice stalagmites, and ice hinges hanging from the ceiling are 2 to 5 meters long.

Great Corridor in the Duča Cave. Photo: P. Hovorka

In the southeast part of the cave, about 980 m a. s. l., traces of river modeling are preserved on the wall of the cave. We consider they are the remains of the underground spaces created by the Palaeo-Hnilec during the Pre-Upper Eocene stage (as B. horizon in Stratenská Cave). Similar remnants of river modeling in the level of about 985 – 990 m. a. s. l. were also found in the Duča depression. At the time of the 3rd high terrace formation (Mindelian), the slopes were undercut, and and the subsequent destruction remodelled the DC caves to their present shape. The DC is a remnant of once large cave spaces.

The spaces of DC are oriented to the south in the vicinity of DLC. In 2012 – 2014 new spaces of SZ – JV direction were discovered. They correspond to the 3rd and 4th level of the cave system. The underground corridor reached the length of 1,248 m. On January 30, 2015, cavers discovered the continuation from Stratenská Cave into the Duča Cave.

2.1.1.4. Dobšinská ľadová Cave

The DLC is a part of DSCS (Tulis – Novotný, 1989). A cave space with ice fill was discovered by E. Ruffíny on June 15, 1870. Dry parts without ice were discovered by J. Mišelnický in August 1947. The cave was surveyed for the first time by L. Šimkovič (Kvietok, 1947–48), then in 1950 by A. Droppa. After mapping by Novotný – Tulis (2001) a complete speleological and geological map of DLC was drawn; the newest map was created using sw. Therion. According to Droppa (1950), the length of ice-filled spaces is 753 m and dry parts reach 729.8 m; the total length of the cave is 1483 m. Part of the cave is open to the public (475 m).

In DLC three types of Steinalm Limestones were found (Novotný – Tulis, 1999a, 1999b). Tectonic structures include: joints, faults without fill, faults filled by tectonic breccia, empty faults, gravitational structures, flexures of folded layers. A great anticlinal fold follows a line from the "Great Hall" to "Fallen Dome" and Duča depression. The most important tectonic faults are developed predominantly in two directions (Novotný – Tulis, 2001): NW – SE with dip direction to NW (35°– 86°) and N – S to NE – SW with dip direction to E – SE / W – NW. Morphologically, the first system of faults is dominant.

Coarse-crystalline ice in the Dobšinská Ice Cave. Photo: J. Tulis

Ice filling ing the Dobšinská Ice Cave. Photo: J. Tulis

After a working action in the Dobšinská Ice Cave. Photo: L. Novotný

Water inlets to the underground are mostly scattered, and are represented by a dripping from the ceiling of varying intensity. Drainage water is the source of the formation of chemogenic cave sediments – cave decoration and ice fill. The space with ice fill represents one enormous underground cavity with a volume of more than 140,000 m^3, sloped in an angle of 400 to the depth of 70 m. The volume of ice monolith is more than 110,000 m^3. Dry parts of the cave are horizontal (Novotný – Tulis, 2001), the widths of corridors are very variable, from 0.5 to 46 m, heights from 0.6 to 6 m. One shaft occurs in "Dripstone Hall".

DLC passages are described as part of the 4th level of the cave system (950 – 930 m a. s. l.), and break-downs on the bottom of the 4th level indicate the existence of lower levels (especially in 925 – 912 m a. s. l.; Tulis – Novotný, 1989, 2002).

The occurrence of fluvial sediments (gravel, sand) brought to the underground spaces from non-karstic areas proves the genesis of the cave by allochthonous underground flow – Palaeo-Hnilec.

Aqueous chemogenic sediments occur mainly in non-iced parts of the cave: stalagmites, stalactites, flowstones, pisoids, coralites, calcite crystals, flowstone dams. Flowstones are common in the cave as well as on surface slopes.. Restits (clays) are the most common top sediments on deposits, gravitational sediments are products of walls and ceilings destruction. Organogenic sediments consist of bats' guano and bones.

The ice fill has a depth of 26.5 m (Géczy – Kucharič, 1995) and a volume of 110 000 m^3 (Novotný – Tulis, 1995, 1996), which is the 2nd greatest underground ice monolith in Europe. It originated under special geological, geomorphological and climatic settings.

On the basis of current knowledge, we are interpreting the course of the Palaeo-Hnilec underground. From the "Ponor Corridor" (about 200 m to the entrance of DLC), we have deduced the course through the fallen blocks to the ice-filled part of the cave. Another course is presumed through the collapsed part under the Duča depression to the Stratenská Cave.

During the Lower Pleistocene and Tertiary, SC + PD + DC + DLC were interconnected to one underground system created by the Hnilec river and Tiesňavy brook. We suppose, that during the formation of the 3rd terrace (Mindelian) by the Hnilec river, denudation,

Members of the Speleological Club Slovenský Raj. Photo: M. Smatana

Caving camp in the Slovenský Raj. Photo: T. Hovorka

slope destruction and sinking was simultaneously occurring. The sinking of the ceilings divided the original one cave into two separate caves. Thus, suitable climatic conditions for the creation of ice fill in DLC were created (Tulis – Novotný, 1989). Dripstones and flowstones continued to form in separated SC. This process took place either in the Upper Mindelian, or possibly Rissian period (Novotný, 1995). The ice fill creation started in the glacial stage of the Rissian period (250 – 140 ka; Novotný – Tulis, 1996).

Long-term observations in the ice-filled part of the cave revealed changes in the air temperature from -3.8 to +0.5 °C. The rock mass was also cooled down to a depth of 0.5 – 1 m. It demonstrates that the entire cave represents a very complex system from the point of view of microclimate, and for its knowledge and understanding, long-term systematic observations are needed in the whole cave system. In 2000, the DLC with SC, for their extraordinary natural values, were registered in the List of World Natural Heritage (UNESCO).

The biggest and most important problem of the cave system is how to find the outlet of underground rivers Palaeo-Hnilec and the Palaeo-Tiesňavy to the surface. Some caves on the left slopes of the Tiesňavy valley confirm our assumptions that the Palaeo-Hnilec brook outflowed from the underground in the Tiesňavy Valley. This is also the most important task that members of Speleological Club Slovak Paradise are currently dealing with.

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Young generation of cavers. Photo: P. Smatana

BOBAČKA CAVE AND PERSPECTIVES OF NEW DISCOVERIES IN MURÁNSKA PLATEAU

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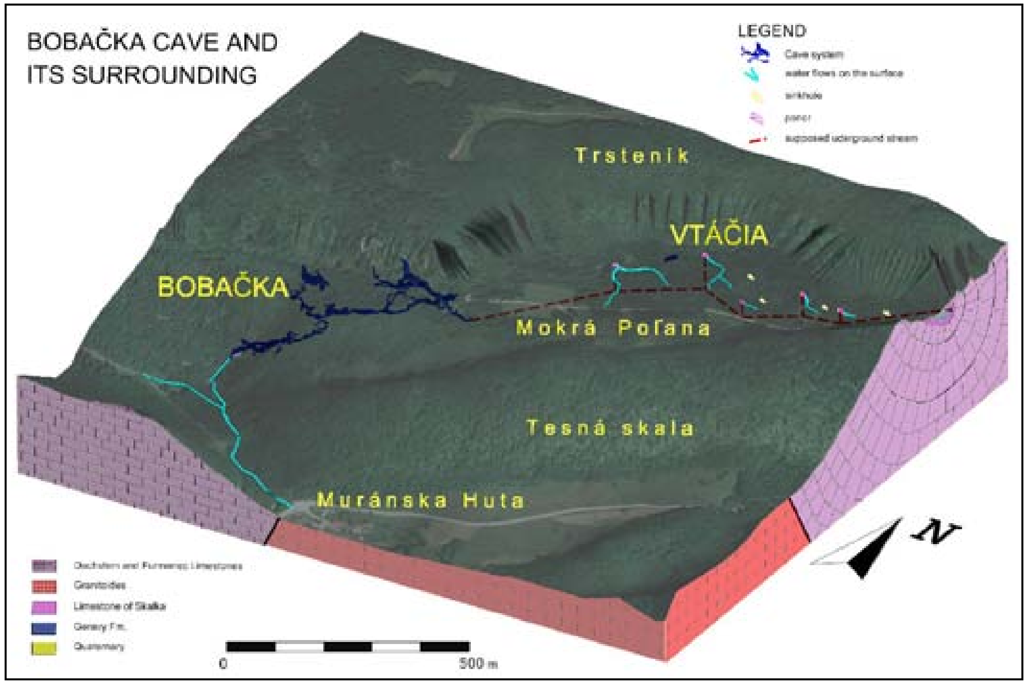
Speleoklub Muránska planina – Slovak Exploring Team

The Bobačka Cave represents the most important endokarst phenomenon within the entire Muránska plateau karst region. Up until the spring of 2017, the length of surveyed cave spaces reaches 4564 m and the cave still continues. It is now the 13th longest cave within Slovakia. This fluvially active cave was created at least in two genetical phases, both of them suppose an attendance of several allochtonous water streams. Despite the cave originating in the massif of triassic and Jurassic limestones, the cave sediments consist predominantly of pebbles and sands of cristalline massives.

The cave spaces, which were dated by P. Mitter, are developed in several levels. The horizontal main corridor from the 2nd entrance to the terminal sump is a wonderful experience for all visiting cavers – spaces are great, well decorated and half of the cave has an active water stream at its base. The few sumps can be easily bypassed by higher developed corridors, which are richly decorated with flowstone and dripstone formations.

The Bobačka Cave represents predominantly a divers' challenge. The so-called "Old Bobačka" was known from time immemorial. The entrance is situated near the resurgence. The cave ended after 120 metres by a sump. This point was dived through in 1973, when P. Ošust and T. Sasvári dived to the opposite side and climbed a chimney to the cave's continuation. Cavers surveyed the cave to a length of 1250 m and used a cave map to decide about digging the second "dry" entrance only a few metres from the old one. That was the time when the activity in the cave was taken over by the members of OS Tisovec (S. Kámen, B. Polák, D. Ježka et al.), cavers from Muráň, Revúca and Košice.

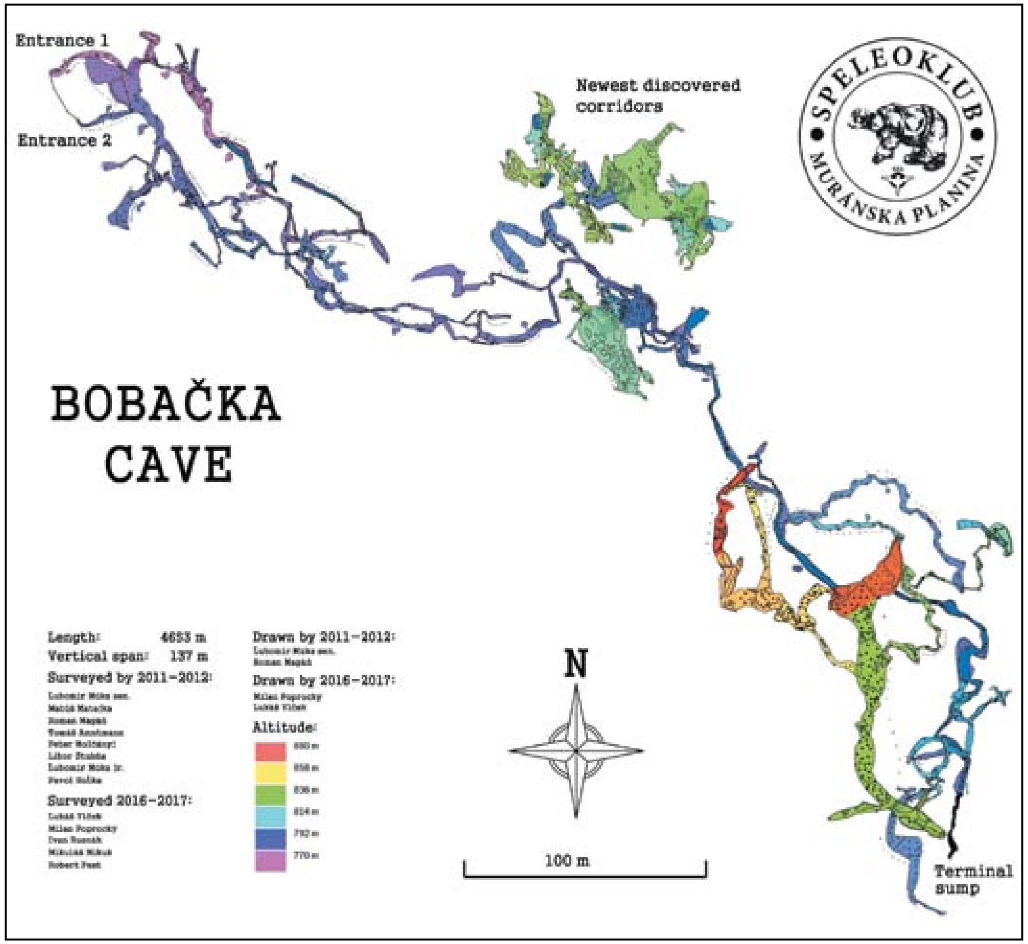
01 – Formations in the main corridor of the cave. Photo: K. Papuga



Further important exploration and discoveries followed between 1985 – 1989 by V. Korfanta, P. Martinove, L. Kováč, K. Merta, M. Terray, M. Kuchár and others. They continued exploring and surveyed about 800 metres of corridors. Diving in the terminal sump was realized by V. Ďurček, Z. Hochmuth and F. Koľbik in 1989; they also dived in the sump in the middle of the cave. Both sumps ended by narrowings after about 20 metres. Unsuccessful attempts to dive through the sumps were realized B. Šmída, J. Blaho, M. Ševeček and Z. Schusterová in 2001 and 2016.

The discoveries of upper level corridors came in 2001 – Mammoth Corridor and surroundings. They were realized and described by B. Šmída et al. Another upper level was discovered by authors of this article, who climbed the chimneys, enlarged narrowings and surveyed the new-discovered spaces in cooperation with many local cavers and an international team of cavers from Poland and the Czech Republic – M. Mikuš, R. Pest, A. Konopelski, R. Wykręt, K. Halfarová, T. Pospíšil, J. Macháček, D. Janák and others in 2016 – 2017. They discovered the most voluminous dome of the whole cave – the Great Dome (the longest parameters ca 60 × 30 × 25 m), Jesenícky dóm (Dome of the Polish-Czech friendship), Paks Hall, Gandalf's Dome etc. The domes, corridors, chimneys and shafts are richly decorated not only by flowstone and dripstone formations, but also by crystals of aragonite, gypsum, calcite helictites, morphogenetically unusual forms of flowstones,

Diving in the terminal sump. Photo: M. Poprocký



hydroxilapathite crusts etc. Many of the chimneys are still untouched by climbers and some cave corridors have not yet been surveyed. We suppose the continuation of the cave deeper inside the massif, where the water streams and air draught directions lead us to.

The cave is important from the hydrological point of view. The NE – SW cave direction crosses through the plateau Some of the waters are autochtonous, proved by a tracing test on Mokrá

Untouched chimney in the last-discovered spaces. Photo: L. Vlček

Poľana in 1963 (coloured water reached the 1 km distant resurgence with denivelation of 135 metres in 10 hours 10 min.). Here we found a new cave in 2016 – the 200 metres long Birds' Cave, with massive air draught and beautiful dripstone formations. Other waters have alochtonous provenance – they come from the Javoriny massif, where there are few known ponor depressions with caves up to 100 m long and several metres deep. Theoretically, the catchment area of Bobačka resurgence rises from the Hron Valley on the north to the Veľká Lúka on the south. The yield of resurgence is from 30 – 100 l.sec^{-1} to Qmax = 291 l.sec^{-1} to an immeasurable volume. There are geological and hydrological indices of possibility for discovering one of the longest cave systems of Slovakia. We will see...

The Bobačka Cave is one of the most important caves within Slovakia. In 1970's cavers were thinking about opening the cave to the public. Because the water from the cave is still used as a source of drinking water for adjacent settlements, this idea is still a future venture.

Speleoalpinistic aproach to exploration. Photo: L. Vlček

Dripstone decoration in the Jesenícky Dome. Photo: L. Vlček

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MANGALICA CAVE: SLOVAK – POLISH PROJECT IN TISOVEC KARST

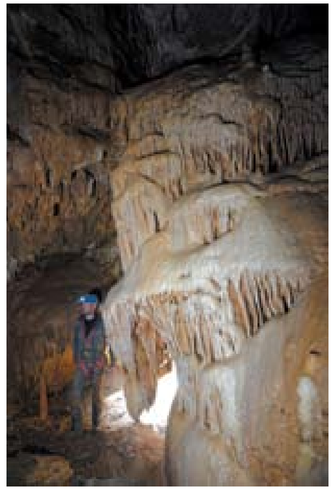
Lukáš Vlček – Mariusz Miedziński – Robert Pest

Slovak Exploring Team

Tisovec Karst in central Slovakia belongs to the area of the Muráň karstic plateau, which is built mainly of Mesozoic limestones and dolomites, as well as other sedimentary rocks of several geotectonic units. It is divided by several Tertiary faults of a S–N orientation, which underpin the direction of the drainage of underground water from ponors to resurgences. The central part of Tisovec Karst represents a semiclosed, irregular depression of about 1 km in diameter, called Suché doly (Dry valleys). Because the depression is geologically divided into two units, the direction of underground water flow, following the lithological settings and tectonics, is divided too. Tracing tests proved Teplica resurgence, in the north of the area, has the most number of connected ponor caves; the supposed connection with resurgence Bôrová to the south is still unclear. The distance between the caves and resurgences is about 2 km and the time of positive tracing tests is about 22:30 to 23:30 hours, which is evidence of complicated siphonal spaces in the unknown part of the massif.

Suché doly karstic area. Photo: L. Vlček

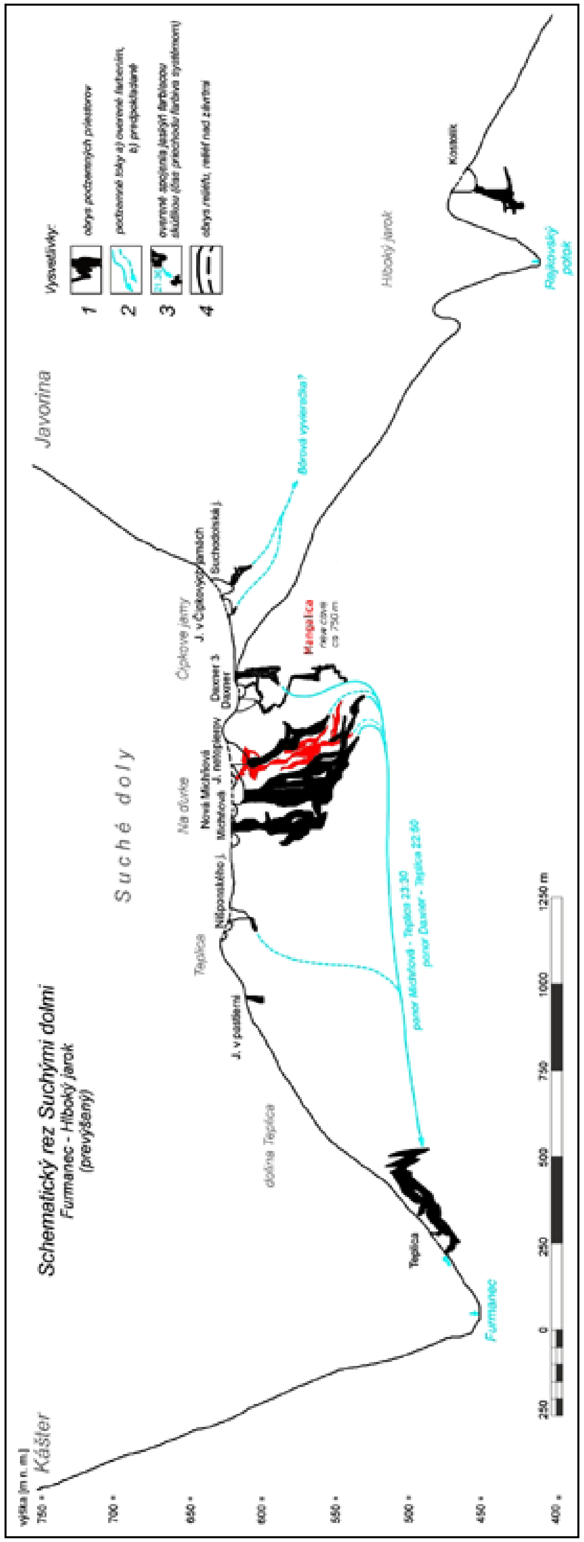
Untill spring 2017 we knew 15 caves, together more than 2.5 km long, within the area of Suché doly: the most important were Nová Michňová (1227 m / 97.5 m), Michňová (336.5 m / 72 m), Jaskyňa netopierov – Bats' Cave (175 m / 69.5 m), Daxner (350 m / 65 m) and Suchodolská Cave (42.5 m / 22 m). All



Dripstone decoration in the domes under the shallow surface. Photo: M. Miedziński of them are up to 100 m deep, and end in narrowings, sedimental plugs or water sump at the bottom. In May 2017 we discovered a new cave, which is still unexplored to the end; exploration of the shafts and chimneys is still continuing.

The name of this new cave is Mangalica. It consists of a few domes and several shafts with a depth of 6 to 30 m, which are interconnected by thin but high meander corridors. From the depth of -70 metres they continue with 3 branches; the deepest one led to a 200 m long horizontal corridor which ended with sedimental sumps on both sides. Two others are vertically developed, with narrowings in the deep and with still unknown continuations in chimneys. Domes, shafts and chimneys are spacious; the diameter of the biggest shaft is about 7 metres. The cave is well decorated by dripstones and flowstones, dripstone pools, straw stalactites etc. Crystals of calcite and gypsum occur on the rocky walls. Geological borders are visible inside the cave. They are accompanied by tectonic shales and breccia and in many places are covered by a muddy film.

The history of the discoveries of Mangalica Cave began a few years ago, when we regularly visited tens of sinkholes in the surroundings of Michňová and Nová Michňová caves. Between 2011 – 2013, we found one sinkhole was naturally deepened along a small rocky wall, but after 2013 the deepening stopped. In May 2017 we visited the sinkhole again and decided to start digging along the rocky wall. After one digging action we reached a small shaft, but the entrance to the cave was too narrow. A second action took us another way, which had previously been filled full with muddy sediments. Only 3 meters



Schematic exceeded longitudinal cut of area of Suché doly. Explanations: 1. caves outline, 2. underground streams – a) proven by tracing tests, b) supposed, 3. proven continuation of caves with time of transition, 4. surface, surface above the sinkholes. Drawn by L. Vlček

of digging was enough to discover a narrow fissure corridor steeply descending to the first dome, second dome and series of shafts of the main cave line. There are only a few places left to dig at -70 m; some chimneys were climbed and up until now, the remaining unclimbed chimneys are still unmapped. The mapped length of the cave has reached 700 m with a depth of 75 m. It will be longer soon.

The history of cave exploration has also another dimension – international cooperation. From the first moment, speleological actions were organized as international expeditions of Polish and Slovak cavers, coordinated by the Slovak speleological group. The number of Polish cavers interested in the Mangalica discoveries far outweighs the number of Slovaks, so we can infer that the discovery of Mangalica Cave is the biggest cave discovery by Polish cavers in this area of Slovakia in the whole history of Slovak-Polish speleological cooperation. We are thankful to many friends from many speleological clubs (in alphabetical order): Aleksander Bzducha, Janusz Deveń, Kazimierz Gięd ś, Dušan Hutka, Katarína Hutková, Karolina Charaziak, Przemek Chrobak, Ivo Kámen, Łukasz Kuśnierz, Mariusz and Paweł Madej, András Kovács Levente, Slawek Haterniak, Andrzej Konopelski, Mateusz, Marysia, Pola and Bartek Latoń, Adam Małachowski, Mariusz Miedziński, Paulina Bobak – Miedzińska and Tymek Miedziński, Krzysztof Papuga, Krzysztof, Viola and Julka Pawlusiak, Robert Pest, Milan and Martin Poprocký, Monika Tršková, Peter Veták, Lukáš Vlček, Szymon Wajda, Łukasz Wolak, Bolek Zięba and Jerzy Zygmunt (Slovak Exploring Team, Speleoklub Tisovec, Speleoklub Tatrzański PTTK, Speleoklub Brzeszcze, Speleoklub Muránska planina, Speleoklub Częstochowa, OS Čachtice, Speleoklub Olkusz, Speleoklub Aven Sosnowiec, Sądecki Klub Taternictwa Jaskiniowego PTTK, Speleofanklub Krówie Oko and friends).

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Vertical parts of the cave. Photo: R. Pest

WHAT, IF ANYTHING, DO WE KNOW ABOUT THE JAZERNÁ CAVE?

Lukáš Vlček – Dušan Hutka – Peter Kubička – Ján Blaho – Michal Ševeček – & Tomáš Lánczos

Slovak Exploring Team – Speleoklub Tisovec – Section of Speleodiving – Speleo Bratislava – Speleoklub Trnava

The Jazerná Cave, (the Lake Cave), is situated in the SE part of Muráň Plateau, near the city of Tisovec (the area is called Tisovec Karst). The altitude of the entrance is 483 – 485 m a. s. l., approximately 20 m above the Periodical Spring in the Furmanec Valley, and 23 m above the erosional basis of Furmanec brook. The length of the cave is 270 m with a vertical span of 42 m. It was one of the first discovered caves in the area, known since 1952 (Kámen, 1953a, b, c). A few underground lakes, interconnected through siphons with the Periodical Spring, were discovered in the cave. One of the first speleodives in Slovakia happened in the Jazerná Cave. The flooded space is situated deeper than the erosional basis of the adjacent valley.

The first explorers of Jazerná Cave, 1952. Photo: D. Ježka

The water of the Periodical Spring is one of two intermittent springs within the area of the Western Carpathians. The spring discharges from the 10 m long cave with the same name. The oscillation of the discharge is $Q = 2.0 - 70.0\ l.s^{-1}$ in time periods of ca 45 minutes (Kámen, 1953; Padúch, 1998; Michalko and Vojtková, 2003). Nowadays the spring is used as a source of potable water for the Tisovec region. The periodicity of outflowing water was described also by Pacl (1949) and Kámen (1955, 1958, 1959a, b). All the cited articles are concluded by a hypothesis assuming a depressurized siphon system;however, this assumption has not yet been proven. Mišík (1953), Kámen (1954, 1959a) and Vlček et al. (2013) emphasized the need for protection of this unusual, and – from the geomorphological, hydrogeological and speleogenetical points of view – extremely important karst site.

Dry part of the cave. Photo: L. Vlček

The cave morphology, space configuration and still not clearly explained origin of the water in Jazerná Cave, led to an explanation of the formation of the cave by a hypogenic speleogenesis. The cave was modelled by atmospheric water flowing from the Hradová (Grúniky) massif and maybe also by the sinkhole water from the Kášter massif crossing the valley uprising through the deep tectonic faults situated close to the axis of the Furmanec Valley. Hints for this conclusion came from the hydrogeological mapping and papers of Vojtková and Malík (2002), Michalko and Vojtková (2003), Vojtková et al. (2008) and also from a detailed study of the geological map of this area (Vojtko, 2000).

The underground hydrological system of the Jazerná Cave and the Periodical Spring were investigated by speleodivers in the last few years (P. Kubička, J. Blaho, M. Ševeček). They have discovered a new space at the bottom of a flooded abyss of the Jazerná Cave. Another strange phenomenon which occurred, and was documented the first time in 2014, is a cloud of mud periodically blown into the water body from the thin corridor at the bottom of the above mentioned abyss. The explanation of this unusual phenomenon is still unclear.

The boat at the lake. Photo: L. Vlček

Diver in a side lake. Photo: J. Ondruš

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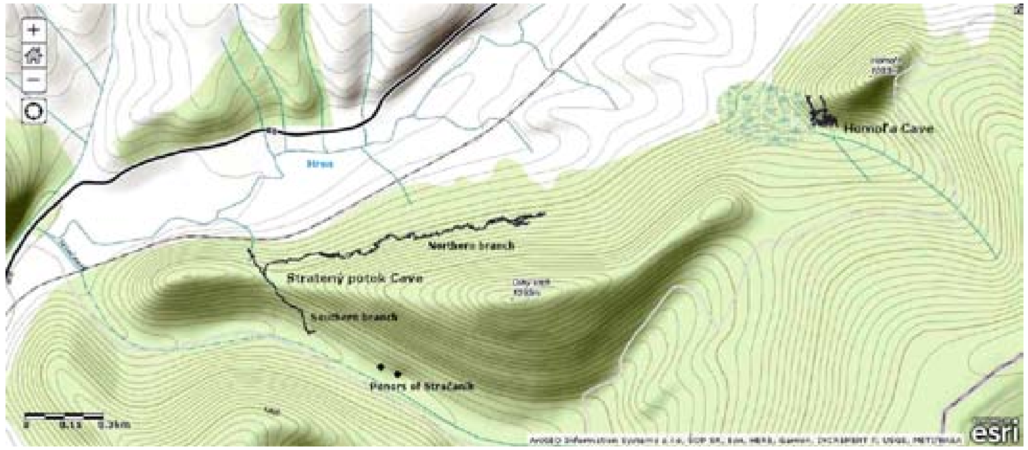
NEW DISCOVERIES IN THE STRATENÝ POTOK CAVE (MURÁNSKA PLATEAU)

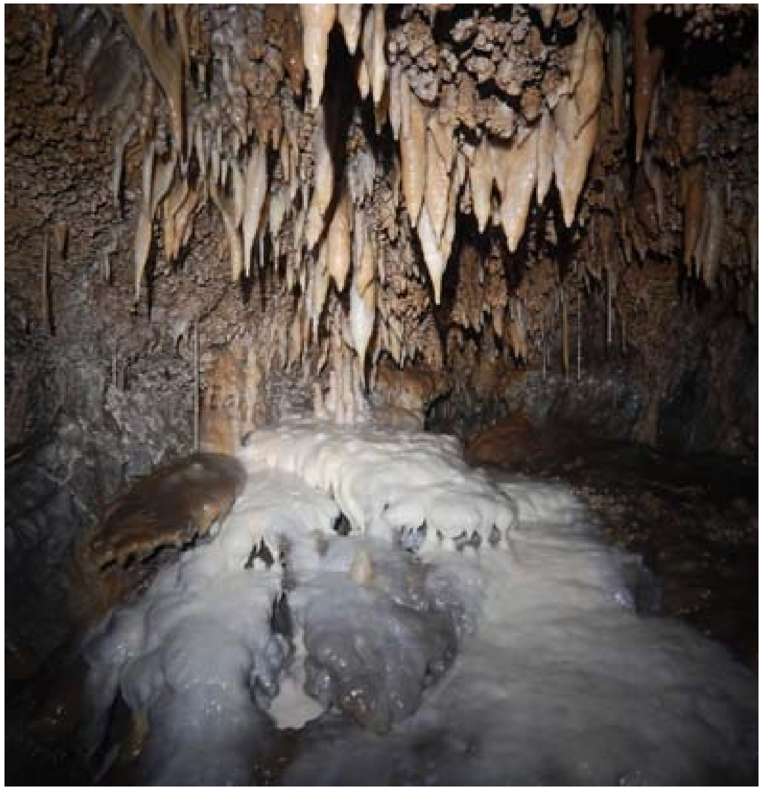
Jozef Psotka
Speleoclub Drienka

The karst area in the northeast part of the Muránska planina plateau has interested cave explorers from the first quarter of the 20th century. It's an area of contact karst, with streams originating on crystalline rocks disappearing underground on contact with the limestone terrain. The Stračaník stream, which disappears underground under the Dlhý vrch Hill and the big resurgence near the railway viaduct on the opposite side of the hill, hinted at the existence of a large cave beneath. Several generations of cavers have tried to penetrate the cave; in 1926 it was the caving group from Banská Bystrica, a member of Karpathenverein – a German national tourist organisation (Schön, 1926). During the 1950s the area was explored by cavers of the Karst section of the National Museum in Prague (Skřivánek, 1958). They dug in sinkholes and in resurgence too. A tracer experiment was performed in 1958 and it proved a hydrological connection of the stream from the sinkhole cave Homoľa and the disappearing Stračaník stream with the resurgence near the railway viaduct (Benický, 1959). In 1960, cavers from Tisovec, and later in 1970 a group of cavers from several clubs of the Slovak Speleological Society, tried to penetrate through the sinkholes and resurgence (Kámen 1961, Chovan 1972), but none of these attempts was successful. Since then, in 1988 there were attempts by cavers of Speleo Detva Club to enlarge a narrow crack above the resurgence, but they did not

The Water Corridor. Photo: V. Papáč



continue later. During the 1990s cavers from Revúca (Speleoclub Muránska planina) worked on sinkholes of the Stračaník stream, but they couldn't continue through the narrow crack, and later their dig was destroyed by floods. In the early 2000s sinkholes were excavated again by members of Speleoclubs Muránska planina, Drienka and Comenius University, but their dig was not successful because of unstable blocks and large amounts of sediments. They also tried to work on the resurgence side but it was obvious that the impassable narrow crack couldn't be overcome without technical means. The cave was finally discovered in 2003 by a then beginner but enthusiastic caver, I. Pap, with R. Macháň, who used a generator and drill to overcome the 16 m long crack. The cave was named Stratený potok (Lost creek) and it was explored and surveyed at the beginning of the year 2004. It reached a length of 1542 m and had 25 m of height difference (Pap et al., 2004). Discovery of the cave was greatly popularized by the media. It has caused some problems with the authorities because the explorers did not have a caving permit. Since then, caver I. Pap discovered a large cave Mesačný tieň (Moon shadow) in the High Tatras



Dripstone formation in the cave. Photo: V. Papáč and the Stratený potok Cave was forgotten. After several floods the entrance crawlway become impassably filled with sand.

Members of the Speleoclub Drienka started to work in the cave in 2013 after an agreement with the Speleoclub Muránska planina. Cavers from the Drienka club have been working in this karst area since 2001 and have surveyed two larger caves (Homoľa Cave 1737 m long, Ladzianskeho Cave 1212 m long) and discovered and surveyed a number of smaller caves. After digging and enlarging the entrance crawlway they started to explore the Northern branch of the cave Stratený potok, which is connected hydrologically with the sinkhole cave Homoľa, the entrance of which lies 2400 m from the Stratený potok Cave. After 13 working trips a 20 m long impassable narrow was finally enlarged; it leads to a large continuation of the cave. Following the narrow fissure passages, there are larger, comfortable walking passages which lead again to an active stream. The stream passage has a length of about 700 m and is terminated by a sump. Newly discovered passages had several constrictions which were partially enlarged by drilling. Through two fissure chimneys an upper inactive cave level was discovered. It has larger dimensions than the lower level and there are a lot of speleothems and breakdown deposits. Continuation of the upper level was discovered after overcoming a 30 m long breakdown. Explored passages (ca 400 m long) are the most spacious in this cave and consist of two levels of former stream passages. They are terminated by a large breakdown in which a spot with a strong air draught was located. This is the most promising place for further continuation of the cave, but it requires a lot of work and a lot of difficult transport in particular. The participants of the exploration and survey of the new discoveries in the Stratený potok Cave were: P. Fencik, M. Gaško, D. Majoroš, M. Miškov, V. Papáč and J. Psotka (Speleoclub Drienka), P. Imrich and F. Majerníčková (Speleoclub Šariš). The cave map was drawn by P. Imrich. The cave reached a length of 3189 m with 40 m of elevation difference.

Dripstone formations in the upper floor of the cave. Photo: V. Papáč

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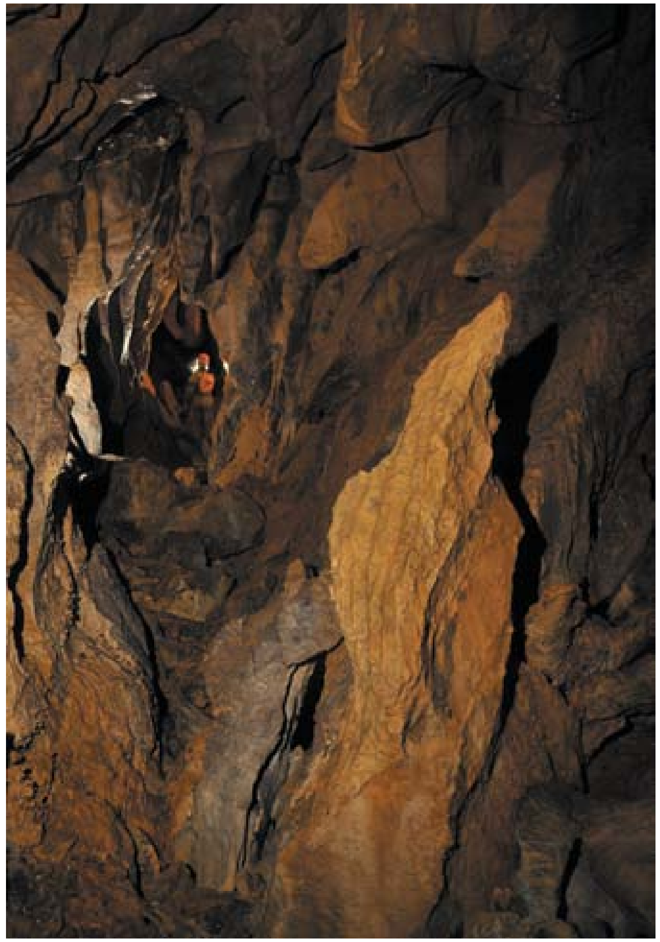
THE THIRD FLOOR OF PROSIECKA CAVE

Juraj Szunyog

Speleoclub Chočské vrchy

Prosiecka Cave was discovered through a fissure entrance and a tight cave with a provisional name O-3. Efforts to discover the cave system in the Prosiecka Valley began almost a hundred years ago. When I first entered cave O-3, in 1997, the cave was 57 m long. After years of efforts of cavers from the Speleoklub Chočské vrchy, the length of the known parts is now nearing three kilometres.

When the second floor of the cave ended without a clear continuation, we started to look upwards. Although cave continuations often seem illogical, our assumption was correct. The cave continues on the 3rd floor.



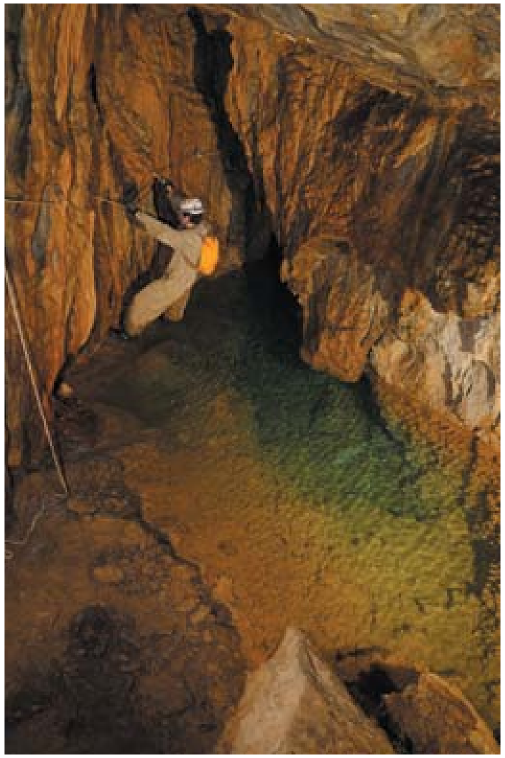
Corridor in the opposite direction. Photo: J. Szunyog

At the end of the second floor, we found three places with air draught, where it seemed that long-term work couldn't be avoided. They are mentioned in an article in Bulletin '2013. The fourth place with the biggest air draught was my secret at that time. It was discovered on July 23, 2013. Being so distant from the entrance, we were unable to develop a meaningful activity in the cave. It was necessary to proceed systematically in the cave; not just mapping but also enlarging the main route.

The most urgent enlarging was required in the Abyss of Sighs – a vertical crack crawling with a total elevation of 13 m. It was an unpleasant slippery place, wrapped in a semi-soft mantle of moonmilk full of water, which we then brushed off our overalls for the remainder of the main route of the cave. In the fissure where the ladder was fixed, both the ladder and the man did not fit together easily; it was necessary to squeeze against the ladder and slide down it. This could not work in the long term. When we found another floor, during 2014, it was necessary to enlarge the Abyss of Sighs to a length of 16 m. At the top of the shaft, we placed four iron footholds, so that on the ladder you can climb even with your backpack on. With Slávka we transported the debris to cracks and niches in the cave. Enlarging the space called Krkaháje behind the Abyss of Sighs was also needed.

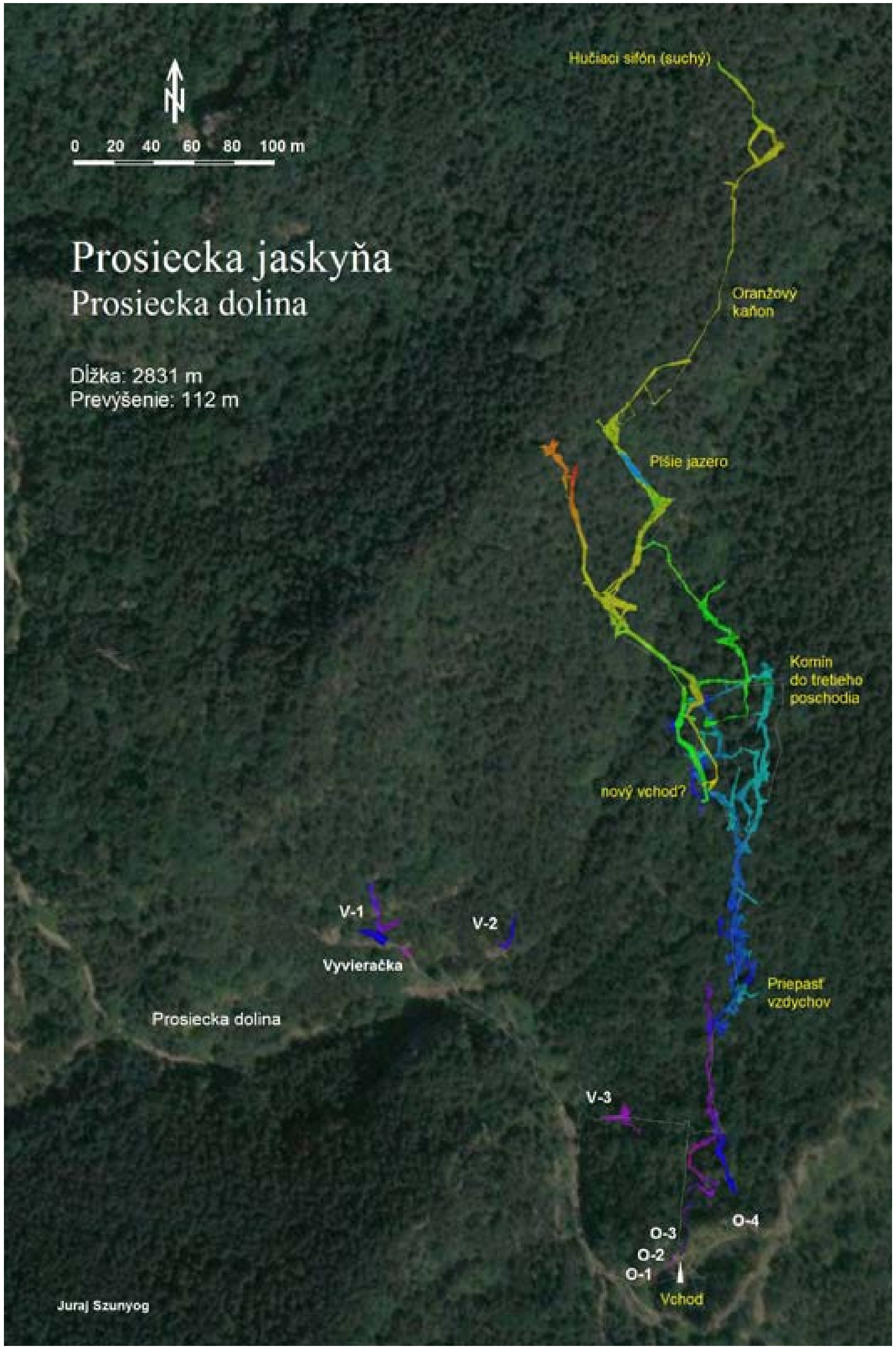
All this unpleasant effort was motivated by what could come next. The first floor had a length of 300 m, the second 1200 m. Would the third one be four times longer than the previous one? What about other floors? But back to reality! The decisive air draught site was the narrow chimney similar to the Abyss of Sighs. It was partly wet, but at least there was no moonmilk. In its center, however, a rig was created from the hard sinter, which made a support point for pushing ourselves upwards. At the end of 2015, the 25-meter-long chimney on the 3rd floor became another major enlarging place. In addition to the 8 m long vertical section at its top, all its narrow parts had to be enlarged. The bonus is a horizontal crawlway, 7 m long. The chimney starts at the top of the 2nd floor in Buffet II. By overcoming it, we get 21 m higher up to the third-floor horizontal corridors, which are a bit more comfortable to pass because sloping cracks are rarely found there. On December 4, 2015, with Slávka, we mapped the chimney to the 3rd floor, and officially discovered the 3rd floor. On December 12, we mapped the horizontal corridors to the small breakdown with an air draught to a total length of 238 m. Behind the breakdown we found a low crawling to the hall (Buffet III), from which the corridor led to the massif.

There is a 20 m long lake in a straight corridor directing to the massif. Within 10 meters the water level is lower than gumboots, but then the depth increases to 1.5 meters. Due to finding the remains of two dormice in this part of the cave, we called the lake Dormice Lake. At Christmas 2015 I gave myself a present of a small inflatable boat for one person and one child. After Christmas lunch on December 25, 2015, I set off with a boat, paddles, photo equipment and a great curiosity to Dormice Lake with Slávka and Martin. At Buffet III we inflated the boat using a “frog“ pump. Slávka, as the smallest of us cavers, sailed us one by one to the opposite shore. Dormice Lake and the small hall behind are the most beautiful cave spaces, filled with colourful dripstone formations. These spaces led to the Black Canyon, where the black flowstones are decorated



Traverse above the Dormice’s lake. Photo: J. Szunyog

Dormices’s lake. Photo: J. Szunyog



Small lake behind the Dormice's lake. Photo: J. Szunyog

with cream-colored dripstone formations. The 30 meters long canyon ended with an extreme narrowing through which only I crawled, but after another 60 meters I was stopped by another narrowing in the Orange Canyon.

Then we turned our attention to the corridor leading back to the southwest. We walked a relatively spacious corridor 200 m down to the sloping part, where the corridor ends with a sedimentary siphon. We focused on finding a second branch that brought us to two Tea Lakes, that were named after the yellow color of the water. Above the northern lake, we found the fine roots of trees. We knew that the surface could not be far away and the idea of a new entrance to the cave came immediately. Theoretically, we could bypass the most uncomfortable 1st and 2nd floors. Arrival at Buffet III would be reduced from 1.5 or 2 hours to a quarter, moreover, with considerably easier transportation of material. The surface survey had already been realized, but we did a new measurement of the distance between cave and surface using the avalanche beacon. Peťo Holúbek came with his friends at the end of the Demänová Expedition 2016 and he went with me, bringing his beacon to the place in the cave with roots. On the surface, the avalanche beacon showed the distance 24 m twice, at two places 10 m apart each from other. We decided on a place under a small wall, and on March 25, 2016, we started removing humus, roots and rocks. In addition, it was necessary to drill in solid rock along a centimeter-wide fissure. Later, we moved to a place about 3 m downhill and dug another 1.5 m deep hole. But after 20 trips and 197 holes, it did not look very promising. In the autumn we moved about 10 m southwards, where small eroded holes in the rock are situated; they continue narrowly into the depth. At this place, with the working name "Dormice's Entrance", we made 6 trips; we drilled 70 holes and reached a depth of 1 m. The following members of the speleoclub attended the work: Slávka Szunyogová, Ľuboš Halička and Juraj Szunyog. Non-cavers Ludmila Gruchalová and Marek Orolín helped as well.

At the end of Orange Corridor. Photo: J. Szunyog

Digging on the surface was a pleasant change compared to difficult trips in the cave. Later, this was my only contact with the cave, as I got spine inflammation, which prohibited me from entering the underground throughout the whole summer of 2016. I could not even finish the traverse of Dormice Lake. After five months I entered the Prosiecka Cave again; on September 17, 2016 I finished the traverse. On the same trip, I enlarged the narrow passage in the Orange Canyon. Subsequently, an additional 200 m of corridors directing northwards deep into the massif were discovered. The canyon-like parts are a close fit for a caver; the walls are 6 to 7 m high, and are covered by flowstone. Gradually, however, the flowstone formations are more sparse, and the canyon spreads to a rough, breakdown-like corridor. Behind the first dry siphon there is the end of the cave, the Singing siphon, filled with sediments. The main route from the cave entrance to the end of the cave is 997 m long. The Singing siphon will become our main workplace during the winter season 2017/2018. Using a potentially new entrance to the 3rd floor, the main way would be about 570 m shorter, without crawling parts. It will take up to several years, and so I sometimes continue in enlarging the most uncomfortable parts of the old way. As we still do survey the cave, this approach is necessary.

In March 2017, the total length of the cave was 2831 m with a vertical span of 112 m. The cave leads generally to the north, to the main sinkhole in the meadow Svorad. As the crow flies, the cave now reaches a distance of 658 m. On the underground way from Liptov to Orava regions, we have not yet discovered an active water flow or spacious underground halls, but we are looking forward to another surprise behind the Singing siphon. The fact that the cave only gradually releases its secrets immensely motivates us and encourages us to perform better during the next exploration.

I am thankful to all who help to increase the knowledge of Prosiecka Valley's underground and to those who, due to the difficulty of the cave, do not dare to go with us into the depths, but support us morally at least.

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THE MODRÁ CAVE (THE BLUE CAVE) IN THE LOW TATRA Mts.

Ján Šmoll

Speleoclub Chočské vrchy

On the northern side of the Low Tatras (highest peak Ďumbier Mt., 2043 m a. s. l.) there are two valleys (Demänovská valley and Jánska valley) in which extensive cave systems are located. To the east of Čertovica pass spreads Bocianska Valley, that is known not only for its picturesque villages such as Vyšná Boca and Nižná Boca and the ski resorts Čertovica and Bačova roveň, but also for mining that dates back to the 16th century. In 1560, 60 kg of gold were mined and the region began to be compared to Kremnica. More than 120 mines and 130 mining earthworks give evidence of active mining of gold, silver and iron ore.

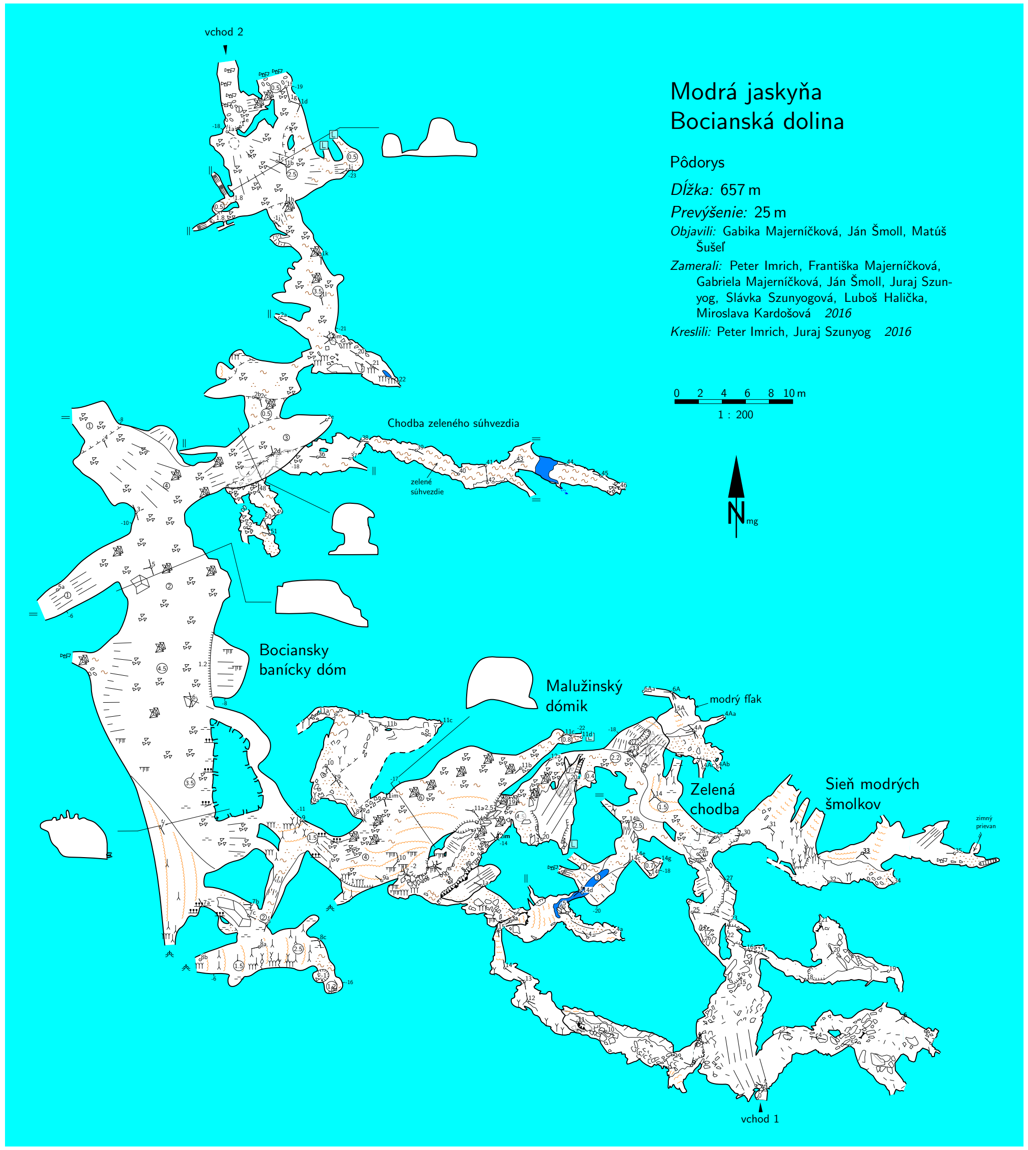
Since 2015 a speleological survey has been carried out in this area by the speleoclub Červené vrchy, and gradually new discoveries have been revealed. Above the village Malužiná dolomites begin to occur. The survey revealed that waters streaming in the valleys Bocianka and Malužianka sink in multiple sinkholes into the underground above the village Malužiná. Throughout centuries these sinkholes have been gradually filled and levelled in the process of road building. Due to the mining activity they have always been regarded as old mining works.

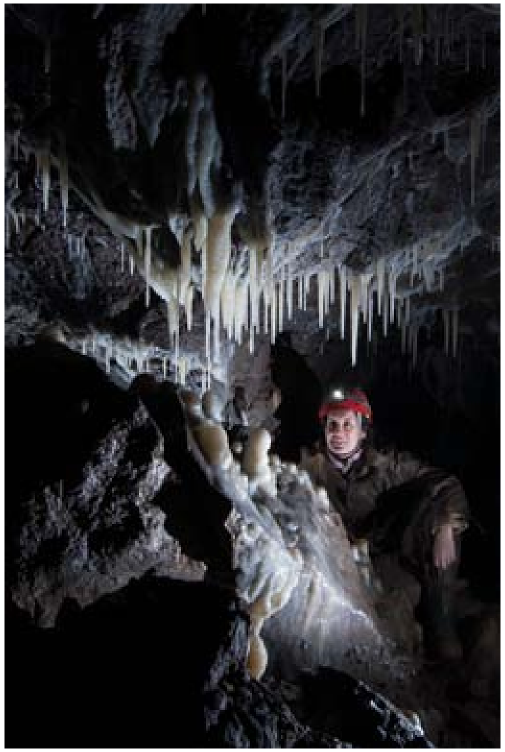
On the turn of years 2015/2016 winter arrived with temperature lows of up to -20 and -25 °C. The draft identified in one of the sinkholes was a clear signal to begin digging works. After only 6 hours of digging we entered new cave rooms. We stared at the never before seen speleothems.

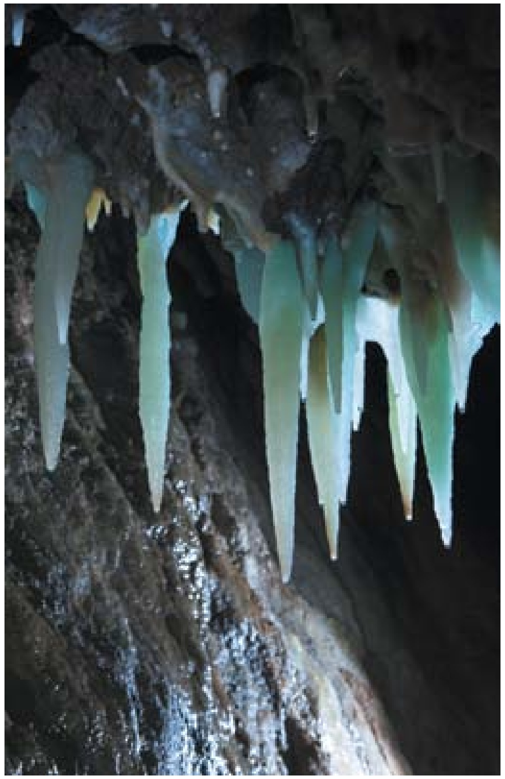
Modrá cave is the only one in Slovakia which boasts blue, green, white, orange and red-brown dripstones. There are only a few similar caves in the world. Research suggests the colour of the flowstone is caused by an admixture of copper, azurite and malachite minerals that are found in the layer above the newly discovered cave.

The cave has been formed in dolomites. There are beautifully modelled passages that are almost 700 m long. In multiple places, several drainage passages ending in 10 – 12 sand siphons can be found. Near the second entrance a draft of cold air can be felt, with a temperature of 5 °C at the base, indicating more extensive continuations. Following this discovery, other rooms with dripstones of these fabulous colours are expected to be found.

Passages and dripstone decoration of the Modrá Cave. Photoset by P. Staník







DISCOVERING A QUARTER BILLION YEARS-OLD REPTILE

Pavel Herich

Speleological club Demänovská dolina

The first and the oldest Slovakian reptile skeleton, from times before the dinosaurs, was found in the Demänová valley. The skeleton was found in a cave, that in the past 10 years has allowed its explorers to discover new underground passages in an unheard of manner. The discovery happened in Štefanová cave, in the place called Eldorado, which fascinated us during the exploration because of its raw carbonates corroded to the "bone"; its vertical shafts, although immediately under a valley floor, are around 10 meters below the Demänovka river.

Every story linked to this world unravels itself at a certain moment and in appearance takes an end; however, in reality there is no beginning and the end is probably determined simply by advancing time. When constructing a story, humans just pick a certain lapse of ongoing time, decide which events give them a meaning and combine them together to create a whole story.

About the discovery

On the 16th July 2016, seven people (S. Solarczyk, A. and M. Atraszkiewicz, I. Šulek younger and older, M. Prokop under the leadership of P. Herich), stepped into the cave. Thanks to the new, hard-won entrance, we did not need to pass through the older galleries, to crawl for long hours, only barely able to walk, climb and scramble. Instead, with the new entrance, we simply went through a vertical shaft to the huge space of Kasprová šikmina. Only one person knew the next passages, the others could only trust that we would find the right way back. The objective of the day was a beautiful, rounded, vertical shaft with black walls called Tajomná šachta v Eldoráde (Mysterious shaft in Eldorado). Every time we had come since its discovery in 2010, the everlasting splash of water drops falling from the unseen ceiling threatened to soak us, so we always hurried. The mysterious shaft concealed open holes high up in forbidding walls, and entrances to new passages, stirred our imagination.

However, since our first steps here a few years ago, something was different. After heavy surface precipitation, the relentless, blood-chilling rain was stronger than ever, deflecting off stone boulders at the bottom of the shaft and soaking our clothes. Even thoroughly wet, we knew that the surface was only 45 minutes

One of the shafts from Eldorado. Photo: P. Herich away and that the discomfort would not last long. Our head-lamps were brighter than 6 years ago when we could barely see in front of our feet. We split up into 3 groups; climbing and map-making were given to the more experienced and the rest went to take photographs and look into nearby, barely explored galleries.

Humans perceive caves differently, depending on if they need to spare strength for a long return journey, or if they can see where they want to get to and are enjoying the company of colleagues.. On this particular day, instead of complicated artificial climbing of shaft walls, we just tried to remember the right moves and hold emplacements, because whole streams were running through the walls, splashing all around. We climbed quickly to the open holes without ropes. In next to no time, and totally soaking wet, we entered the galleries, which had been hiding from us all that time...

We had not reached the ceiling, though. The wild choke stone of huge boulders leaning to a natural vault of a vertical chasm, once again drained all the forces and determination we had to follow higher. (Only at home, after synthetizing the mapping data to the cave's 3D model, did it become apparent that the ceiling through the boulders reaches just a few meters under a paved road in the Demänová valley. Ivan had had an impression of seeing some concrete structure, perhaps of a bridge, which showed on the maps. If this is the case or he just glimpsed greyish dolomite layer, will only be cleared up only after future climbing). Finally, we mapped the spaces, while the others kept on going or returned slowly to the agreed meeting place under a big rounded boulder.

This massive eye-catching stone had fallen from the surface riverbed of the Demänová river, likely through a shaft similar to the one we had just climbed. The ceiling had to be too close to the surface, and damaged by water percolating through carbonate layers, the shaft had collapsed and quickly filled with stones and water. The boulder has always attracted the glances of cavers, but in its shadows, in the ceiling of the gallery, waiting to catch attention, was a tiny hardly noticeable fossil: only a few centimeters long, a skeleton of a dorsal part of some creature, a couple of vertebrates and ribs. Some 240 million years ago, a small animal perished...

Stone made of bones

Incredibly and by pure coincidence, some remnants of the animal, deposited at the bottom of shallow, very salty, almost anoxic sea, were preserved. The skeleton had withstood waves and storms, and something had apparently covered it in a way that had preserved fine structural details during the long period it had been exposed to the elements in the future sedimentary layer of limestone. Later, it had to undergo a process of diagenesis and thus become a part of the layered carbonate sedimentary rock (gutenstein limestone and dolomites).

During 239 Ma (roughly estimated), carbonate mud hardened, emerged from the sea (perhaps even several times), underwent splitting and continental drift, folding and thrusting over dozens of kilometers... Then only a few millions of years ago, the Demänovka river began to cut its valley and canyon through this cracked, thick, tilted sheet of carbonates, taking the waters either from meteoric precipitations or from two glaciers situated higher up in the mountains under the main ridge. The river was flowing at the surface of granitic basement, but at contact with carbonate sediments it disappeared immediately underground, where, through fissured rocks and layers, the development of caves began. While the mountain ridge Nízke Tatry (Low Tatras) was being uplifted and the Liptov basin was subsiding (still ongoing processes), the Demänová river with its tributaries began to create a narrow canyon with steep walls at the surface and caves underground. By incision through the sedimentary layers from the younger to older ones, cave formation affected deeper layers, till the first water drops after a long time reached our fossil again.

Next to the huge boulder. Photo: J. Šurka

During the last million years, the sinking Demänovka river has been enlarging smaller holes, gradually reaching a shallower depth under the groundwater surface, till the moment of the cutting of horizontal galleries along its water level together with lateral erosion. The skeleton found itself hanging in the ceiling and fortunately it stayed there! During cyclic glacier melting, important water streams loaded with gravels, sands and bigger pebbles, formed and eroded the bottom of the valley at the surface. The streams passed underground in large quantities through sink-holes or older cave floors. Quartz grains from granites were abrasive agents eroding everything that stood in the passage. Later, after running water had formed a levelled ceiling in the galleries with a slightly corrosive effect, the old creature was uncovered. Just one water transported pebble accurately impacting on the bones, and we possibly would never have been able to identify the tiny black strips of ribs in the ceiling of a gallery...

Found fossil. Photo: J. Šurka

Careful chiseling of the fossil from the cave ceiling. Photo: J. Šurka

Paleontological results

How many of these creatures are present in carbonates of the Demänová valley? Or somewhere else? Perhaps after the first discovery, others will follow, though likely only in a small amount. We asked paleontologist A. Čerňanský, if he would examine the fossil and, together with J. Šurka and M. Olšavský, they soon found themselves in Liptovský Mikuláš, ready for an underground trip. It had already been rumored that the oldest Slovakian fossil of a vertebrate had been found, probably the first reptile of the Mesozoic, in the oldest Dinosaur period. Equipped with a precise cave map that had been worked on all the years we had been exploring the cave, the trio soon arrived at the place. During their second trip, they chiseled the fossil out of the rock, and after a quarter billion years spent in total darkness, it was brought into the light again.

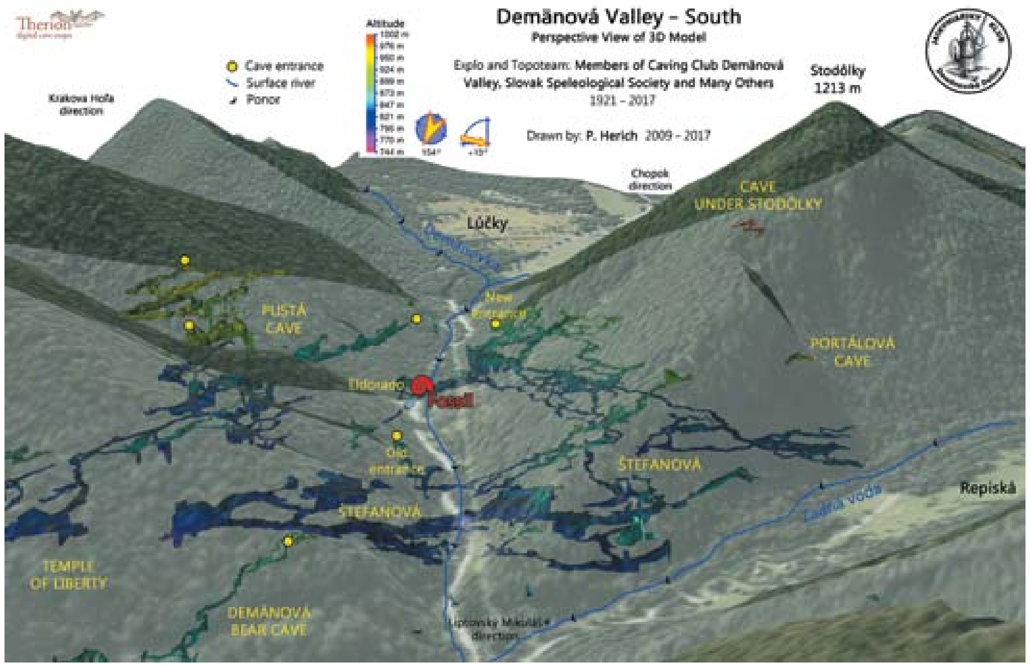
This precious stone was recently scanned with a micro-CT instrument at Slovak Academy of Sciences in Banská Bystrica, and the assumptions that a genuine reptile was found in the Demänová valley were confirmed. According to the preliminary results from our three researchers, the fossil consists of 9 vertebras in the anatomical position, ribs, pieces of pelvis and long limbs. Finally, the finding corresponds to *Pachypleurosaur*, a viviparous aquatic reptile with body length of 1.2 m, long neck and tail and living in a shallow, very warm and salty sea.

Conclusion

It has been a matter of wide debate, whether or not the reptile should have been left at its original place, in the safety of a demanding and extended cave, known only by few people. However, the importance and necessity of closer inspection decided the matter. So, by our intervention, we changed the fate that naturally awaited the fossil, which in a hundred thousand years, would have been destroyed by the incision of the Demänová river and perhaps delivered back to the sea. Instead, we brought it to the uncertain, ever-changing world of human-beings, where it will be an object of research and later it will be consigned to some museum, from where, hopefully, it will not disappear after the first reorganization.

Slovakia got its first "dinosaur" of tiny proportions, but maybe similar in scale to the area that our country covers on the Earth... It is a small, fragile old fossil; should anything happen to it now it has been unearthed, its future existence could be much shorter than its incredibly long one on earth so far.

In the Demänová caves, we often encounter fossils of the same age, small marine organisms, which raise associations with our own existence, its duration and contribution to the life-cycle. Every sedimentary layer locks inside the information about environmental conditions at the time of the sedimentation; one of them has delivered an old reptile, others will preserve for the future traces of our own presence. I wish that any tourist, skier or any other visitor to the Demänová valley, walking on its paved road under the ridge of Nizke Tatry and inevitably walking just a few meters above silent and dark underground galleries, would think about the traces locked in the stone, that he leaves behind him.



Overview of 3D model of Štefanová cave with surface topography and fossil emplacement. Photo: P. Herich

COMPLEX RESULTS OF TRACING EXPERIMENTS ON KRAKOVA HOĽA Mt.

Marián Jagerčík
Speleo Detva

Karst exploration on Krakova hoľa Mt. began in the sixties, when Mr. Petr Hipman (1940 – 1999) with members of his speleo team Speleo Detva discovered five deep caves. Two of these caves were later connected to one cave system: Systém Hipmanových jaskýň, which is currently the deepest cave system in Slovakia. During explorations, cavers used many different techniques, including tracing of underground waters and air exchange flow. These techniques had an important influence on the decision-making of the next exploratory steps of the cave system in this karst region, as well as explorations in the Jánska dolina Valley, where the underground waters are mainly drained.

Hydrological tracing experiments

1. Experiment preparation

Preparation is the most important activity. It is necessary to acknowledge the specificities of the place and principally:

a. distance and altitudinal difference of the appearance of expected dyed water in the karst and non-karst localities
b. flow-rate in sinkholes or underground streams
c. time needed for water to reappear in karst springs or in underground streams
d. the volume of the dye (fluorescein in our case) dissolved in the ethanol

2. Experiment realization

It is important to prepare the experiment in detail in order to avoid repeating it; however, in complex and long systems it is virtually impossible to avoid repetition. For a successful experiment, these following conditions should be respected at minima:

a. in case of affecting water sources, inform and ask for permission for the dyeing experiment from the owners or persons in charge of the water source
b. involve a necessary number of observers; the best choice are cavers, who can observe the dyeing experiment even in underground streams
c. for dye identification in the water, you need good eyes, but other necessary equipment includes:
   - Clean bottles (0.25l) with seals for sampling after the expected time of reappearance of the dye
   - UV lamps for observing the dye mainly during the night
   - Dye detectors of the fluorescein in case of important dilution

TRACING EXPERIMENTS

Water dyeing in Záskočie cave 1D

One of the first important successful experiments was already realized in 1977. During the experiment, a large amount of flourescein was used. The downfall was a late observation of the reappearance of dyed water in the karst spring, since the dyed water had already been flowing for several hours before its estimated arrival time.

Water dyeing in Starý hrad cave 2D

After the first dyeing experience, this experiment was perfectly organized and realized. All karst springs where the dye could reappear were observed, but principally the karst spring Medzibrodie. The dyed water appeared after 14 h. During this experiment, we used a large quantity of fluorescein; half of it would have been sufficient.

Experiment in Občasná vyvieračka (Temporary karst spring) in Čierna dolinka 3D

This experiment was successful too. Initially, although the estimation of the arrival time was pretty long, the dyed water was not observed. Then cavers began betting 2 bottles of champagne that the water had reappeared. The youngest member had to run to the karst spring to verify the bet. Thus, we learned that the dyed water reappeared where we expected.

Water dyeing in cave Slnečný lúč 4D

This was our last successful dyeing experiment. However, the dyed water was again detected after the estimated reappearance time in the underground stream, and only thanks to a caver's experience and intuition. We observed the dyed water after double the estimated time (Fig. 1).

Water dyeing in Javorová priepasť

Even 2 experiments were not sufficient to give us an answer to where underground water flows in this system. The most likely reasons for the negative experiments were insufficient flow rate (circa 2 l/s) and the important distance to karst springs (more than 3.5 km).

Finally, I would like to mention that in order to obtain a successful tracing experiment, it is important to note the essential parameters and then to determine the next possibilities of future experiments. Table 1 show the parameters of realized experiments on Krakova hoľa.

Fig.1. Dye injection in cave Slnečný lúč. Photo: E. Hipmanová

Table 1: Data of water dyeing experiments on Krakova hoľa.

Experiment Id	Place of dye injection	Place of dye reapperance	Amount of fluorescein [l]	Flow rate [l/s]	Distance [m]	Alt. difference [m]	Time lapse of dye reappearance [hours]	Time (estimated when not observed) [hours]	Transfer rates	
									Distance [m/h]	Altitudinal [m/h]
1D	Underground stream in Záskočie cave	Karst spring Medzibrodie Jánska dolina	3.5	4.5	2000	402	42.5÷68.5	55.5	36	7
2D	Underground stream in Starý hrad cave	Karst spring Medzibrodie Jánska dolina	5	30	2340	390	14	14	167	28
3D	Sinkhole in Čierna dolinka	Občasná vyvieračka (Temporary karst spring) Čierna dolinka	0.25	5	500	50	8÷20	14	36	4
4D	Undreground stream in cave Slnečný lúč	Slnečná cesta in cave Večná robota (underground stream)	1.2	2	400	329	10÷24	17	24	19
5D	Underground stream in cave Javorová priepasť	Not identified	5	2	?	?	?	?	?	?

AIR EXCHANGE TRACING

Similar to water dyeing experiments, air exchange tracing gives a lot of information to cavers, perhaps even more than water dyeing, since the water has only one direction, as it follows gravity. By tracing air exchange, we may determine the position of the lower and upper entrances, or to determine the places where the air exchange takes place in the cave (it appears or disappears). All is based on the principle that cold air is denser than warm air.

Different methods of exploring the air exchange (draft)

I would distinguish two different methods which use our senses – optical (sight) or olfactory (smell).

Optical method

This basic method is used almost by every caver. We use white smoke for air dyeing. Thus, we may use:

Cigarette smoke

Dyeing with a smoke tube: In our caves we use smoke tubes coupled with a small balloon (Fig. 2), or you may buy Dräger tubes CH25301 for detecting air currents.

Dyeing with smoke shell or fresh wood: We used this method for tracing at the surface, as well as in the cave, but with a special breathing apparatus. The movement of fresh air shows the direction of the draft.

Olfactory method

This method is based on using our sense of smell (Fig. 3). The best substance we used for tracing is mercaptan (ethylmercaptan – ethanethiol). This gas is used as an additive to natural gas to allow for detection of damage to pipes or gas appliances. The vapors of this gas are well distributed with the draft, even in caves, though in contact with a choke of stones, it may be partially filtered. However, if enough quantity is used, its detection is 100% successful. You have to respect some basic instructions using this gas; read carefully the notice provided by the gas distributor.

After a certain time, the cave has clear air again (the draft is doing its job) and we can no longer detect the gas.

Using this method, it is important to note that the use of gas as a detector may be used in both directions, depending on the outside air temperature and the temperature in the cave (summer

Fig 2. Tracing air exchange using smoke tube in Večná robota Cave. Photo: O. Ratkovský

Fig. 3. Gas dispersion. Photo: J. Slančík

or winter regime, fig. 4). This basic principle determines where we have to search in the cave for the 'dyed' air's (smelly or odorant) reappearance.

The olfactory method may be used for determining:

New cave entrances 4A This method is very simple and it needs just one caver who will release gas into the air in the cave, at the place where the draft disappears into unknown parts of the cave. Then this caver should not be in contact with the other members participating in the experiment, in order not to confuse them with the rest of the smell on his clothes. The other members then search at the surface using their noses to detect the place where the dyed air reappears. Thus, we identified that Večná robota cave, where we have just started to do exploratory works, communicates with Starý hrad cave. It is important to notice that this method may be used during summer and winter draft regimes. It depends on which entrance we want to identify – the lower during the summer, or upper during the winter.

New cave galleries 3A The principle of this method is that we release the gas in one cave and then we do exploratory works in the second cave, where the gassed air was detected. However, many places in the cave may be implicated. Of course, we take into account the air flow direction in the caves. This method may be used in both summer and winter draft regimes. For this experiment, it is necessary to mobilize all cave members, because it is a relatively difficult project (fig. 5). You need at least one caver to release the gas in one cave and the others have to go to the second cave for the smell detection, where the gassed air may reappear. The cavers, who will be identifying the smell's reappearance, should not be in direct contact with the gas used to taint the air, in order not to compromise the experiment. All the observations (when and where) should be reported, to enable the appropriate conclusions to be drawn from the experiment (where to dig?).

Table 2. summarizes our air exchange experiments on Krakova hoľa.

Experiment Id	Place of dye injection	Place of dye detection	Quantity of mercaptane [l]	Distance of gas transfer [m]	Alt. difference [m]	Time for gas transfer	Commentary
1A	Záskočie cave – na Predných upper entrance	Záskoče cave – na Predných lower entrance – test	0.2	703	121	4 h	Summer regime
2A	Večná robota cave entrance	Starý hrad cave entrance n.1	0.5	1330	382	- 41h without detection -from 41h to 171h not controlled - after 171 h identified	Summer regime
3A	Starý hrad cave – the final choke	Večná robota cave Vetva M	0.2	280	133	6.5 h	Winter regime
		Čiarková sieň		304	204	7 h	
4A	Cave Slnečný lúč Veterný sifón	Surface (Mrazivá diera)	0.2	179	44	3 h	Summer regime

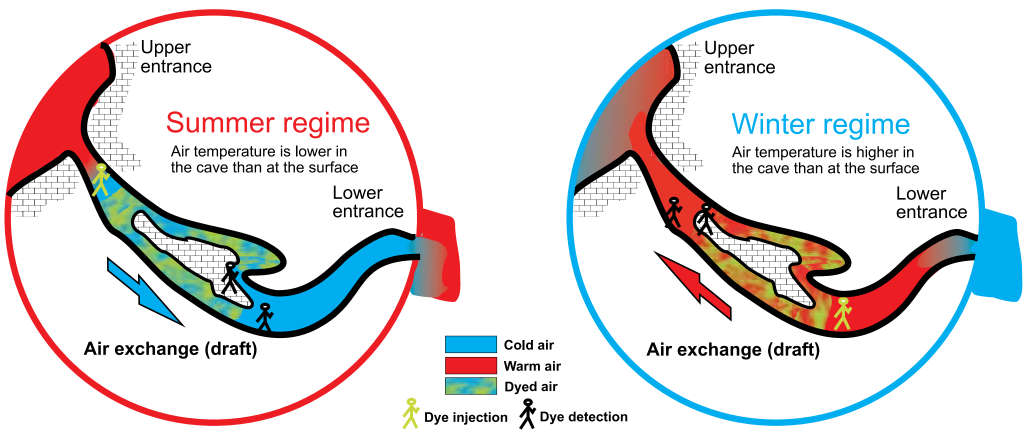
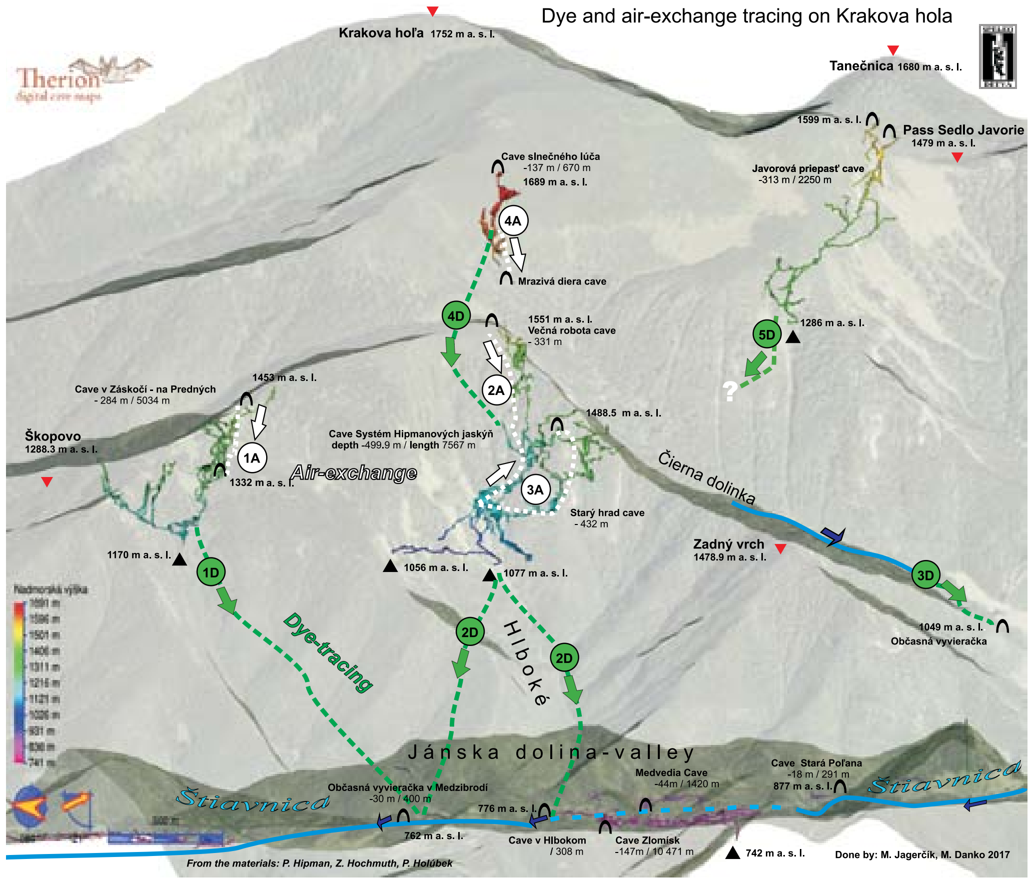


Fig. 4. Summer and Winter regime. Drawn by M. Jagerčík



was safer for working than in Vetva M, though even here we had one accident.

In Večná robota cave, where we were searching for new galleries, we noticed the gassed air at two places – in the final choke in gallery Vetva M ending at -224 m and in Čiarková sieň, which was 80 m higher. Finally, we decided to continue in Čiarková sieň, because the place was safer for working than in Vetva M, though even here we had one accident.

All the tracing experiments (water and air) from Krakova hoľa are summarized in Tab. 2.

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SLOVAČKA JAMA ON KARDJICA – JAKUPICA PLATEAU (MAKEDONIA)

Ján Šmoll
Speleoklub Červené vrchy

In 1990 – 1991 we explored plateau Monte Canine in Slovenia, and in 1992 the karstic areas in Makedonia and Kosovo (Jugoslavia at that time). We discovered a lot of karstic phenomena – shafts' entrances and caves (Liptovská 1 and Liptovská 2 = CEKI 2, Velika Klisura etc.).

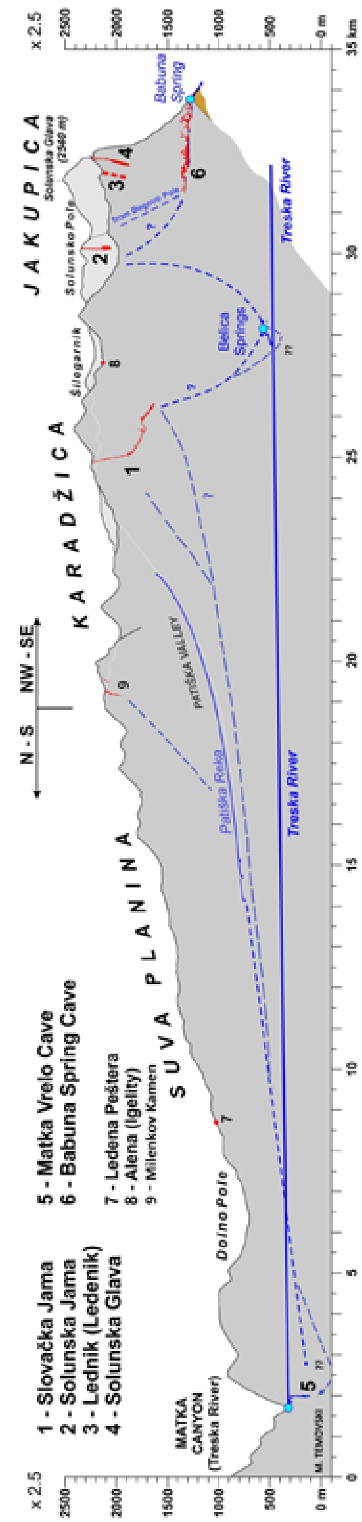
In 2001 we explored the karstic plateau of Jakupica mountain in Macedonia, and between 2002 – 2004 we investigated the so-called Golems, which are drawn as black dots on the map. We surveyed only Golem No. 11 in 2004 because it was situated almost 6 hours from our camp. In autumn 2015 M. Miškov, Ľ. Očkaik and J. Šmoll descended by rope to a depth of 80 metres. Between the rocky wall of the cave and the ice monolith a hole was melted with a strong air draught. From 2005 till present we have discovered more than 4 kilometres of cave corridors, shafts and halls with a total depth of 650 metres. The cave continues in a few branches and there are tens of chimneys which are unclimbed yet.

In 2017 a group of cavers led by P. Pokrievka and K. Kýška found a continuation through the semi-siphon which was pumped out, and then P. Pokrievka and A. Holúbek discovered over 0.5 km of new corridors. Newly discovered spaces from the depth of 650 m continue without any barrier.

Slovačka jama in Karadjica plateau is a wonderful example of the alpine cave system: shafts, chimneys, kilometres of horizontal passageways, karst formations and underground pools, beautiful meander passages, several sumps, and perhaps up to 10 watercourses and tributaries that flow through this cave, make this white-marble cave unique.

The entrance of Slovačka Jama, Karadjica Mts. is located at 2240 m a. s. l., which is still about 240 metres deeper than the highest point of the plateau. The air draught shows that this entrance must be a lower one of some bigger cave system. In winter the air draught sucks in and it blows during the summer. The entrance is often completely glacied all year round, depending on snow conditions during the winter.

Passages and shafts in the Slovačka jama Cave. Photo: J. Szunyog



Interior of cave and cross section of massifs.
Photo: J. Szunyog, Section: M. Temovski

The potential of further discoveries in this locality is huge. There are sinkholes and shaft entrances in megadepressions and polje on the top of the plateau with circumference of 1 to 20 kilometres. The vertical span of the supposed cave system is about 2 kilometres, but the tracing tests haven't been realised yet. The cave system can be deeper than the difference between the upper entrance and a resurgence, because some resurgences (e.g. Vrelo) represent caves of vaucluse type. For example, the Vrelo Cave, with an entrance at 330 m a. s. l. continues to the flooded depth of 214 metres with further continuances to deeper parts of the massif.

Slovak, Czech, Makedonian and Polish cavers participated in the expeditions to Slovačka Jama Cave: Ľ. Očkaik, J. Klesken, J. Vykoupil, P. Holúbek, A. Holubek, Ľ. Rybanský, M. Hurtaj, M. Jagerčíková, E. Kapucian, J. Syzunyog, M. Sluka, S. Votoupal, J. Psotka, M. Gaško, L. Vlček, P. Herich ml., Ľ. Štubňa, I. Majer, G. and F. Majerníčková, P. Imrich, J. Vajs, I. Demovič, P. Vaňek, M. Kučera, Š. Labuda, M. Hajduk, P. Plavec, K. Kyška, P. Malik, M. Vrábel, P. Pokrievka ml., P. Neuschel, P. Pokrievka st., P. Ivančík, M. Lejava, J. Šmoll, I. Žežovski, K. Dudzinski and others.

CAVEDIVNG IN MEXICO

Karol Kýška
Speleodiver

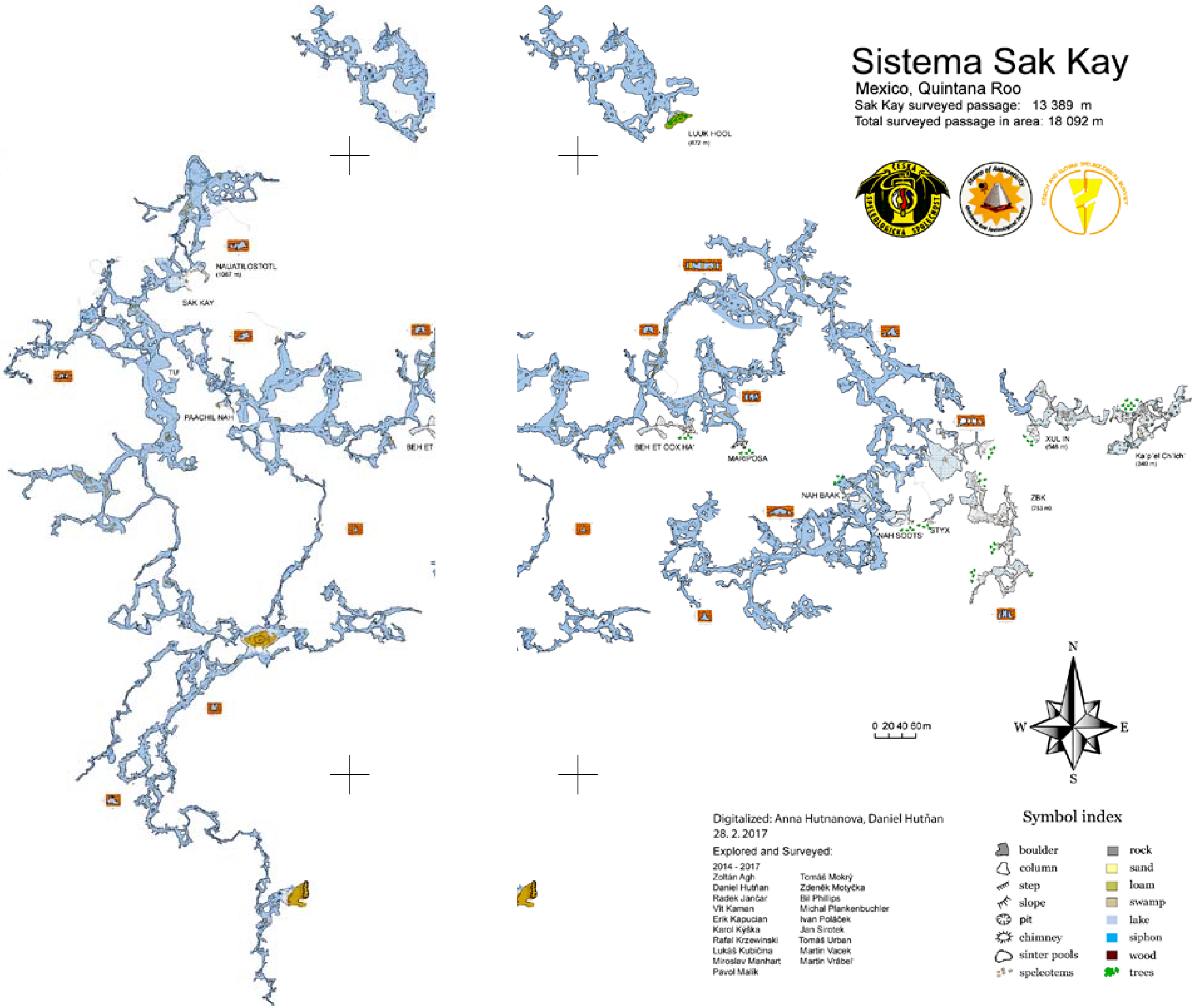
The members of Slovak Speleology Society annually participate in expeditions into underwater caves at peninsula Yucatan in Mexico. These expeditions are carried out with the co-operation of cave divers from the Czech Speleology Society.

Czech and Slovak cavers explored the Yucatan from 2003, until February 2012, when they found and surveyed more than 100 km of caves, underwater caves and a few dry caves.

Exploration is ongoing in the area of the villages Chemuil and Akumal. One of the greatest successes is the conjunction of the K´oox ball and Tux ku paxa systems. The K´oox ball system, with its length of 92 784 m, is rated as 3rd amongst underwater caves (source QRSS). And it is in 1st place as a mapped underwater cave. In the Akumal area they are exploring the Sistema Sac Kai, with 13 389 m. After four years, the total passage discovered and surveyed in this area is 18 092 m.

With these results, the members of Slovak Speleology Society belong to the leaders of exploration in the Yucatan.

The members are: cavedivers Dan Hutňan, Karol Kýška, Martin Vrábel, Pavol Malík, Michal Plankenbuchler, and drycavers Lukáš Kubičina, Barbora Kýšková, Martin Vacek, Erik Kapucian, Zoltan Ágh, Tomáš Urban, Ivan Poláček and Zdenko Hochmuth.



Diving in Tux Ku Paxa, Mexico. Photo: K. Kýška

Diving in Sak Kai Cave, Mexico.. Photo: K. Kýška

Diving in Tux Ku Paxa. Photo: K. Kýška

Diving in Tux Ku Paxa. Photo: K. Kýška

CAVEDIVNG IN SARDINIA

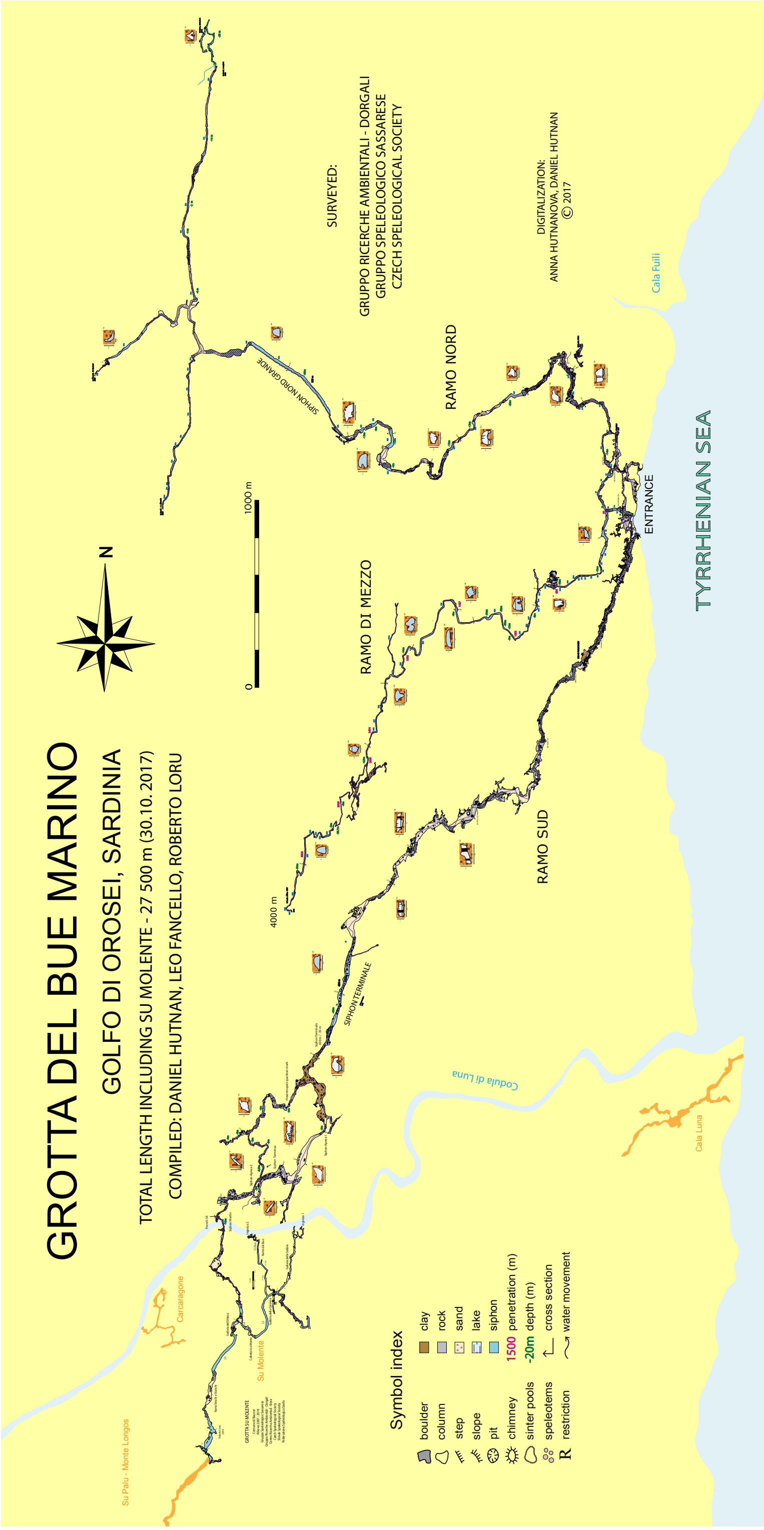
Karol Kýška
Speleodiver

This very important caving region in the Mediterranean is near the little town of Cala Gonone in the Supramonte mountains.

Here the cave-divers from Slovakia, in close cooperation with Czech and Sardinian cavers, are exploring the Bue Marino system – Su Molente – Su Palu – Su Spiria.

The longest cave system of Italy is located on Sardinia. It was formed by the connection of four caves: Su Palu, Su Spiria, Su Molente and Bue Marino. This connection was reached by Sardinian cavers in June 2016. The 27 years of Czech and Slovak cave-divers' activities in the Codula di Luna Valley, have contributed significantly to the discovery of the longest Italian cave.

Our activities are still continuing in Bue Marino cave in all three parts.



Bue Marino Ramo Nord between 19 – 20 sump. Photo: K. Kýška

Bue Marino Ramo Nord – the Neverending chimney. Photo: K. Kýška

Bue Marino – Sardinia 2016. Photo: L. Kubičina

RETURN TO THE CRYSTAL MOUNTAIN

Lukáš Vlček – Branislav Šmída

Slovak Exploring Team – Speleoklub UK Bratislava

I am browsing the last issue of Lonely Planet's Guide to Venezuela. A coloured parrot in the dark-green branches of rain forest trees on the cover makes me nostalgic. My eyes plough the text subconsciously and come to the description of the table mountain called Roraima. The highest tepui, a mountain covered by clouds and myths, mountain-mother, where the Gods settled and from where all water of the world was born. I am remembering my first unchained desire. My first touch of the mountain, and the voice of Roraima calling me to herself. The call does not stop. It is still sounding.

An enormous mysterious underground cave of Roraima mountain – The Crystal Eyes Cave – was speleologically documented by Slovak and Czech cavers in 2003. But the whole story began much earlier. In fact, we do not know how old the cave is, or how far back in time the ponor river started to model a cave in the hard quartzite rocks. It's discovery in 2002 was realized by two friends – Slovak caver Zolo Ágh and Moravian photographer Marek Audy. They ended their South America travelling by trekking on the highest peak of Guyana Highland – Roraima Mt. They knew that table mountains represent particularly interesting phenomena, not only from the landscape point of view, but also in cultural and historical terms. The legends that circulate between the people inhabiting the surrounding forests and the savannah at Orinoko and the Amazon's border area, are full of respect which sometimes turns to shivers.

Walter Raleigh discovered Roraima Mt. for Europe's public in 1596, but the top plateau was reached by an expedition led by Everard F. Im Thurn only in 1884. Thurn was already excited by his ecosystem isolation, a world not found elsewhere on Earth, with the exception of the table mountains of the Guyana Highlands. Through the first scientific research of the mountains and the inspirational novel by Sir Arthur Conan Doyle "The Lost World", the concept of the "islands in time" was created; thanks to areas' perfect isolation from its surroundings, it was said to perfectly preserve the past. Is this theory correct? What do we know about it today?

Roraima Mt., view from adjacent savannah. Photo: B. Šmída

While Thurn's expedition lasted for two months, Zolo and Marek climbed up the mountain in two days. Today, there is even a quite comfortable tourist path, from which the natives can guide you to a flattened surface

Vein of quartz crystals outcrooped on the surface of plateau. Photo: M. Audy

Variegataed underground of tepuis. Photo: M. Audy

of the meseta. From the village of Paraitepui, the last island of civilization on the way, a swarm of Pémon children follow you out. Everyone hopes to get back from the "world up there", alive and healthy. Up there, at the top of the stone monolith, standing out in the clouds, there is nothing that looks like the world under the clouds. The desolate stone landscape, divided by single standing rock towers, alternates with a maze of stone statues which evoke to the human mind scenes from everyday life. But when you look at them more closely, you will find that they are not from our world. The stone is black, scarred by deep grietas – rocky cracks that in some places you can skip over, but in others you have to go around for hours. The air is thin, the fog is pushing into the lungs. But when the clouds retreat and you get close to the rock's edge to look at the hundreds of meters of deep drifting beneath you, you will experience a great feeling of untouched nature! If nearby mountains or scraps of the surrounding forest appear through the clouds, you will find that the world that lies down there is somewhat unrecognizable and perhaps you need to live there no longer.

The pair of cavers were returning from the perpendicular edge of the mountain into the inland, when they suddenly stumbled on a large rocky amphitheater recessed into the surface of the meseta. "See! Below its stone wall, the river is sinking! Are you thinking the same thing?": an expression confidently stated from knowing the Moravian Karst or Slovak Paradise! There was no need for more words! They pulled the headlamps out of their backpacks, and jumped into the sinkhole exploration. In the pungent jungle at the bottom of the collapse, the fallen rock blocks crossed and they walked through the cave! After a couple of meters, the corridor grew, the river flowing at its base created cascades, gathered side tributaries and created lakes! There were domes in which the small headlights of the cavers were not enough for lighting. The Quartz crystals were glittering in the river. There were two small holes in the rocky bottom of the underground river which was filled with milky-coloured crystals; at that point Zolo and Marek decided to name the cave – and from that moment the world has known the cave as Cueva Ojos de Cristal – the Crystal Eyes Cave.

Small lakes full of abraded crystals. Photo: M. Audy

And how does it end? We asked the discoverers just after their return. Marek smiled widely at us and shook his head energetically. "This is the point. The light of the lamps weakened and we did not have a spare light. In short – we have not finished." "What do you think about the prospects of further discoveries?" Ask Braňo Šmída, the later speleoexpedition leader in Venezuela, which expedition do we consider to be one of the most dangerous and courageous cave projects of the beginning of the 21st century. We are both geologists and we do not want to believe that large caves, such as our couple of friends described, could have been created in quartzitic sandstones. Quartz is still water insoluble! Underground photos convince us of the opposite! A small dose of skepticism was reflected in our decision: "We will document the Crystal Eyes, and if the cave does not continue, at least we will have an adventurous trip to the tropical forest!" Well, before leaving Europe, not one of us could fall asleep from thinking about the exciting prospects awaiting us in Roraima.

"Throw the rope down there!" shouted Braňo, carefully, with unceremonious respect, looking down to the bottomless deep of a wide-spread crack in the rock massif. "How did we climb out without climbing gear yesterday? I do not understand!" The corridor that we had left the cave by, half-crawling, half-swimming in the vast lake or bypassing the rock blocks to get to the bottom of a massive crack through the body of the mountain, we have never been able to find again. Maybe it fell during the rain, when the quantum waters flow into the underground and the huge stones are shuffled like candies... It is the year 2003, the cave opens with dozens of corridors in all directions. In two years we've connected it to the surrounding caves and the Crystal Eyes Cave System is emerging.

The following expeditions already required harder logistics, demanding transport, and the best Slovak and Czech cavers, speleoalpinists and adventurers, who were not afraid even of the devil, to explore the caves. Surveying and movie making from the helicopter and abseiling hundreds of meters into deep shafts with dangerous jungle at their bases. The "Crack of flying devilkins", is in a terrible locality called Marek; access is along a rope descending among the nesting colony of cave oil-birds *Steatornis caripiensis*, and it has not yet been explored to the bottom. The so-called guácharo is the only bird in the world that can navigate in absolute darkness, like bats, using echo location. The world's most numerous colony lives in the cave on Mount Roraima. The cave system of Crystal Eyes was surveyed to 15.24 kilometers and became the longest cave in the world in quartzite rocks, as well as the longest Venezuelan cave. For a short time at any rate.

Within a short time, not even a half year, a significant Venezuelan naturalist contacted us. "What do you know about a man called Charles Brewer Carías?" We asked each other. He was a reputable scientist, discoverer, inventor, adventurer, writer, but also a former minister, the greatest expert on table mountains as well as the Indian tribes living in Venezuela and Brazil border territory. A distinguished charismatic seventy-years old man, who, at his respectable age, blows us out of the water

Dissolution of sandstones forms new unique materials. Photo: P. Medzihradský

not only with his broad knowledge, but also with his physical condition. “I will show you a cave that will make you not want to return to Roraima again! It’s so great that not only has no one surveyed it, but no one has even taken a decent picture!”

“I’m building up a team for research and documentation of this cave, and I think you will be great for the job! Come and you will see!” – written in his last e-mail. A flight across the ocean, a few days in Caracas, a helicopter transfer to Chimantá Mountain, just a few dozen miles away from Mother of All Waters, a jump from the helicopter, anchoring the rock walls with screws, plates and ropes, transporting the material through jungle and then, shock! A cave portal the size of which we in Europe are not accustomed to at all! An airplane could fly across the huge corridor that follows into the interior of the mountain!

Suddenly Tepuis was swarming with expeditions! Successful co-operation with Venezuelan naturalists is being transformed into serious scientific expeditions with great, world-class results. Scientific questions arising from field observations are being solved on academic grounds all over the world. The Cueva Charles Brewer cave system reached the length of 17.8 kilometers and became the largest quartzite cave in the world. Simultaneously, English, Spanish, and Italian explorers are starting parallel cave discoveries. Inspiration is extremely strong. They are all discovering a phenomenon, even the existence of which was doubted a few years ago. Great fluviokarst caves in quartz rocks! How did they even arise? How did the table mountains originate? How did life originate and develop on them? And what about the bizarre formations inside the caves, like living stones growing along their walls?

We do not know much about the origin of table mountains, and theories that explained their origin to date were not correct. Slovak researchers have come to the conclusion that not everything on the table mountains is hard quartz, but there are also less hard sandstones or sands within the rock body. It turned out that only a part of the rock had been strengthened in the geological past, and the weakly hardened sandstones and sand in the surroundings, has been taken by water. A weak sediment even lies below the tepuis, the top of which is hard and the base softer. It is enough that when the erosion bites into the substrata the undercutted wall falls – so the walls of the table mountains are constantly vertical-shaped.

When research began, the only theory that explained the speleogenesis of the unique table-mountains’ caves was the dissolution theory of quartz cement in quartzitic sandstone rocks, which supposed purging the quartz grains and the flushing of them by water. But that would require a whole lot of time, so the caves were considered one of the oldest worldwide. The Americans came up with an even more bizarre theory, according to which the underground tepuis “feed” microorganisms. But when the cavers discovered unpaved sand in the caves, it was clear that there was a much easier explanation. If water flows over them, a smaller cave can be created literally overnight.

And why are the table mountains on the surface and in the underground typical of such a high degree of endemism? Endemic species

Flattened surface above the Crystal Eyes Cave. Photo: M. Audy

develop relatively quickly everywhere where the plant or animal population has been isolated from its parent group. Separated in this way, it adapts to the conditions in the given place – it creates characteristic features and builds the body in harmony with the surrounding environment. The steep walls of the tepuis are the perfect insulating agent, because not every creature can overcome such a barrier. However, unlike the vision of the islands in time, A. C. Doyle’s Lost World, it turns out that table mountains represent dynamic evolutionary laboratories, and local species are phylogenetically younger than their relatives from a flat environment. A terrestrial Galapagos, a steep world covered by the veil of fog, secrets and mysteries.

The helicopter rotor has been rotating continuously for a third day! This expedition to the table mountains is the biggest in living memory. We unpack supplies from boxes, build a camp. Every participant knows exactly what he has to do. We have three weeks for the survey. It is raining. Raining. The cold of the mountains pushes into the soul. In difficult conditions, the good mood of even the hottest expeditionist is diminishing. There are first injuries, falls, fractures of bones, bruises, wounds that require urgent treatment. Richard lost his eye! Step by step sinking into the mud, we try to move to the north of the mountain; we thought that the pedestrian transfer would not be so demanding. We descend into the darkness of the abysses beside the roaring waterfalls, with the rope in one hand and the machete in the other. A dangerous combination! We swim in the lake of the cave, into which the storm pushes hectolitres of water flowing from the surface – we have to be fast enough to build our underground camp away from the expanding river. And what motivates us to do so? What pulls us – again and again – to discover the secrets of nature hidden for millions of years? That we are moving the milestones of scientific knowledge forward? That we represent Slovakia as a country of hard-natured researchers who do not even feel the most difficult obstacles? Perhaps. But maybe we just hear the inviting voice of the Crystal Mountain. A voice that accompanies us day and night. It is magically attractive.

Sun down from the savannah: Roraima – the mountain of gods. Photo: M. Audy

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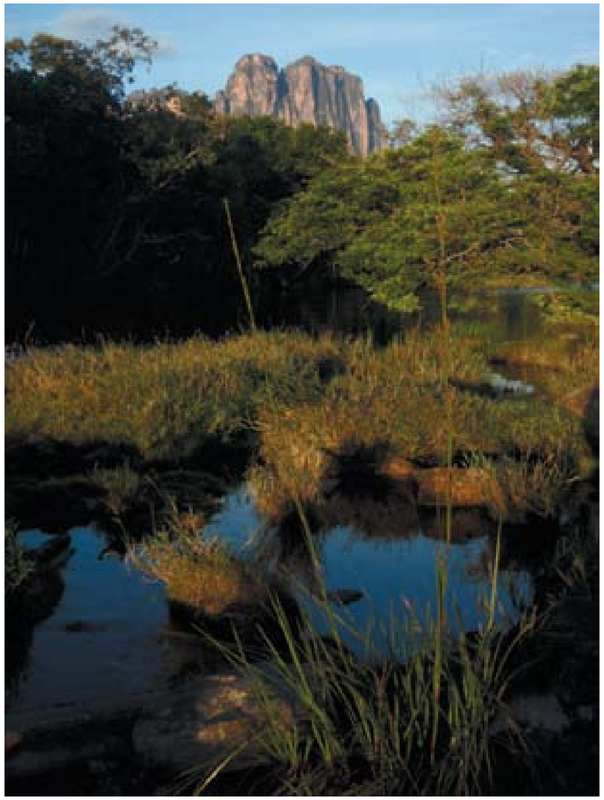
SPELEOLOGICAL EXPEDITION TO THE AKOPÁN TEPUY, SE VENEZUELA

Lukáš Vlček – Marek Audy – Zoltán Ágh – Richard Bouda – Kamila Hrúzová

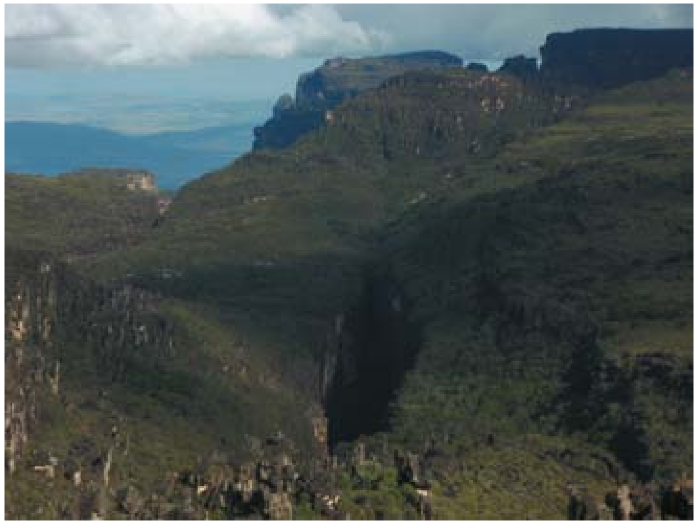
SSS – ČSS – GE SVCN

The table mountains of Guyana Highland have been a point of speleological interest of Slovak and Czech cavers for more than 13 years. The international expeditions to "tepuis" represent the most courageous and most demanding caving projects of the beginning of the 21st century, not only from the point of view of sport activity or scientific results, but also for planning and logistics. The expedition Tepuy 2015 was not an exception: complicated plane and car transport, climbing the mountain etc. were needed; we cancelled helicopter transport at the last moment.



Akopán tepuy: a view from Río Yunek close to the same named Indian village. Photo: L. Vlček

This time, we focused on the next quartzite massif of Venezuela: Akopán Tepuy in the Chimantá massif. We had explored Chimantá caves before: in 2004, 2005, 2007, in 2009 twice. These expeditions were aimed at the Churí Mt. (2550 m a. s. l.), where the world's largest quartzite cave system has been created – Sistema Charles Brewer, with an actual length of 17.8 km and a possibility of another continuation. The Churí massif and Akopán plateau (2250 m a. s. l.) are divided by a geological border – a belt of volcanic rocks – as well as geomorphologically – by the deep valley of the wild mountain river Yunek. Our first attempt at climbing the mountain was in 2012, but the attempt collapsed half way because of a serious injury and the following rescue action. Even the expedition in 2015 was not without accidents. The most serious one ended in tragedy. Due to an airplane crash close to the



Grieta with Cueva Monika on the surface of Akopán Mt. Photo: L. Vlček

Descent to one of the deep grietas in the central part of tepuy. Photo: M. Audy

Portal of Cueva debajo del Torre. Photo: L. Vlček

Pemón village Yunek, we lost one of our team members, adventurer, pilot and good friend – a Venezuelan caver Octavio Colson. It was at the beginning of expedition, so we had to take the decision whether or not to break the expedition and return back to civilization. After a few days among the Indians, we decided to continue the expedition to Akopán tepuy. We gave a last goodbye to our deceased friend Octavio; his body was taken over by the authorities.

Continuing the expedition, we climbed the table mountain Cerro Euroda (1820 m a. s. l.), where we found and documented two pseudokarst caves in quartzitic sandstones, and, after a three day long walk and climb through the jungle, we reached the wide surface of meseta Akopán, where we worked for 10 days. During this time we discovered and documented ten caves with a length of 21 to 1320 metres and a depth of 3.5 to 250 metres: Cueva Monika, Grieta con Río, Cueva Fresas con Crema, Cueva con Puentes, Cueva de Ciempiéses, Cueva del Raíz, Cueva debajo del Torre, Cueva Blanco – Rosa, Fracturas de Lluvia, Cueva de Lagartos. The largest one, Cueva Monika, was reached after a rope descent to the most spacious grieta of the mountain. Spaces inside are up to 100 × 80 × 30 metres; in the lowermost parts there are corridors up to 25 metres wide with underground flow. The survey and research required a sophisticated speleoalpinistic approach. During the speleological survey of Akopán Mt. we identified a few ponor and resurgences, as well as underground streamlines of mountain drainage. The hydrological and speleogenetic scheme of Akopán Mt. is unique and very different from the other massifs of the Macizó Chimantá group. Caves with spacious corridors have been discovered only in the easternmost tip of the massif. In the inland they are smaller and different, and at the northern parts of the meseta, the surface rivers are swallowed by huge grietas and mega-depressions, which direct the water to the wide, but extremely low, cave corridors. After every rain the collectors are quickly filled with water; the water level rises in tens of metres in a moment t, therefore the exploration of these caves is highly dangerous. Water on the W-E oriented grietas is directed by caves to the north – into the valley of the Yunek river. During the rainy period, the huge resurgences spout water under high pressure as great natural nozzles.

Besides deep water drainage from the bottoms of the grietas, several caves of superficial karst and fissure-modelled pseudokarst caves have been found on Akopan Mt, which locally drain the modest hills in the central part of the mountain. Superficial caves represent underground mazes with several entrances; water runs through them all year. Corridors have a width of 5 to 20 metres, with a height of up to 4 metres. The water usually flows from them into deep cracks in a rock massif. Their genesis is closely related to the strata in the quartz sandstones of the Roraima geological group. The spaces were created on thin layers of weaker sandstones, detailed bedded and detailed cross-bedded sandstones or claystones and clays, by the gradual hollowing and abrasion of rock material.

Exploration of caves on Akopán Mt. during the expedition in 2015 was realized by: Marek Audy, Zoltán Ágh, Richard Bouda, Kamila Hrúzová and Lukáš Vlček from the Slovak Speleological Society (SSS) and Czech Speleological Society (ČSS). The expedition was covered by the Speleological Group of Venezuelan Society of Natural Sciences (Grupo Espeleologico de Sociedad Venezoelana de Ciencias Naturales, GE SVCN) and our Venezuelan friend, nestor of speleology in quartzite massifs of South America, Charles Brewer – Carías gave us a helping hand again. Simultaneously with the speleological expedition, there was also an expedition of natural scientists from Commenius University, Slovakia, which was concerned with the geology and biota of table mountains. Jan Kaštovský from the University of České Budějovice was once again professionally involved in algae of the "Lost World".

Participants of speleoexploration of Akopán Mt. with Venezuelan friends in Caracas, from the left: L. Vlček, J. Kaštovský, Ch. Brewer-Carías, M. Audy, K. Brewer, R. Bouda and Z. Ágh

THERION – DIGITAL CAVE MAPS

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1. Introduction

For a long time it has been a nightmare for cave surveyors to draw a map of a large and complicated cave system. The nature of underground surveying does not allow us to achieve an accuracy comparable with high-precision geodetic measurements. This implies that we can never get the final map of any cave unless it is just a few dozens of metres long and contains no loops. When a new passage is discovered which connects between known parts of a cave, the new loop does not usually fit perfectly into the old map. We need to do some error distribution (slight changes in the positions of stations) in order to fit the new loop into the whole network of loops. If we changed only the new loops, they could be distorted substantially, and the old ones would not be improved.

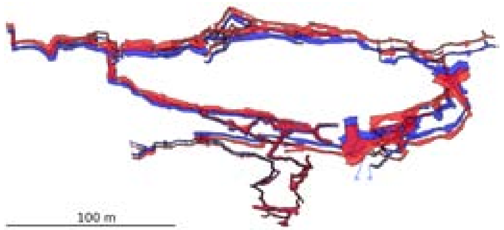


Fig. 1: Relative position of passages before (blue) and after (red) loop closure between stations A and A'

Such sequential loop closure used to be common in the time of hand-drawn maps, when surveys were plotted using ruler and protractor. Computers brought a great improvement more than 30 years ago: the error may be distributed over the whole loop network at once; information from each loop may improve (or distort) all other loops. This approach ensures the best error distribution and the least distortion in the centreline network. After the addition of new surveys all the loops are recalculated and we get better estimates of survey station positions than ever before.

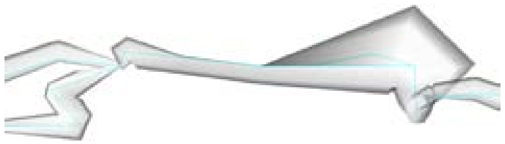
This is great so far. We get the best centreline estimate, so we may draw the most precise map. But here is the trap. If we finish the map and add a new loop later, the map will not fit the most recent centreline. The changes will be modest, but visible. The only way to keep the map up-to-date is to redraw it. But for large caves it is too much work. Should it be done after each new loop closure? Once a year? Or should we take a step back and close the loops sequentially, distorting only new surveys?

No, the correct question is: 'Can we get complete (hand-made-like), up-to-date maps directly from the computer?' The answer is: 'Yes.' There has been a long evolution in surveying programs, the outline of which is given below. Originally, surveying programs helped with loop closure and centreline drawing; nowadays, some of them are capable of producing the complete map.

The evolution of programs for cave surveying:

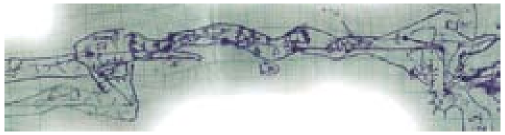
1. Programs for loop closure, error distribution and centreline plotting. The centreline is then used as a background layer for the hand-drawn map. This does not solve the problem when a new loop is closed – after recalculating the centreline a new map has to be drawn by hand.

2. Programs that plot a preliminary 2D map or 3D model based on additional information added to each survey shot or station, usually LRUD (left-right-up-down) data. The map is very rough and cannot replace complete maps with finely detailed passage walls and interior.



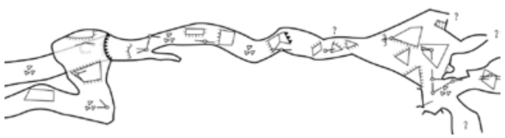
The majority of programs fall in category 1 or 2.

3. Programs that use scanned survey sketches (that are transformed, or 'warped' to fit the survey stations) to display the preliminary 2D map. This needs to be hand-traced to get a more refined final copy.



The problem with loop closure remains – the whole map needs to be redrawn by hand if new loops change the centreline significantly. WinKarst and Carto are of this type.

4. Programs that create complete maps. Maps which do not require any additional ink strokes. At least three programs aim to fill such a requirement: Therion, Walls and TunnelX.



This article describes the main features of Therion.

2. Architecture of Therion

Therion is a complete package which processes survey data and generates maps or 3D models of caves. It runs on a wide variety of platforms: Linux, Windows and Mac OS X. It is completely free, released under the terms of GNU GPL, with source code available. It does not require any other commercial software to run.

Therion consists of several layers: it has its own language specification (described in The Therion Book), data editor (called XTherion), processing engine (called Therion) and model viewer (called Loch).

The basic design decision was to create (1) a universal language which would be able to describe almost all features present in the cave or in the karst area in general, and (2) some kind of compiler which would translate this abstract representation to a visually pleasing map or 3D model. This approach is on the one hand really powerful, but on the other hand it is much less user friendly than most graphical WYSIWYG editors (the user has to learn a lot before using the program).

There is a strict separation between data and presentation. Data files contain an abstract description of the cave (position, type and other attributes of all cave / karst objects) without any information about how they should be displayed in the map. For this purpose there are definitions of map symbols and page layout in other specialized languages: MetaPost (generic vector graphics description language) and TeX (typesetting language). In the map processing stage the abstract data and appropriate presentation definitions are processed together to get a map visualization.

The language of Therion belongs to the family of *markup languages*, such as XML or more familiar HTML. For readers familiar with Web page design and creation, here is an illustrative analogy between HTML and Therion languages:

Data creation tool	any HTML editor (may be more or less WYSIWYG)	XTherion (less WYSIWYG)
Data files	HTML files	Therion data files
Layout definition	CSS styles	MetaPost and TeX macros
Visualization	Web browser rendering engine	Therion
Output	Web page displayed in the browser	map & model displayed in appropriate viewers

The language defines just a few basic data objects: *centreline* for all data measured by compass, clino & tape, *scrap* for a simple section of 2D map, *map* for a collection of scraps, *surface* for entering of topographical or aerial maps or digital terrain models. Scraps may contain *point*, *line* and *area* symbols. All objects are encapsulated in *survey* objects, which make it possible to build complex hierarchical models of karst comprised of cave systems that consist of caves which entail passages and chambers

made up of individual rocks, pits or water flows...

Although there are no more objects, the real power is in the attributes which can be assigned to each object. Attributes define more detailed information about the object, like *height* (predefined attribute) or *climbing grade* (example of user-defined attribute) for the *chimney* line symbol.

The separation of data and presentation makes Therion fully customizable. For existing symbol types it is possible to define your own complex visual representation. If there is no symbol for a particular need, it can be defined by the user. For all symbols user-defined attributes can be created and later evaluated.

3. Creating the Data

There are basically two distinct kinds of data recorded in the cave: centreline measurements and survey sketches. They are entered into Therion in different ways.

Centreline data can be entered in the integrated editor in tabular form or – if there is an existing centreline in Survex or Compass (PLT) format – simply imported. It is possible to combine both approaches. This should be familiar to anybody who has used any cave-surveying software. The input language is based on the language of Survex.

In order to integrate different surveying data and styles, Therion directly supports various geodetic coordinate systems and conversion between them. For compass measurements there is a facility for automatic computation of magnetic declination.

For map drawing there is a special map editor. The cave map is split into simple sections – scraps (usually corresponding to survey sketches, which serve as a background for digitisation). Each scrap contains survey stations, which are used during the output map generation to align the scrap with the centreline (the scrap is 'warped' on the fly, the original data is never changed). Besides the stations, there are three kinds of symbols which allow anything in the cave to be described: points (station, stalactite, label...), lines (wall, pit, rock border...) and areas (water, sand...). The symbols are not drawn exactly: only the position and attributes are specified (e.g. you do not draw a pit as a line with small ticks on one side, but just draw a line and specify as its attribute that this line should be displayed as a pit). All symbols are only rendered later during the map generation, just after the scraps are warped; see below. This allows easy switching among different map symbol sets (e.g. UIS and your local symbol set, if you define it) and adapting all map symbols to a particular output scale.

If there is no time to definitively draw a scrap in XTherion, it is possible to just calibrate the survey sketches and display them correctly warped on the centreline for a quickly generated preview map.

There is also a third kind of data, which is usually not measured by cavers, but obtained from external sources: digital terrain models and raster surface maps (aerial, topographical, geological). Therion combines all the available data to create a map or 3D cave model.

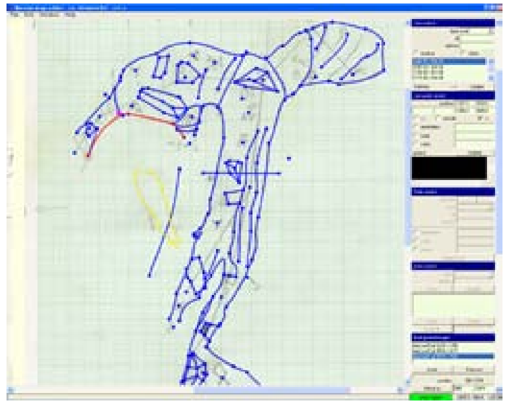


Fig. 2: XTherion – map editor

4. Paperless cave surveying

When Beat Heeb introduced the DistoX and PocketTopo application in 2008, a new challenge arose. How to manage a huge amount of data and cave drawings generated by paperless cave surveying method? Fortunately, Beats method of cave surveying was very similar to the idea of Therion and only small changes were required to adapt Therion to process the data exported from the PocketTopo application.

Xtherion editor allows you to import both centreline data and digital survey sketches from a single PocketTopo file.

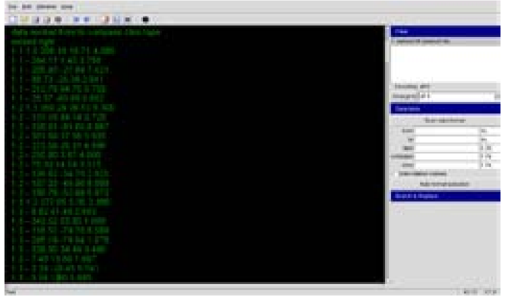


Fig. 3: Data imported from PocketTopo

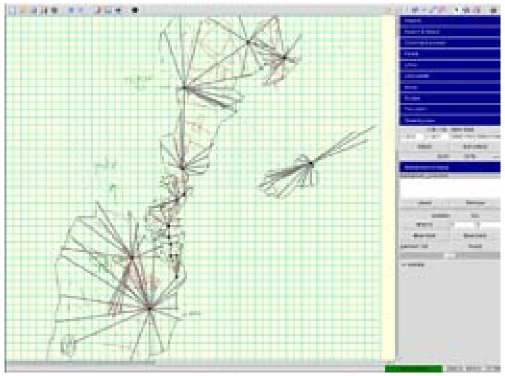


Fig. 4: Survey sketch imported from PocketTopo

Using these sketches you can draw the cave map as you would do with scanned images displayed on the background.

Other applications running on handheld devices and cooperating with DistoX like Auriga or TopoDroid directly support data export in the Therion format.

5. Data Processing

The missing link from abstract data to final maps and models is the Therion processing engine. When run, it reads the centreline, closes loops and distributes errors (using Survex and its least squares optimization).

Then it reads scraps, warps them to fit the centreline and joins them smoothly, and reads the definition of the symbol set which should be used and renders the map.

If the scraps are too distorted after the warping process, they may be processed in two steps: firstly, scanned sketches are warped to fit the survey stations and only then digitized and again (slightly) warped on the centreline whenever it is changed in the future due to new loop closures. In the first step

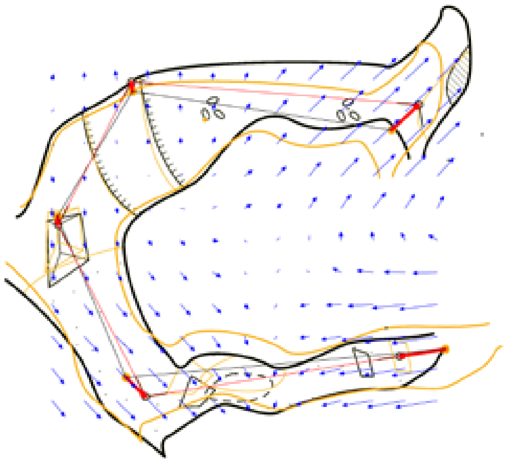


Fig. 5: The passage before (brown) and after (black) warping. The blue arrows visualize the transformation

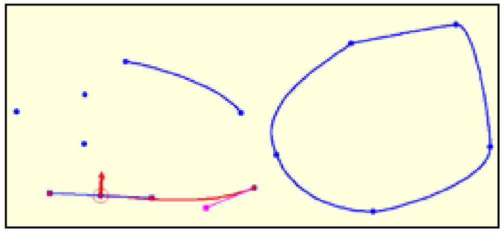


Fig. 6: Abstract point, line and area symbols in map editor. Selected object displayed red, attributes are not shown

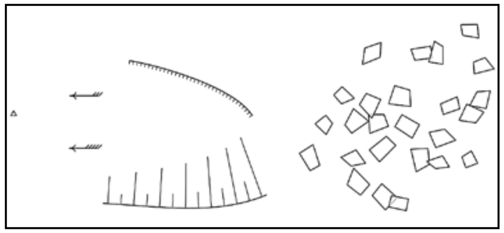


Fig. 7: Visualized symbols from previous picture

additional warping reference points (passage dimensions corresponding to LRUD data), besides the survey stations, may be used to improve the results for non-proportionally drawn passages.

In the final step Therion traces all the passage walls from the map and creates a very detailed 3D model. All computations are hidden from the user, she only needs to draw scraps of the map as described above.

6. Map Output

Depending on the user's needs, skills and time available to enter data, it is possible to generate different kinds of maps: just centreline; centreline with LRUD envelope; map built from warped scanned (bitmap) survey sketches; detailed vector map (or possibly a combination of all of them).

When displaying complicated multilevel systems, you may choose between displaying levels as opaque or transparent, optionally coloured by depth; selected levels only; selected levels with the preview of some levels below (filled grey) and above (stroked as thin outline). Some levels may be shifted by a specified offset.

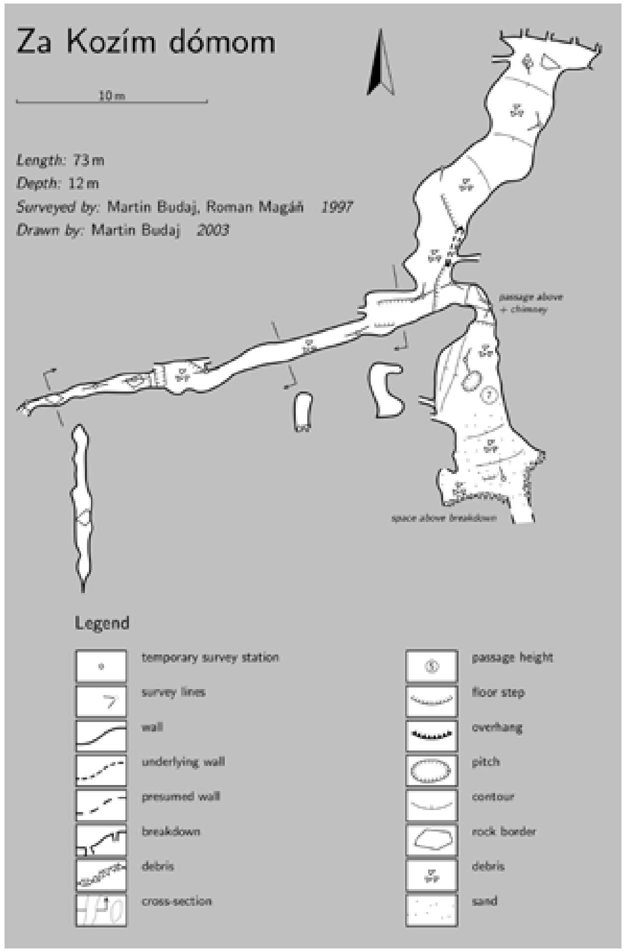


Fig. 8: Map with legend generated automatically

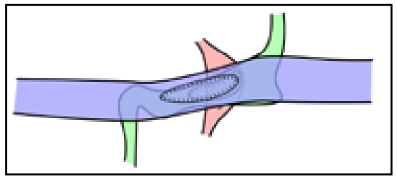


Fig. 9: Overlying passages displayed using transparency and different colours

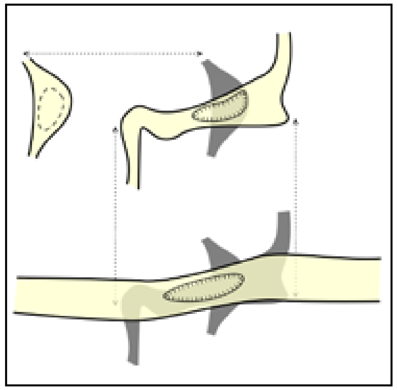


Fig. 10: The same passages displayed using map offsets

The output maps are very flexible – the map is not only up-to-date, reflecting all changes in centreline, but in addition you may change the scale, symbol set and format: either one-sheet map or multi-page atlas with cross references and hyperlinks.

Maps may contain the whole cave or only selected part(s).

Therion can process three forms of map: plan with cross sections, elevation or extended elevation.

You may choose to hide some groups of symbols, so with one setting you can get a simple map containing only the passage outline and centreline; or you may instruct Therion to highlight all symbols denoting possible continuations in red… All variants are generated from one source simply by changing processing options. You draw the map once and get dozens of different customized maps as output.

In addition to print-ready maps (in PDF or SVG formats) you can export a map in various GIS formats (ESRI shapefile, DXF, KML), which contain the abstract objects with attributes assigned to them. As these maps can be exported georeferenced, they can be easily imported into another GIS project and processed further.

7. Cave Models

The map is reused once more while creating the 3D model. In addition to the tube-like models generated from LRUD data by almost all surveying programs, Therion uses precise passage outlines and information about passage height as specified in the 2D map to create much more realistic models without any additional work (Fig. 11).

The model is combined with a digital terrain model and topographical map, if available.

For quick previews, when no maps are drawn, the model is generated from LRUD data.

The spectrum of available formats includes Therion, ESRI shapefile, DXF, VRML, 3DMF, Survex and Compass formats (Fig. 12).

8. Database and Lists

Besides the maps and models there is another useful output. The centreline data can be exported to an SQL database, where queries like 'which passages were surveyed by *X.Y.* in April of 1973' could be given.

For exploration management in large cave systems there is a commented list of all (possible) continuations marked anywhere in the centreline or maps.

Projects covering larger karst areas may benefit from the structured list of all caves and their entrances.

9. Using Therion

Therion is especially suitable for large cave systems. Indeed, maps of some large cave systems over five continents (see https://therion.speleo.sk/wiki/doku.php?id=proj) have been generated by Therion. Without Therion some of them would not have any usable map, only a lot of partial maps, sketches and notes which nobody would be able to put together.

It might seem that Therion is overkill for small, simple caves. Quite the contrary; it brings the benefit of a uniform symbol set, and the ability to display a particular cave in any scale, or all the caves in one scale, printed on the top of a topographical map.

10. Conclusion

Therion is quite a complex beast requiring some effort to tame it, but – all in all – it is well worth learning.

See Therion's Web page (https://therion.speleo.sk) for examples, screenshots and documentation. Here you can download Therion and example files, read the Wiki pages and participate in the mailing list.

11. Acknowledgements

The first version of this article was published in Spelunca in 2008. Wookey helped us substantially to improve the language of that version of the article.

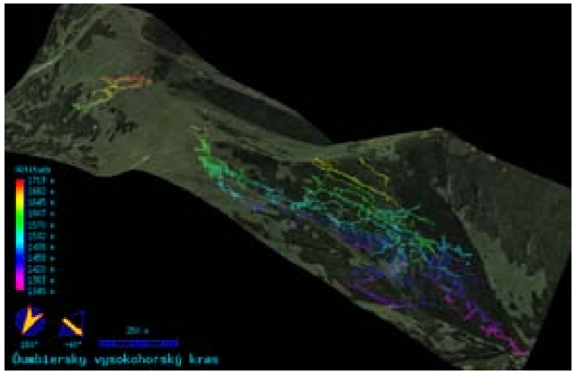


Fig. 11: Dead Bats Cave 3D model displayed in Loch

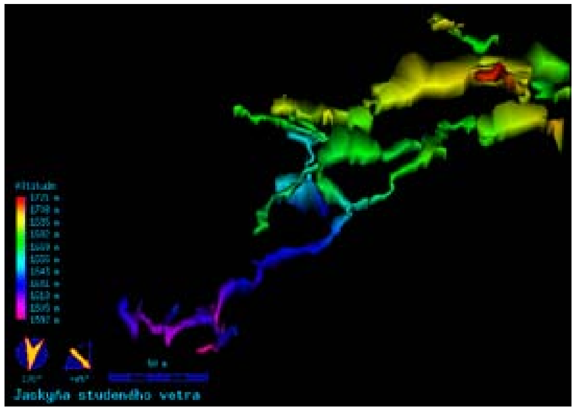


Fig. 12 More detailed 3D view

SPELEOFOTOGRAFIA: SLOVAK PHOTOGRAPH CONTEST WITH THE THEME OF CAVES AND CAVING

Lukáš Vlček – Pavol Kočiš – Mária Ošková

Slovak Speleological Society – Slovak Museum of Nature Protection and Speleology

Although the first cave photography was already happening in the 19th century, taking pictures underground is still anything but a piece of cake. Complex planning and preparation are just the beginning. Apart from the specialist equipment, taking pictures underground requires a considerable amount of courage, caving experience and skills in lighting, and it especially requires a well-coordinated team of cavers. Speleophotography means teamwork. The photographer usually needs assistance with transportation, arranging the scene and lighting. From the moment of pressing the shutter release button, cavers wait in the dark underground sometimes for a few minutes, or even a few hours... Let's flash! So this photo is really extraordinary! The Speleofotografia Contest is full of remarkable pictures!

The idea of a Speleofotografia Contest was born in Slovakia in 1982. The contest's intention was to put on display pictures representing different caving activities. For the first two years, the event was held only among Czecho-Slovak cave photographers, but in 1984 it became international. Tens of photographers from all over the world have participated in Speleofotografia. In 2014, the organizationally upgraded contest represented 80 photographers from 20 countries of Europe, America and Asia. With more than 550 pictures, they initiated viewers into the atmosphere of the mysterious world of caves. 54 photographers from 17 countries of Europe, America and Asia submitted 327 photographs for the 18th Year of the international speleology photography contest. The photos, in two thematic categories, portray the beauty of the caves in all their aspects and unique speleo-moments which can only be seen in the world of the underground.

Most of the Speleofotografia participants belong to the world elite in caving. Their masterpieces are increasingly moving towards reproducing the dynamics of speleological activities. All sorts of difficulties of discovery and exploration of caves are on show, and they demonstrate that caving is amongst the most demanding, but also challenging and stimulating, of human activities. Pictures expose the hardships of exploration for cavers, whose activities sometimes balance on the edge of human possibilities. The photographers have taken pictures from discoveries which represent the fruits of their voluntary, but often dangerous and exhausting labour. They also show the journeys to and through the caves; mysterious creatures living in unusual environments, the breathtaking magnificence of an underground kingdom where the human-being is diminutive

Cristian Ţecu and Cosmin Nistor (Romania) – Velvet Voyage

in comparison with the dimensionality of the world of stone, flowstone formations and cave rivers, abseiling pits, overcoming underground rivers and lakes, and crawling through narrow squeezings. Through the theme of static cave decorations – clusters of crystals, cave pearls, dripstone formations and shiny castles of ice, a sense of beauty is expressed in the detail. What surprises are still waiting in the caves? The photos of the talented photographers participating in the Speleofotografia Contest have convinced us of the fact that the underground environment is full of unexpected wonders.

Cosmin Nistor – Photo No. 13

Speleophotography is always about having a great team. No photographer is able to act without assistance from people who help him in the art of creation. Usually exposing a picture is preceded by difficult transportation of photo-equipment (tripods, lenses, flashes, batteries) into and through a cave, climbing on ropes, going through thin meanders or dangerous collapses, fording rivers or lakes underground, even carefully sqeezing through a crawling so as not to harm the fragile cave decoration. At least once in a life time each caver asks himself: Why am I doing something so crazy as this?! But the moment when the flash-light lights up the scene changes everything; it brings an understanding of the cave photographers' effort. Another miracle has been created. Nature means Art. Caves are keys to the perfect feeling of it.

You can find details of the Speleofotografia Contest at http://speleofotografia.sss.sk/?lang=en

Peter Gedei (Slovenia) – Ice Chamber

Rémi Flament – Gravity

SLOVAK SPELEOLOGY IN LITERATURE

Lukáš Vlček
Slovak Speleological Society

The Speleological Library in Slovakia represents, in particular, three periodical magazines: Spravodaj SSS, Slovenský kras and Aragonit. Since the 1970s, the Spravodaj (Bulletin) of the Slovak Speleological Society has been published by the Slovak Speleological Society; this year sees the 47th volume. It is traditionally published in four issues a year. The journal is focused on the results of basic speleological exploration, survey and research in Slovakia, as well as the work of Slovak cavers abroad.

The Museum of Slovak Karst originally kept a yearbook, but this has been replaced today by a scientific magazine published by the Slovak Museum of Nature Conservation and Caves, and the Slovak Caves Administration – Slovenský kras, subtitled Acta Carsologica Slovaca. The magazine has been published since 1958 and contains hundreds of papers which constitute the main written contribution to the topic of caves and karstology in Slovakia. This year is the 60th issue of the magazine's 55th volume. The publication was issued annually for a long time, but since 2008 the Slovak Karst has been published as a magazine twice a year, with occasional supplements.

The third magazine of Slovak speleology is the Aragonit, which initially originated as a yearbook of the Slovak Caves Administration. In 2007 it became a peer-reviewed magazine, and since 2008 it has been published in two volumes each year. Certain impacts on Slovak caves is attributed to the Slovak Museum of Nature Conservation and Caves' yearbook, the name of which suggests that it contains articles from speleology – Sinter. Its first volumes were devoted almost exclusively to caves and karst protection. Useful information about local caving are included in the regional yearbooks Jaskyniar (2007 – 2011) and Hory a jaskyne (2012 – 2017). The Society for the protection of bats in Slovakia (SON) publishes the peer-reviewed magazine Vespertilio, whose 6th issue was conceived as a catalog of hibernation sites of bats in Slovakia. Many books and monographies with a speleological topic have been published in the last years in Slovakia.

Since 1996, the Administration of Slovak Caves has been organizing, at two-year intervals, an international scientific conference called Research, Use and Protection of Caves. The papers from the conferences were initially published in the Proceedings, and since 2007 the contributions from the conferences in the Slovenský kras and Aragonit journals have been published. In the past, Slovakia has held several conferences, symposia and colloquia, as well as speleologically oriented congresses of an international character. Papers from the proceedings, e.g. from the ISCA Congress (International Show Caves Association) can be found on the web-site of the Slovak Speleological Society.

In the Library section of the www.sss.sk website, we intend to make all information from these magazines available to the public, as well as give full access to the Library of the Slovak Speleological Society for registered users.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