SCIENTIFIC CONFERENCE MARKING
THE FIRST CELEBRATION OF
INTERNATIONAL DAY OF CAVES AND
KARST

MEDNARODNA ZNANSTVENA
KONFERENCA OB PRAZNOVANJU PRVEGA
MEDNARODNEGA DNEVA JAM IN KRASA

EXPLORE, UNDERSTAND AND PROTECT: TOWARDS SUSTAINABLE MANAGEMENT OF CAVES AND KARST

RAZISKUJMO, RAZUMIMO IN VARUJMO: K TRAJNOSTNEM UPRAVLJANJU JAM IN KRASA

PROCEEDINGS
ZBORNIK



Postojna
2026

Editors / Uredniki:
Tinkara Mazej, Nadja Zupan Hajna, Blaž Kogovšek

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INTERNATIONAL DAY OF CAVES AND KARST
13th of September

OPENING ADDRESSES

UVODNI NAGOVORI

WELCOME TO THE FIRST CELEBRATION OF THE UNESCO INTERNATIONAL DAY OF CAVES AND KARST

DOBRODOŠLI NA PRVEM PRAZNOVANJU UNESCO MEDNARODNEGA DNEVA JAM IN KRASA

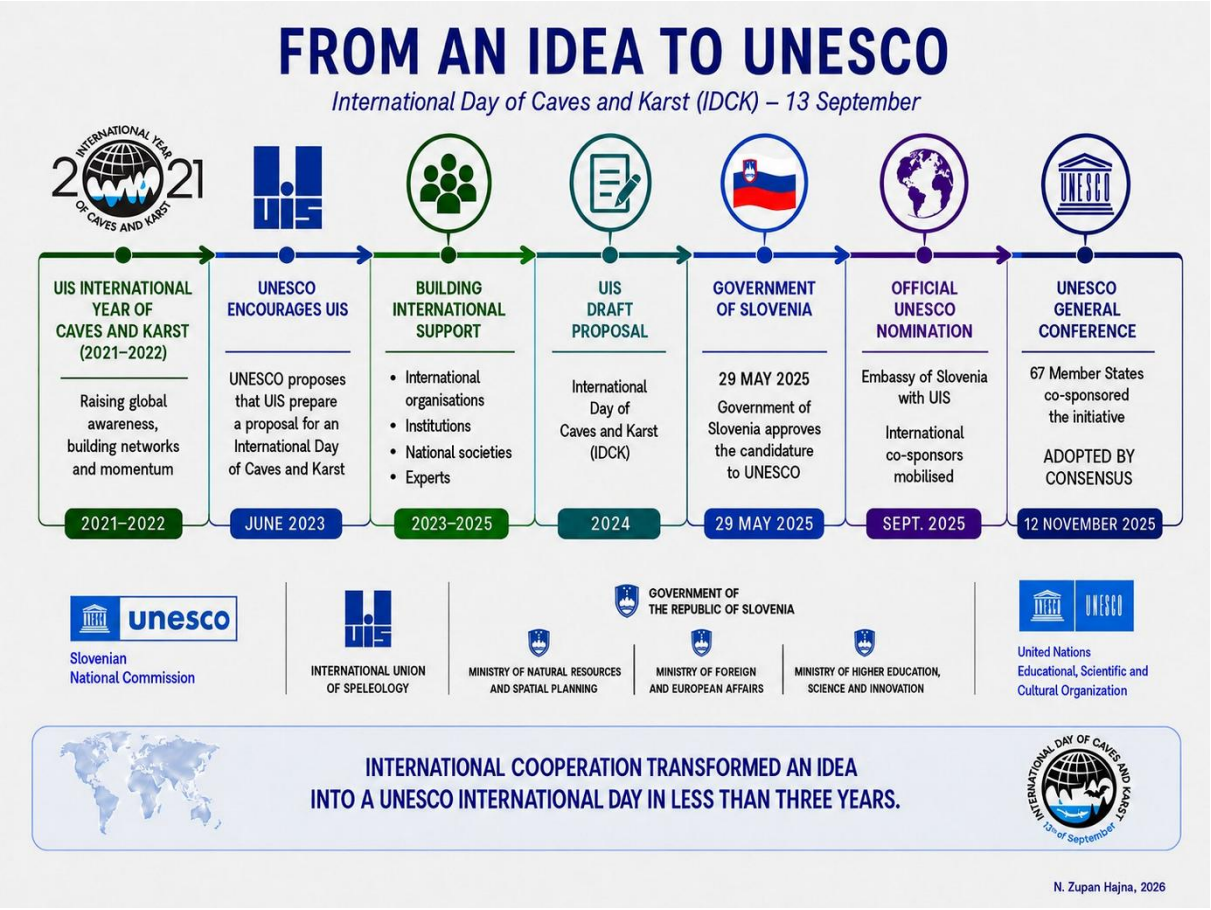


Figure 1: Key milestones from the UIS initiative to UNESCO's adoption of the International Day of Caves and Karst in 2025.

The year 2026 marks a historic milestone for the international cave and karst community. For the first time, the UNESCO International Day of Caves and Karst (IDCK) will be celebrated worldwide on 13 September, following its proclamation by the UNESCO General Conference in 2025. This recognition represents far more than the establishment of another international observance. It recognises the fundamental importance of caves and karst to humanity and provides a permanent global platform for promoting their scientific, environmental, cultural, educational, and socio-economic values. This volume documents the scientific conference organised as part of this inaugural celebration and reflects the breadth of contemporary research and international cooperation in cave and karst science.

The establishment of this International Day is the result of a journey that began during the International Year of Caves and Karst in 2021–2022. What was initially an ambitious idea gradually developed into a global initiative through scientific cooperation, persistent international advocacy, and the support of institutions and organisations from around the world. Its proclamation by UNESCO demonstrates what can be achieved when the scientific community unites around a shared purpose.

Every year, the International Day of Caves and Karst will bring together speleologists, cavers and researchers, protected-area managers, show cave managers, educators, policy-makers, local communities, and all those who value the underground world. Through scientific meetings,

educational activities, exhibitions, cave visits, conservation projects, and public events, it will encourage a greater understanding of caves and karst and inspire their protection for future generations. The International Day will also highlight the essential contribution of caves and karst to addressing global challenges, including the sustainable management of groundwater resources, biodiversity conservation, climate research, geoheritage, and sustainable development.

It is therefore especially fitting that the first official international celebration is being held in Slovenia, a country internationally recognised as one of the birthplaces of modern karstology, speleology, and speleobiology. The international term karst derives from the Slovenian name Kras for the Classical Karst, whose landscapes have shaped the development of karst research for centuries. With more than 16,200 registered caves, internationally renowned show caves such as Postojna Cave, the Škocjan Caves UNESCO World Heritage Site, the Karst Research Institute ZRC SAZU, and the headquarters of the International Union of Speleology (UIS), Slovenia has long played a leading role in the exploration, scientific study, conservation, and sustainable management of karst.

The scientific conference, Explore, Understand and Protect: Towards Sustainable Management of Caves and Karst, forms an integral part of this inaugural celebration. Its title builds on the motto of the International Year of Caves and Karst "Explore, Understand, Protect" and extends it towards the shared goal of sustainable management. The conference brings together scientists and cavers from around the world to exchange knowledge, present new research, strengthen international cooperation, and contribute to a sustainable future for caves and karst.

This first celebration is intended not as a single event, but as the beginning of a long-term global tradition. From this year onwards, every 13 September will provide an opportunity for organisations, institutions, protected areas, universities, museums, schools, show caves, geoparks, and local communities across the world to celebrate caves and karst in their own way. Together, these local initiatives will demonstrate that caves and karst are not isolated scientific curiosities, but essential components of our natural and cultural heritage, deserving greater recognition and lasting protection.

On behalf of the Organising Committee, it is my great pleasure to welcome all participants to Slovenia and to this historic occasion. We are honoured to welcome you to the first celebration of the UNESCO International Day of Caves and Karst and sincerely hope that the scientific discussions, field excursions, and celebrations will inspire new collaborations, lasting friendships, and a shared commitment to protecting caves and karst throughout the world.

Your presence makes this first celebration truly international. May the first celebration of IDCK mark the beginning of an enduring global tradition that will continue to inspire research, education, cooperation, and conservation for generations to come.

Nadja Zupan Hajna
On behalf of the Organising Committee

ADDRESS BY THE PRESIDENT OF THE INTERNATIONAL UNION OF SPELEOLOGY

NAGOVOR PREDSEDNIKA MEDNARODNE SPELEOLOŠKE ZVEZE

Dear Colleagues, Dear Friends,

It is my great pleasure and privilege to welcome you on behalf of the International Union of Speleology to the scientific conference 'Explore, Understand and Protect: Towards Sustainable Management of Caves and Karst', organized on the occasion of the first celebration of the UNESCO International Day of Caves and Karst in Postojna, Slovenia, from 10 to 13 September 2026.

This conference and celebration represent an important milestone, not only for the scientific community dedicated to the study of caves and karst, but also for everyone who shares responsibility for the protection of our natural heritage.

Its theme captures a powerful message: that exploration must lead to understanding, and understanding must lead to protection. In a world facing increasing environmental challenges, this connection has never been more important. And that is the main reason why the International Union of Speleology (UIS) decided to use it not only for this conference, but also as the slogan for the International Day of Caves and Karst.

Caves and karst landscapes are among the most fascinating and fragile systems on our planet. They are archives of geological time, reservoirs of biodiversity, and vital sources of freshwater for millions of people worldwide. At the same time, they are highly sensitive to human impact, making their sustainable management both a scientific challenge and a global responsibility.

It is particularly significant that this first celebration is taking place right here in Postojna, a place renowned not only for the diversity of the underground world and exemplary karst formations, but also for its long tradition of exploration, scientific research and nature protection.

I would like to express my sincere gratitude to UNESCO, the conference organizers, the authors, reviewers, partners and all contributors whose dedication made this event and these proceedings possible. Their efforts advance scientific knowledge, strengthen international cooperation and raise public awareness of the value of caves and karst.

As we celebrate this historic occasion, I trust that the passion for exploration will continue to deepen our knowledge, that understanding will guide our actions, and that our collective commitment will help protect caves and karst for future generations.

Zdeněk Motyčka
President of the International Union of Speleology

A LONG TRADITION OF KARST RESEARCH BEHIND A GLOBAL CELEBRATION

DOLGA TRADICIJA RAZISKOVANJA KRASA KOT TEMELJ SVETOVNEGA PRAZNOVANJA

It is a great honor to welcome first celebration of the International Day of Caves and Karst, proclaimed by UNESCO and observed worldwide on 13th September.

The establishment of this day marks an important moment for caves and karst. It draws attention to a world that is often hidden from our eyes, yet is closely connected with the surface, water resources, biodiversity, natural processes and human societies. It also provides an opportunity to bring the scientific, environmental, cultural and social importance of caves and karst closer to people around the world.

Karst is of great global importance. Carbonate rocks on which it develops cover about one-fifth of the world's land surface. Karst aquifers are among the most important sources of drinking water, as they are estimated to meet roughly one-quarter of global drinking water needs. Karst areas provide numerous other ecosystem services, including carbon sequestration and renewable energy resources. They are also exceptional ecosystems, since they provide unique habitats with a high level of biodiversity and contain species adapted to life in the permanently dark subterranean environment. Caves and karst landscapes preserve records of past geomorphological, climatic, ecological and anthropogenic conditions. In many areas, natural, historical and cultural heritage are closely connected, while caves and other karst phenomena also contribute significantly to tourism and local economies.

At the same time, the special characteristics of karst processes make karst environments particularly vulnerable. Pollution can move rapidly through the subsurface, while the self-cleaning capacity of karst aquifers and subterranean ecosystems is limited. Quarrying, urbanization, intensive land use, excessive groundwater abstraction and other interventions on the surface and underground drainage can permanently destroy karst features, disrupt hydrological connections and alter the natural processes that shape karst phenomena. Some of these changes are irreversible. The protection of karst therefore requires interdisciplinary research, education, responsible management and public awareness.

The Karst Research Institute of the Research Centre of the Slovenian Academy of Sciences and Arts has been contributing to this effort for almost eight decades. Its work builds on a much longer tradition of karst research in the Classical Karst, where generations of explorers and scientists studied caves, underground waters and surface karst features and laid the foundations of modern karstology. The Institute continues and develops this tradition through interdisciplinary research and innovation, education and international cooperation. Its location in Postojna, in the center of the Classical Karst, and its role as the seat of the International Union of Speleology give it a distinct position within the international karstological community. One of the Institute’s distinctive features is that it brings together different scientific disciplines within a single institution, where their approaches from different disciplines are intertwined.

Researchers at the Institute conduct basic interdisciplinary research on karst features and processes, as well as ecological studies of karst, in a holistic and integrated way. They develop regional karstology and strive for the protection of natural heritage. At the same time, their applied research builds on an understanding of karst in order to support practical planning of life on karst, the use of natural resources and sustainable development. The innovative solutions developed through this work are often internationally transferable.

Education and the exchange of knowledge have always been central to the Institute’s mission. Institute members are involved in teaching at several higher education institutions. Together with the University

of Nova Gorica, the Institute implements the unique Doctoral study programme of Karstology accredited as the UNESCO Chair on Karst Education. The Institute's researchers are strongly involved in international cooperation, contributing to the development of karstology in many countries and connecting researchers across the international karstological community. For more than thirty years, the Institute has also organised the International Karstological School "Classical Karst", which has become one of the main annual meeting points for karstologists from across the world.

The Institute supports karst research through its library, laboratories, research infrastructure, data collections and publishing activities. It publishes the international diamond open-access journal Acta Carsologica and the book series Carsologica. In cooperation with the Speleological Association of Slovenia, it also contributes to the documentation of Slovenian caves, it develops digital collections that make karstological data and metadata more accessible to researchers and the public.

These activities have helped knowledge developed on the Classical Karst reach far beyond Slovenia and therefore it is not surprising that the idea of establishing an international day dedicated to caves and karst originated at the Karst Research Institute. The initiative was formally submitted by the Republic of Slovenia at the proposal of the International Union of Speleology, in cooperation with the Slovenian National Commission for UNESCO and the Permanent Delegation of the Republic of Slovenia to UNESCO in Paris.

The proclamation is also a recognition of Slovenia's long tradition of karst research, speleology and nature conservation. Slovenia has an exceptional karst heritage and a strong community of researchers, speleologists, educators and conservation professionals. It is home to the Karst Research Institute ZRC SAZU, the seat of the International Union of Speleology and the Škocjan Caves, which have been inscribed on the UNESCO World Heritage List since 1986. Postojna lies at the heart of the Classical Karst and has long been one of the major international centres of karstology and speleology. The Classical Karst gave the scientific term karst to the world and became one of the principal reference areas for the study of karst phenomena and processes. For this reason, it is particularly meaningful that the first official celebration of the International Day of Caves and Karst is taking place here.

The first celebration takes place under the honorary patronage of the President of the Republic of Slovenia, Dr. Nataša Pirc Musar, and under the patronage of UNESCO. Its preparation has required the commitment and cooperation of many institutions and individuals. Special thanks go to the Permanent Delegation of the Republic of Slovenia to UNESCO in Paris for its diplomatic work in building broad international support that contributed to the adoption of the initiative by the UNESCO General Conference. I would like to express sincere gratitude to the Slovenian National Commission for UNESCO, the International Union of Speleology, Postojnska jama, the Škocjan Caves Park, the Municipality of Postojna, the Municipality of Pivka, Zavod znanje, the Speleological Association of Slovenia and all our partners in Slovenia and abroad who have recognized the global importance of caves and karst. We also extend our thanks to all those who contributed to the establishment of the International Day of Caves and Karst and to its first worldwide celebration. Finally, sincere thanks go to all sponsors, financial supporters and other partners whose assistance helped make this occasion possible.

This day is an opportunity to celebrate caves and karst! At the same time, it is also a reminder that their future depends on our ability to understand them, protect them and pass on knowledge about their importance to future generations.

Nataša Ravbar
Head of the Karst Research Institute, Research Centre of the Slovenian Academy of Sciences and Arts

PROGRAM

PROGRAM

SCHEDULE

URNIK

Thursday, September 10th, 2026 *Četrtek, 10. september 2026*	
EXCURSION 1 *EKSKURZIJA 1*	
8:30	**Gathering at the Postojna bus station** *Zbor na avtobusni postaji Postojna*
08:30–17:30	**Whole day excursion 1:** Škocjan Caves and Pivka intermittent lakes ***Celodnevna ekskurzija 1:*** *Škocjanske jame in Pivška presihajoča jezera*

Friday, September 11th, 2026 *Petek, 11. september 2026*		
FULL-DAY CONFERENCE *CELODNEVNA KONFERENCA*		
08:00–12:30	**Registration** *Prijava udeležencev*	Cultural Centre Postojna Kulturni dom Postojna
09:00–10:15	**Opening ceremony** *Otvoritvena slovesnost*	
09:00–09:05	**Nadja Zupan Hajna:** Welcome address	
09:05–09:30	Welcome addresses by distinguished guests	
09:30–09:45	**Zdeněk Motyčka:** The International Union of Speleology and Its Mission	
09:45–10:00	**Jurij Kunaver:** Postojna, Venue of the 4th International Congress of Speleology and the Founding of the International Union of Speleology (September 1965)	
10:00–10:15	**Nadja Zupan Hajna:** From an Idea to a UNESCO International Day	
10:15–10:45	*Coffee break and poster presentations*	
10:45–12:35	**SESSION 1** *SKLOP 1*	
10:45–11:05	*Invited lecture* **John Gunn:** UIS/IUCN Guidelines for Cave and Karst Protection	
11:05–11:20	**Paul W. Williams:** Future Challenges for Cave and Karst Conservation	
11:20–11:35	**Rosana Cerkvenik:** Škocjan Caves as an Example of UNESCO World Heritage Management	
11:35–11:50	**Kaja Batagelj:** Postojna Cave as an Example of Balancing Tourism with Conservation of a Natural Asset	
11:50–12:05	**Neven Bočić:** Barać Caves (Croatia) – From History to a Modern Visitor Centre: Research, Protection and Tourism Development	

12:05–12:20	**Corrado Greco:** Exploring Caves with Valentina and Proty: A New Innovative Way to Communicate Underground Sciences in Show Caves	Cultural Centre Postojna Kulturni dom Postojna
12:20–12:35	**Val Hildreth-Werker:** Sustainable Cave Conservation Management: Mitigating Human Impacts	
12:35–14:00	*Lunch break*	
14:00–15:35	**SESSION 2** ***SKLOP 2***	
14:00–14:20	*Invited lecture* **Ilias Valiakos:** Geoparks, Karst and Caves	
14:20–14:35	**Clayton Ferreira Lino:** Integrating Public Policies for Cave and Karst Protection at National and Subnational Levels: The Case of Brazil and the State of São Paulo	
14:35–14:50	**Anu Kahuna:** Building the Aspiring Transboundary UNESCO Global Geopark Kras-Carso	
14:50–15:05	**Valentina Balestra:** Microplastic and Microfibre Pollution in Karst Systems: The First Six Years of Multidisciplinary Research Efforts	
15:05–15:20	**Stein-Erik Lauritzen:** Norway's Marble Karst: Safe and Sustainable Management?	
15:20–15:35	**Fadhil Ahmed Ameen Lawa:** Geodiversity and Karst Features of the Sharbazhair Province, Sulaimani Governorate, Kurdistan Region, Iraq	
15:35–15:50	*Coffee break*	
15:50–17:20	**SESSION 3** ***SKLOP 3***	
15:50–16:05	**Paul Griffiths:** Sustainable Karst Management and Responsibility for Legacy Disturbances in a Protected Area	
16:05–16:20	**Bai Bing:** International Standardization on Karst	
16:20–16:35	**Katarina Kosič Ficco:** Integration of Karst-Specific Approaches in Existing Conservation Frameworks through Cooperation	
16:35–16:50	**Tim Stokes:** Why Another Textbook on Karst and Caves – Developing an Accessible and Interactive Open Textbook	
16:50–17:05	**Mario Parise:** Geohazards in Karst: Impacts on Society and Natural Environment, and Actions of Risk Mitigation	
17:05–17:20	**Filippo Gregori:** Karst Landscapes under Pressure: Desertification Regimes across the Mediterranean Bioclimatic Gradient	
17:20–20:00	*Break*	
20:00	**3D cave presentation (Csaba Egri and Peter Gedei; organised by the Stereoscopic Society of Ljubljana) with UIS Commissions Photo Contest Results** ***3D predstavitev jam (Csaba Egri in Peter Gedei; izvedba Stereoskopsko društvo Ljubljana) z rezultati fotografskega natečaja UIS Komisij***	

Saturday, September 12th, 2026 *Sobota, 12. september 2026*		
HALF-DAY CONFERENCE ***POLDNEVNA KONFERENCA***		
08:30–11:00	**Registration** ***Prijava udeležencev***	Cultural Centre Postojna Kulturni dom Postojna
09:00–10:35	**SESSION 4** ***SKLOP 4***	
09:00–09:20	*Invited lecture* **Zoran Stevanović:** Sustainable Management of Karst Waters	
09:20–09:35	**Irma Losada Olmos:** Built on Water: Yucatán's Karst Aquifer and the Maya Train	
09:35–09:50	**Limaris Soto:** Karst Literacy Is a Foundation for Effective Policy, Groundwater Protection, and Hazard Mitigation	
09:50–10:05	**Carlos Carsolio:** Hydrodynamics and Thermodynamic Autoregulation of the Perennial Seepage in the Etruscan Well of Perugia: A Hydraulically Isolated Perched Lens Hypothesis Under Severe Estival Drought	
10:05–10:20	**Gheorghe M.L. Ponta:** Hydrogeological Investigations to Delineate the Recharge Area of Bobcat Cave for the Protection of Alabama Cave Shrimp on Redstone Arsenal, in Madison County, Alabama, USA	
10:20–10:35	**Tullio Quaia & Luca Terribili:** Delineation and Characterization of Karst Areas in the Friuli Venezia Giulia Region	
10:35–10:50	*Coffee break*	
10:50–12:05	**SESSION 5** ***SKLOP 5***	
10:50–11:05	**Johannes Mattes:** Collecting Empires: Dominik Bilimek and Early Subterranean Zoology between Politics and Field Research	
11:05–11:20	**Slavko Polak:** A New Precise Definition of the Dinaric Karst Zoogeographic Boundaries Based on Genomic Studies of Cave Beetles	
11:20–11:35	**Marc Mentens:** Biodiversity of Underground Tipan Cave and Naga-Kabasalan Protected Landscape (NKPL), Zamboanga Sibugay, Philippines	
11:35–11:50	**Chiara Manfrin:** Subterranean Landscape Fragmentation Drives Cryptic Diversification in the Olm (Proteus anguinus)	
11:50–12:05	**Pei Wang:** Geodiversity Sustains Biodiversity in Karst	
12:05–12:30	*Coffee break*	
12:30–14:20	**SESSION 6** ***SKLOP 6***	
12:30–12:50	*Invited lecture* **Franci Gabrovšek:** Understanding Karst: Science as a Basis for Sustainable Management and Use of Karst and Caves	
12:50–13:05	**Nathalia Vanessa Uasapud Enríquez:** From Knowledge to Conservation: Community-Based, Low-Cost Management of Tourist Caves in the La Danta Karst System, Colombia	
13:05–13:20	**Ros Fatihah Muhammad:** GIS-Based Mapping and Characterisation of Karst Hills in the Gua Musang–Lipis Area, West Malaysia	
13:20–13:35	**Angel Acosta-Colon:** The Puerto Rico Cave Visualization Project	
13:35–13:50	**Csaba Egri:** Using 3D Technology in Cave Documentation, Conservation,	

	Presentation and Education	
13:50–14:05	**Łukasz Lewkowicz:** Speleological Activity of the Zwoliński Brothers in Poland: A Brief History	
14:05–14:20	**UIS Speleological Education for Children and Youth Commission:** Video	

Saturday, September 12th, 2026 *Sobota, 12. september 2026*		
OFFICIAL CEREMONY *URADNA SLOVESNOST*		
17:15	**Gathering and group photo on the steps in front of the Postojna Cave** *Zbor in skupinsko fotografiranje na stopnicah pred Postojnsko jamo*	Postojna Cave Postojnska jama
18:00	**Train ride into the cave; cave visit and celebration** *Vožnja z vlakom v jamo; ogled jame in proslava*	
20:00-21:00	**Reception** *Sprejem*	

Sunday, September 13th, 2026 *Nedelja, 13. september 2026*		
EXCURSION 2 *EKSKURZIJA 2*		
9:30	**Gathering at the Postojna bus station** *Zbor na avtobusni postaji Postojna*	
09:30–11:00	**Celebrating the Unica spring as one of the World's Most Important Karst Aquifer Springs by the International Association of Hydrogeologists (IAH)** *Obeležitev uvrstitve izvira Unice med najpomembnejše izvire kraških vodonosnikov na svetu po izboru Mednarodnega združenja hidrogeologov (IAH)*	Planina Cave parking lot Parkirišče nad Planinsko jamo
11:00–17:00	**Excursion 2: Entrance section of Planina Cave, Rakov Škocjan and Cerknica Polje** *Ekskurzija 2: Vhodni del Planinske jame, Rakov Škocjan in Cerkniško polje*	

LIST OF POSTER PRESENTATIONS

SEZNAM POSTERJEV

	1st AUTHOR	TITLE
1	Shirin Bahadorinia	Assessment of Geotourism Potential in Iranian Caves: A Case Study of Alisadr and Katale Khor Caves
2	Clarissa Brun	Learning from the Underground: Educational Strategies for the Conservation of Karst and Cave Heritage
3	Raffaele Bruschi	Passive atmospheric microplastic deposition in caves: a monitoring framework from Postojna Cave
4	José María Calaforra	The Gypsum Karst of Sorbas (Almeria, Spain): Towards a new UNESCO "GeoPark"
5	Allan Calux	Brazilian Speleological Society and National Center for Cave Research and Conservation: Partnership for the Conservation of Karst and Caves
6	David Farkas	Insights into Drip Water in the Buda Castle Cave
7	Fulvio Forti	Researching CO2 in Some Caves in the Classic Karst
8	Mladen Garašić	UIS and Croatian Speleologists and Scientists
9	Sándor Gönczy	The Developing Dynamics of the Surface of a Karstic Salt Dome: The Instance of Solotyvno (Ukraine, Transcarpathia)
10	Filippo Gregori	Underground Climate Change (UCC): A Citizen Science Network for Monitoring Climate Change in Caves
11	Hegedűs Gyula	Organized Hungarian Speleology
12	Huang Fen	Mechanisms, Potential, and Measurement Methods of Karst Carbon Sinks
13	Martin Knez	Karstification of Cultural Heritage
14	Enrico Merlak	Extrusions of Iron Oxides in Karstified Calcareous Soils of the North Adriatic: A Study and Mapping Project for Site Protection
15	Marta Murru	Karst as a Cognitive Tool for Inhabiting an Extended Temporality
16	Legrioui Radhia	The Hammamet Karst Aquifer as a Strategic Groundwater Reservoir (Semi-Arid Region, North East of Algeria)
17	Ljubomir Risteski	Utilizing Structural Lineament Mapping with Digital Elevation Models for Understanding Speleogeneic Patterns in the Mammoth Cave Plateau
18	Astrid Švara	Hydrogeological and sedimentological changes in the contact karst of the Postojna Basin: Geodiversity as an archive of the past
19	Madara Vitkovska	Mapping the Distribution of Karst Sinkholes Across Latvia Using High-Resolution LiDAR Data
20	Xiao Qiong	Carbon Sequestration in Karst Surface Aquatic Systems
21	Zhong Liang	International Research Centre on Karst, UNESCO
22	Zhou Wenlong	The formation mechanism and potential heritage value of the World's super cavern The Miao Chamber in Ziyun County, Guizhou, China
23	Tomaž Zorman	Sustainable Tourism and Conservation Measures in the Škocjan Caves

EXCURSIONS

EKSKURZIJE

EXCURSION 1: ŠKOCJAN CAVES AND THE PIVKA INTERMITTEN LAKES

EKSKURZIJA 1: ŠKOCJANSKE JAME IN PIVŠKA PRESIHAJOČA JEZERA

PIVKA INTERMITTEN LAKES

Marjetka Šemrl, Helena Šneberger Mandelj

Pivka is a karst landscape formed by water and shaped by man

When the underground of the Green Karst is filled with water, the southern slopes of the Javorniki forests are reflected on the surface of 17 Pivka intermittent lakes. Nowhere else in the world are there so many of them in such a small area. Here, water dictates the rhythm of life between the two extremes – severe drought and flooded fields. The landscape's mosaic of fields, meadows and forests tells us a story of how man has adapted to this water-driven rhythm.

After heavy rains, Karst depressions fill with water and intermittent lakes emerge; therefore, they are called seasonal. Their mysterious disappearance into the karstic underground world in summer gives way to marvelous meadows covered with fragrant flowers, colorful butterflies and birds.

The Pivka Intermittent Lakes boast exceptional species diversity. Researchers have recorded here 182 plant species, 211 beetle species, 106 butterfly species, and 133 bird species. The area is also an important habitat for large carnivores, such as bears, wolves and lynxes.

With the aim of preserving the area's rich diversity, the Municipality of Pivka established The Seasonal Lakes of Pivka Nature Park in 2014. Located in the central part of the Pivka Basin, the park with its 140 km² covers well over half of the Municipality of Pivka. As the park's manager, the municipality's efforts are focused on implementing nature conservation projects that enable the execution of concrete conservation measures and active involvement of target groups (e.g. farmers) in their implementation.



Figure 2: Location of the Pivka Intermitten Lakes.

Guided Tour of the Large Carnivore Centre DINA

During the guided tour, visitors will explore the main interpretation center dedicated to large carnivores in Slovenia and learn about the three largest predators inhabiting Slovenian forests: the bear, wolf, and lynx. The tour presents their characteristics, biology, and ecology, with special emphasis on the challenges and good practices of human coexistence with large carnivores. Through interactive content and exhibition stations, visitors will also become acquainted with modern interpretive approaches.



Figure 3: Large Carnivore center DINA (photo: The Seasonal Lakes of Pivka Natural Park).

Guided Tour of the Ecomuseum of the Seasonal Lakes of Pivka

During the guided tour, visitors will explore the Ecomuseum of the Seasonal Lakes of Pivka, the entry point to the protected area of the Nature Park of the Pivka Seasonal Lakes. They will discover a unique karst world shaped by the constant appearance and disappearance of water, creating an important habitat for numerous plant and animal species. The tour presents the characteristics of the karst landscape, the dynamics of the seasonal lakes, and the natural and cultural heritage of the area.



Figure 4: Ecomuseum of the Seasonal Lakes of Pivka (photo: The Seasonal Lakes of Pivka Natural Park).

ŠKOCJAN CAVES

Rosana Cerkvenik

The Škocjan Caves Regional Park was established in 1996 and is located in the Kras region that has given its name to karst phenomena and to the science that studies them. The Škocjan Caves are a key natural monument within the protected area and have been inscribed on the UNESCO World Heritage List since 1986. All valuable natural and cultural features in the park are of national importance. The whole of the protected area is also covered by the Natura 2000 network and is an ecologically significant site. The areas international significance is also reflected in its inclusion in other international conventions and programs, notably the Network of Wetlands of International Importance (1999), the UNESCO Man and the Biosphere Programme (Škocjan Caves Biosphere Reserve, 2004), and among the First 100 IUGS Geological Natural Sites. The Škocjan Caves Park Public Service is one of the key promoters and partners of art of dry stone construction, knowledge and techniques, which was inscribed on the UNESCO Intangible Cultural Heritage List in 2018. The core zone covers 401 ha, the buffer zone 45,000 ha, and, together with the transition zone (according to MAB Programme), 100,000 ha (Figure 5).

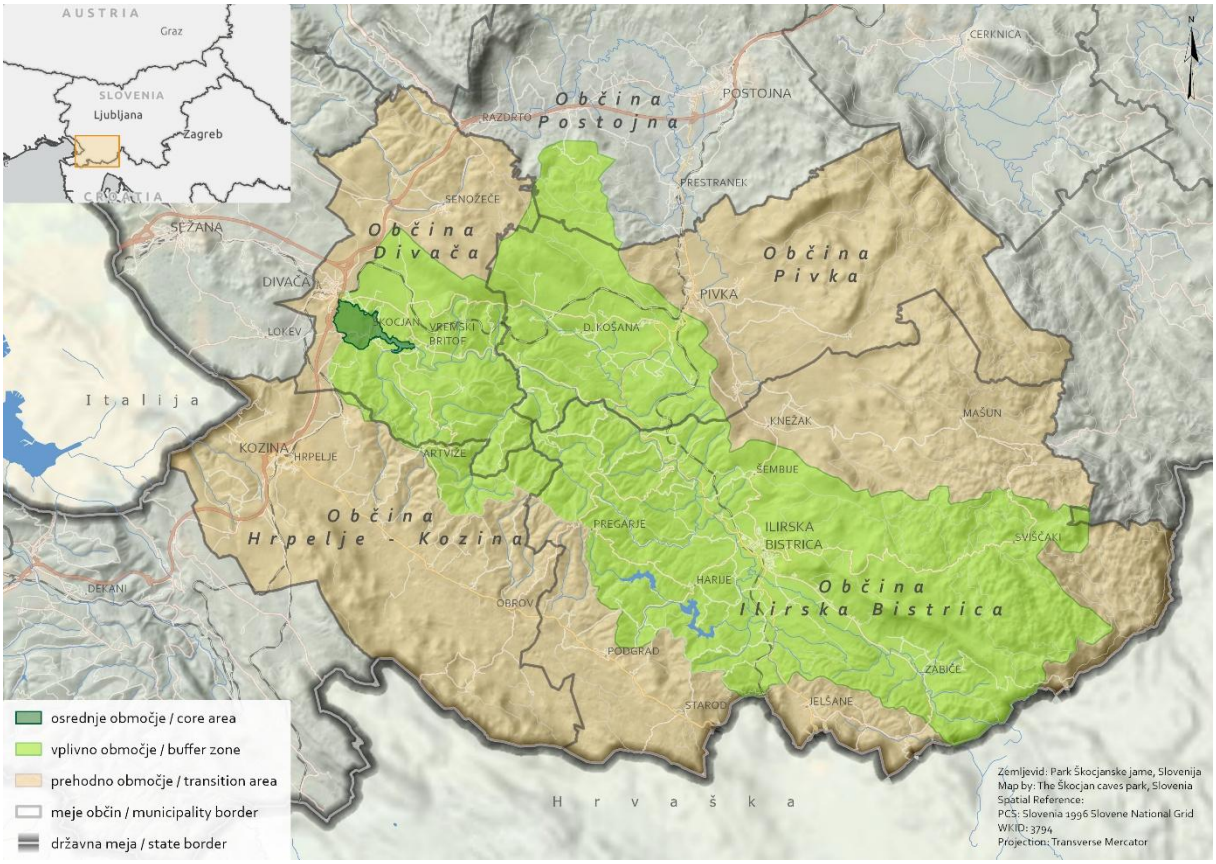


Figure 5: Map: Škocjan Caves Park with its Biosphere Reserve.

The managing authority of the park is the Škocjan Caves Park Public Service Agency, established by decision of the Government of the Republic of Slovenia, which also provides the funds for performing public services in the field of nature conservation. In the framework of public services, the agency carries out a number of activities, among them preparation of the programme for and development of Škocjan Caves, maintenance, renovation and protection of monuments and sites in the protected area; monitoring and analyses of the status of valuable natural features and cultural heritage in the park; coordination of research tasks relating to the park and organizing research work; participation in

international projects; promotion of the park to the public and organization of educational activities; preparation and maintenance of paths and signboards in the park; cooperation with the owners of individual monuments in the park and provision of expert assistance and advice to them; maintenance of the visitor infrastructure in the caves and provision of guiding services in the caves and around the park; and management of the Information Centre. Moreover, the agency plays an important role in developing and promoting sustainable tourism and including the local population and community in the park's educational programmes.

The Škocjan Karst is a vast flat landscape that lies at an elevation between 420 and 450 metres, situated at the south-east edge of the classical Karst. The Škocjan Caves were formed from Cretaceous and Paleocene limestone near the contact with impermeable Eocene flysch rock. This contact point, which lies a few kilometres to the south, has played an important part in the development and formation of the caves. The waters of the surface Reka River accumulate on the flysch rock, consisting of quartz sandstone, conglomerates and marl; after passing onto the limestone bedrock, the Reka River sinks into Škocjan Caves. The development and orientation of cave passages have been decisively influenced by the bedding of rocks and the level of tectonic deformation (bedding planes), i.e. separations between rock layers, as well as faults and distinct fault zones. One of the outstanding values is the volume of the cave which is more than 5,5 million m^3. The canyon's most spectacular physical expression is the enormous Martel Chamber, which exceeds 2 million m^3 in volume.



Figure 6: Underground canyon, Škocjan Caves (photo: Borut Lozej, Škocjan Caves Park archive), Velika dolina (photo by: Borut Lozej, Škocjan Caves Park archive).

The cave was formed by the disappearing Reka River, most of whose waters are collected on impermeable flysch rock. Its average flow rate before sinkholes is 8.95 m^3/s, reaching up to 387 m^3/s during heavy precipitation. Usual floodwaters in the cave reach levels of up to 30 metres; the highest recorded rise in the water level was 132 metres. The Reka River flows from Škocjan Caves through the Karst underground and re-emerges to the surface in Italy about thirty-five kilometres distant, at the springs of the Timavo River.

A very common landscape feature are sinkholes and collapse dolines. The largest collapse dolines are Sokolak (8.5 million m^3), which is 122 m deep, and Globočak (4.6 million m^3). The group of dolines at the entrance to Škocjan Caves – Big Collapse Doline (164 m deep), Little Collapse Doline, Sapendol and Lisična – have a total volume of 6.2 million m^3. A special feature of the surface above Škocjan Caves are unroofed caves.

The Škocjan Caves have long been recognized as exceptional due to their extremely varied terrain and exceptionally diverse flora and fauna. The Park is the habitat of some endemic, rare, or endangered species, which have also been entered in the red list of ferns and seed plants of Slovenia. The area provides shelter to a wide range of sub-Mediterranean and sub-Alpine animal species. Collapse dolines and their surroundings offer shelter to rare and endangered bird species and several bat species, and an extraordinary ecosystem that has developed due to particular geomorphologic and microclimatic conditions has been preserved. Due to particular microclimatic conditions, an extraordinary ecosystem has developed in Velika and Mala dolina, in which the Mediterranean, Sub-Mediterranean, Central European, Illyrian and Alpine bio-geographical elements co-exist. For instance, Alpine (e.g. *Prumula auricula*) and Mediterranean species (e.g. *Adianthum capillus-veneris*) grow side by side. Alpine species found shelter on the colder bottom part of collapse dolines during warmer periods after the ice ages (glacial relicts). Velika dolina is the classical location of *Campanula justiniana* which grows only in the South-Western part of Slovenia (an endemic species) while bats (26 species) and the subterranean cave fauna are the most significant endangered animal species.

The Park encompasses three settlements: Škocjan, Betanja and Matavun. Škocjan and Betanja are typical nucleated villages with well-preserved traditional buildings and are, as such, protected as settlement monuments. Throughout the Park, there are also several archaeological areas and sites (settlements, burial grounds and cave archaeological sites) dating back to the Stone, Bronze, and Iron Ages. In the Reka River gorge, there are ruins of numerous mills, and several ice pits and karst ponds for cattle are preserved in the Park and its vicinity.

EXCURSION 2: THE UNICA SPRING, ENTRANCE SECTION OF PLANINA CAVE, NATURAL BRIDGES OF RAKOV ŠKOCJAN AND CERKNICA POLJE

EKSKURZIJA 2: IZVIR UNICE, VHODNI DELI PLANINSKE JAME, NARAVNI MOSTOVI V RAKOVEM ŠKOCJANU IN CERKNIŠKO POLJE

Matej Blatnik, Cyril Mayaud, Blaž Kogovšek, Nataša Ravbar, Metka Petrič, Franci Gabrovšek

GENERAL INTRODUCTION

The main focus of the field trip is part of the Ljubljanica River recharge area, which is characterized by the alternation of the karst poljes and plateaus, and combined surface-underground flow of water. The total estimated size of the whole Ljubljanica recharge area is almost 1800 km^2, of which about 1100 km^2 is karstic.

Although the region lies only about 26 km from the Adriatic Sea in a straight line, tectonic development has directed its drainage towards the Sava–Danube basin and ultimately the Black Sea, approximately 1,000 km farther east. The karst rocks are predominantly of Mesozoic age and consist mainly of micritic and locally oolitic limestones, together with predominantly late-diagenetic dolomites. Structurally, the entire area belongs to the Adriatic Plate. It comprises several nappes that were overthrust from northeast to southwest during the main phase of the Alpine orogeny in the Oligocene (Placer, 2008). A later change in the direction of plate movement led to the formation of the Idrija Fault Zone, a dextral strike-slip fault system that crosses the area in a northwest–southeast direction (Vrabec, 1994). The Idrija Fault Zone strongly controls the direction of regional groundwater flow.

Several poljes have developed along the Idrija Fault Zone (Gams, 1978). These large, flat-floored depressions are regularly flooded and often represent the only areas where groundwater emerges at the surface. Their development is tectonically controlled, in this case by structures associated with the Idrija strike-slip fault, such as pull-apart zones, whereas the main geomorphological process responsible for their formation is corrosional planation at the groundwater table. In general, water flows from southeast to northwest, with surface flow across the Babno, Lož, Cerknica, Planina, and Logatec Poljes and underground flow beneath the higher karst plateaus of Javorniki–Snežnik, Nanos, Hrušica, Logaški Ravnik, and Bloke. Some surface water is contributed also through flysch area (Pivka Basin) on the SW. All collected water flows towards several large and many small springs aligned along the southern edge of the Ljubljana Basin (Figure 7). The average annual discharge of the Ljubljanica springs is about 38 m^3/s (Mihevc et al., 2010).

There are about 1600 known caves located within the Ljubljanica recharge area. Most of them are accessible fragments of a fossil underground drainage system. The average cave length is 48 m and the depth 18 m. However, the largest cave systems are water-active and sum a total of about 80 km of epiphreatic channels (Šušteršič, 1996).

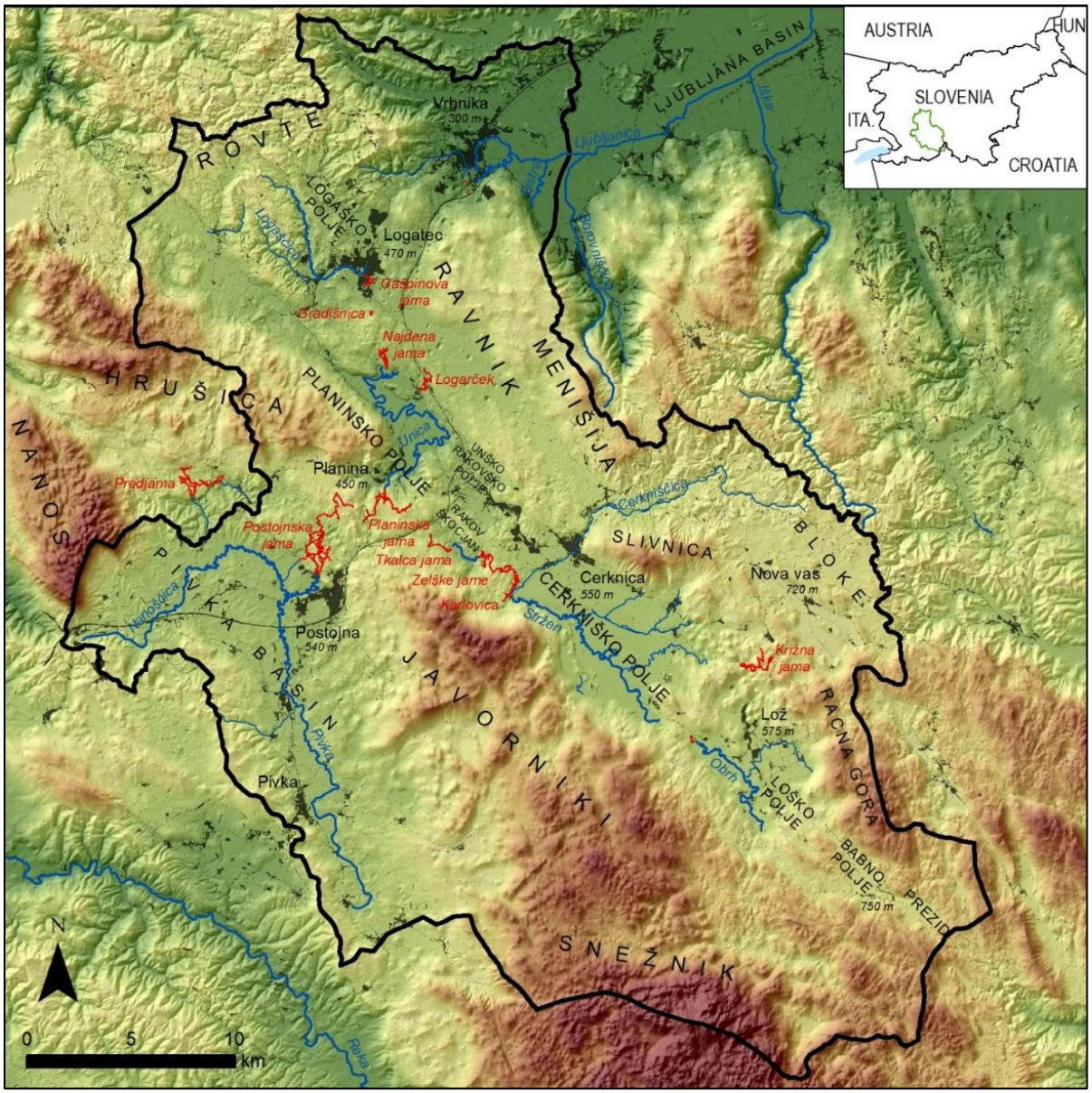


Figure 7: Map of the Ljubljanica River recharge area covering most of the Notranjska Region, with high karstic plateaus, karst poljes and surface rivers. The main caves are shown with red lines.

PLANINA POLJE

Planina Polje (Planinsko Polje) is a typical example of a structural overflow polje. Its main springs are located along the southern margin and feed the Unica River, which subsequently sinks in two major outflow zones along the eastern and northern margins of the polje (Figure 7). The polje covers approximately 10 km², and its floor lies between 445 and 450 m a.s.l. (Blatnik et al., 2019). Most of the polje floor is covered by meadows, while smaller areas on slightly higher ground along the margins are used as arable land.

The polje formed along the Idrija Fault Zone. Its southern and western margins are underlain mainly by Upper Triassic Main Dolomite, whereas the two main springs in the south and the ponors along the northern and eastern margins are located within a belt of highly karstified Cretaceous limestone.

The most important spring is the Unica Spring at the outlet of Planina Cave (Planinska jama; described below), which functions as an overflow spring with discharges ranging from 0.2 to 75 m³/s. Another major spring is the Malenščica Spring (Qmin = 1.1 m³/s, Qmean = 6.7 m³/s, Qmax = 9.9 m³/s; Frantar,

2008), a baseflow spring receiving water from Rakov Škocjan and the Javorniki Plateau. The spring supplies drinking water to more than 20,000 inhabitants. After the waters from the two springs merge, the Unica River flows across the polje surface for approximately 7 km with little loss. Along the eastern margin of the polje, it begins to lose water through the first group of ponors, which have a total outflow capacity of approximately 18 m^3/s. The Unica then continues northwards, where it finally sinks through the second ponor zone, with an estimated outflow capacity of 40–60 m^3/s, and continues underground towards the Ljubljanica springs (Šušteršič, 1996).

Planina Polje (Planinsko polje) may be flooded several times a year, most commonly during the colder part of the year as a result of the autumn precipitation maximum, winter rainfall, and snowmelt. Recent studies have shown that, during the period 1954–2014, flooding occurred on the polje for an average of 38 days per year. The longest total duration of flooding was recorded in 1960, with 137 days, followed by 2014, with 126 days (Ravbar et al., 2021). At the beginning of the 20th century, various measures were implemented to reduce extreme flooding on Planina Polje. The discharge capacity of the ponor zones was increased by constructing barriers and other structures designed to prevent the ponors from becoming blocked by floating debris (Mayaud et al., 2019).

PLANINA CAVE

Planina Cave (Planinska jama) is a major karst spring located along the southern margin of Planina Polje (Figure 7). The cave is approximately 6.6 km long and consists mainly of large active river passages, with cross-sectional areas frequently exceeding 100 m^2. It is known for the underground confluence of two major regional streams. The Pivka River drains a large allogenic catchment in the Pivka Basin, flows through Postojna Cave (Postojnska jama), and reaches the confluence through the Pivka Branch. The Rak River, by contrast, carries water from Rakov Škocjan and Cerknica Polje through the Rak Branch (Gabrovšek et al., 2010). A substantial additional inflow enters the Rak Branch through the siphon of the Javornik flow, located beneath Mysterious Lake. Both branches terminate in sumps that have been explored by cave divers, but no connection with the upstream systems of Tkalca Cave and Postojna Cave has yet been established. The combined flow emerges from the cave as the Unica River, with discharge ranging from 0.2 to 75 m^3/s (Frantar, 2008).

RAKOV ŠKOCJAN KARST VALLEY

Rakov Škocjan is a karst valley approximately 1.5 km long and 200 m wide, through which part of the water from upstream Cerknica Polje (Cerkniško polje) flows towards downstream Planina Polje (Figure 7). At its upstream, southeastern end, the Rak River emerges from Zelške jame (Zelše Caves). The Zelške jame cave system is approximately 5 km long and extends to the large collapse doline of Velika Šujca, where water arrives from Cerknica Polje through the Karlovica cave system. The entrance section of Zelške jame consists of a disrupted system of cave passages and collapse dolines. Its most prominent feature is Mali naravni most (Small Natural Bridge), a narrow rock arch representing a remnant of the former cave ceiling and spanning a collapse doline (Mihevc et al., 2010).

Farther downstream, the valley widens, and several springs along its southwestern side, including Kotliči and Prunkovec, form perennial or intermittent tributaries of the Rak River. The valley then narrows again at Veliki naravni most (Big Natural Bridge), whose arch is 10–17 m high, 15–23 m wide, and 56 m long. Beyond the natural bridge, the river enters a 150 m long canyon that terminates at the entrance to Tkalca jama, an almost 3 km long cave through which water drains towards Planina Polje.

The hydrological connections between the Rak River, Cerknica Polje, and Planina Polje have been confirmed by several tracer tests conducted under different hydrological conditions (Gabrovšek et al., 2010; Kogovšek, 2022). A major hydraulic constriction upstream of the first sump in Tkalca jama causes regular flooding. During major flood events, the water level can rise to approximately 19 m above the cave entrance, frequently inundating large parts of the Rakov Škocjan karst valley.

CERKNICA POLJE

Cerknica Polje (Cerkniško polje) is the largest regularly flooded karst polje in Slovenia, covering approximately 40 km², of which about 26 km² may be inundated. It drains a recharge area of approximately 450 km² (Figure 7). The northern, eastern, and southeastern margins of the polje are underlain mainly by Upper Triassic dolomite, whereas the western and northwestern parts are underlain predominantly by Cretaceous limestone. The polje floor lies at approximately 500 m a.s.l. and supports diverse vegetation adapted to different flooding depths and durations. The area also supports a wide range of fish, bird, and other animal species. Arable land is restricted mainly to areas near settlements that are not exposed to flooding (Blatnik et al., 2024).

The recharge system of the polje is diverse. The main springs are located along the southern margin and receive water from upstream Lož Polje (Loško polje). Several important springs along the eastern margin drain the Bloke Plateau. Another major inflow is the Cerkniščica River, the only allogenic surface inflow originating from the dolomite area. A group of smaller springs along the western margin receives water from the Javorniki Plateau. Outflow is concentrated along the northwestern margin of the polje, where the Cerkniščica joins the Stržen River and the combined flow sinks into the approximately 8.5 km long Karlovica Cave system and several smaller ponors. In addition to estavelles, several ponor zones in the central part of the polje drain part of the water directly towards the Ljubljanica springs (Kovačič, 2010).

Most of the polje is regularly flooded for three to four months per year, whereas the lowest-lying areas are flooded for an average of seven to eight months per year. Over the past centuries, several plans have been proposed to alter the hydrological regime of the polje, but none was fully implemented. Before 1960, most interventions were intended to reduce and shorten flooding. During the 1960s, however, measures were introduced to prolong flooding and support hydropower production. These interventions were later abandoned, and most artificial structures were removed. As a result, the present hydrological regime of the polje largely reflects meteorological conditions (Bidovec, 2007).

Recent studies have shown that, in addition to human interventions, the flooding regime of the polje is changing as a result of climate change. Mean water levels are declining because of slightly lower precipitation and higher evapotranspiration. Seasonal differences are also evident. Changes during autumn and winter are not statistically significant, whereas water levels in spring and summer are noticeably lower because of reduced effective precipitation and a smaller contribution from snowmelt in the upland recharge areas (Blatnik et al., 2024).

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ABSTRACTS

POVZETKI

The Puerto Rico Cave Visualization Project

Projekt vizualizacije portoriških jam

Angel Acosta-Colon[1,2]
[1] *University of Puerto Rico, Arecibo, Puerto Rico*
[2] *International Union of Speleology - UIS*

The archipelago of Puerto Rico contains approximately 2,000 to 3,000 caves across the island's three karst formation zones. These zones include the northern limestone zone, the southern limestone zone, and the scattered limestone zone, encompassing the adjacent islands of Mona, Monito, Caja de Muertos, and Vieques. The Puerto Rico Cave Visualization Project involves acquiring high-resolution geometric data of caves using laser detection and measurement (LiDAR) and photogrammetry. Applications of this LiDAR data range from creating three-dimensional maps for education and outreach, to cave printing, ecotourism, and safety. Other uses for this data include creating computer visualizations and virtual reality experiences for everyone, including people with disabilities or those who have difficulty accessing caves. The photogrammetry product has various applications, but the focus will be on analysing rock art in Puerto Rico's caves. This project aims to create digital and tactile visualization products that can be used by speleologists and the entire scientific and citizen community.

Keywords: *LiDAR, cave mapping, spatial data, photogrammetry, 3D documentation*
Ključne besede: *LiDAR, kartiranje jam, prostorski podatki, fotogrametrija, 3D-dokumentiranje*

Assessment of Geotourism Potential in Iranian Caves: A Case Study of Alisadr and Katale Khor Caves

Ocena geoturističnega potenciala iranskih jam: študija primera jam Alisadr in Katale Khor

Shirin Bahadorinia[1,2]
[1] *University of Nova Gorica, Nova Gorica, Slovenia*
[2] *Department of Geology, Isf.C., Islamic Azad University, Isfahan, Iran*

The sustainable development of cave-based tourism represents a strategic opportunity to promote regional socioeconomic growth while supporting geoheritage conservation. Iran hosts more than ten tourist caves, among which Alisadr Cave is internationally recognized as the country's most prominent show cave. As the only navigable water-filled cave in Iran, Alisadr is located approximately 75 km north of Hamadan, near Kabudarahang, within Jurassic limestone formations. Katale Khor Cave, renowned for its remarkable abundance and diversity of speleothems, lies approximately 160 km southwest of Zanjan near the village of Garmab and has developed within the Oligo–Miocene Qom Formation.

This study evaluates visitor satisfaction and investigates the geotourism potential of Alisadr and Katale Khor caves through a comparative assessment based on internationally accepted geosite evaluation criteria. Visitor satisfaction was measured using a structured questionnaire comprising 23 indicators administered to visitors at both caves. The resulting dataset was analysed using SPSS.

The findings reveal that lighting quality and the diversity of speleothems are the most influential factors affecting visitor satisfaction in both caves, whereas visitor facilities and staff performance exert comparatively limited influence on the overall visitor experience.

The geotourism potential of both caves was subsequently assessed using the standardized methodology proposed by Avila et al. (2015), incorporating criteria related to intrinsic geosite value, tourism potential, vulnerability, and conservation requirements. The results demonstrate that Alisadr

Cave possesses the scientific, aesthetic, and tourism attributes required for recognition as a geosite of national and potentially international significance. In contrast, although Katale Khor Cave exhibits substantial geotourism value, its overall assessment places it within the category of locally significant geosites.

Keywords: *geotourism, geoheritage, geosite assessment, visitor satisfaction, Alisadr cave*
Ključne besede: *geoturizem, geodediščina, ocenjevanje geoloških znamenitosti, zadovoljstvo obiskovalcev, jama Alisadr*

International Standardization on Karst
Mednarodna standardizacija na področju krasa

Bai Bing[1], Zhang Cheng[1], Luo Qukan[1], Tang Chunlei[1], Zhong Liang[1]
[1] Institute of Karst Geology, Chinese Academy of Geological Sciences (CAGS); International Research Centre on Karst (IRCK) under the auspices of UNESCO

The International Organization for Standardization Technical Committee ISO/TC 319 Karst, established in 2018 with its secretariat hosted by the Standardization Administration of China and with the International Research Centre on Karst (IRCK) holding the positions of Chair and Manager, is dedicated to the standardization of karst terminology, investigation and assessment (including mapping, monitoring and modelling), sustainable development, engineering practices, environmental protection, and management in karst areas. In April 2026, the first international standard was published, ISO 8616:2026, Specification of monitoring technology for karst critical zones. It systematically specifies the classification of karst critical zone types, the construction of monitoring station networks, the selection of monitoring indicators, data collection and processing, and information-sharing services. It establishes a full-chain technical system from station network construction to data services, addressing the long-standing challenge of incompatible monitoring data across different karst regions and research institutions. The standard directly supports the United Nations Sustainable Development Goals 6 (Clean Water and Sanitation), 13 (Climate Action), and 15 (Life on Land). Beyond ISO 8616, ISO/TC 319 has successfully set two standard proposals under development, including ISO/AWI TS 26186 Method for calculating the volume of deep karst reservoir space and ISO/AWI 26336 Code for hydrogeological investigation of highways in karst areas. Looking ahead, ISO/TC 319 will continue to expand its membership, develop a broad karst international standards system, and deepen multilateral scientific cooperation to produce standardization products that support sustainable development in karst regions worldwide.

Keywords: *karst, ISO, standardization, karst critical zone monitoring, international cooperation*
Ključne besede: *kras, ISO, standardizacija, spremljanje kraške kritične cone, mednarodno sodelovanje*

Microplastic and Microfibre Pollution in Karst Systems: The First Six Years of Multidisciplinary Research Efforts

Onesnaženje kraških sistemov z mikroplastiko in mikrovlakni: prvih šest let multidisciplinarnih raziskav

Valentina Balestra[1]
[1] *Biologia Sotterranea Piemonte - Gruppo di Ricerca, University of Turin, Turin, Italy*

Microplastic (MP) and microfibre (MF) pollution has emerged as a global environmental issue, with increasing evidence of their impacts on ecosystems and potential implications for human health. Although karst environments play a fundamental ecological role and often host major groundwater resources used for drinking water supply, the occurrence and dynamics of MPs and MFs within these systems have received limited scientific attention. Owing to their distinctive hydrogeological features, karst aquifers are especially susceptible to contamination, as pollutants can rapidly migrate from the surface to underground waters through highly connected infiltration pathways. A comprehensive understanding of the sources, distribution patterns, and transport mechanisms of MPs and MFs in karst settings is therefore essential.

Existing monitoring strategies generally focus on individual environmental compartments, such as either surface or subterranean habitats, and frequently investigate only a limited range of environmental matrices. Such fragmented approaches are insufficient to capture the complexity of karst ecosystems and the interactions linking their various physical and biological components.

This research addressed these knowledge gaps by adopting an integrated multidisciplinary framework to analyse water bodies, sediments, and fauna, quantifying contamination levels, evaluating ecological implications, refining analytical and monitoring methodologies, and providing scientific evidence to support conservation actions aimed at protecting vulnerable habitats, species, and groundwater resources intended for human consumption.

Field investigations were carried out in several regions of Italy, including both surface and underground karst environments, such as springs, aquifers, and caves. Show caves represented an important starting point for the project, functioning as experimental sites where innovative sampling and analytical procedures were developed and tested, and where preliminary datasets were used to evaluate environmental conditions. As the research progressed, these methodologies were optimized and subsequently applied to less disturbed systems, including remote speleological caves and previously unexplored subterranean environments.

The present work represents a first multidisciplinary assessment of MP and MF pollution in karst ecosystems, providing a first evaluation of pollutant distribution among multiple hydrological compartments under different environmental scenarios. Beyond comparing surface and subterranean habitats, the study investigated flowing, dripping, and stagnant waters within underground networks and analysed the exposure of stygofauna, offering new insights into contamination pathways and ecological risks within karst systems.

Keywords: *microplastics, microfibres, karst systems, karst hydrogeology, groundwater*
Ključne besede: *mikroplastika, mikrovlakna, kraški sistemi, kraška hidrogeologija, podzemna voda*

Postojna Cave as an Example of Balancing Tourism with Conservation of a Natural Asset

Postojnska jama kot primer ravnovesja med turistično rabo in ohranjanjem naravne vrednote

Kaja Batagelj[1], Ksenija Dvorščak[1]
[1] *Postojnska jama d.d., Postojna, Slovenia*

Postojna Cave is a prime example of successful long-term management of an outstanding natural asset, combining over two centuries of tourism with the conservation of a highly sensitive subterranean karst environment. As a world-famous tourist destination, the cave significantly supports local and regional economic development, while also serving as an important research centre in the fields of karstology and the biology of subterranean habitats.

This paper presents the most important management strategies used by Postojnska jama d.d. to ensure a long-term balance between providing a high-quality visitor experience and conserving this natural landmark. The primary success factors include systematic infrastructural development, implementation of modern technologies, employee expertise, commitment to quality, development of complementary tourism products, and close cooperation with research institutions.

Special emphasis is placed on measures aimed at mitigating the impacts of tourism within the cave. The most significant achievements include the introduction of remote-controlled, energy-efficient LED lighting, which has significantly lower heat emission in the cave environment, regular removal of lampenflora, replacement of outdated railway technology with electric zero-dust-emission locomotives, gradual replacement of wooden railway sleepers with concrete ones, wastewater treatment and drainage, and systematic removal of allochthonous materials resulting from past human interventions in the cave environment.

A vital part of sustainable cave management is the long-term collaboration with the Karst Research Institute ZRC SAZU, which conducts continuous microclimatic and biological monitoring of the cave system and advises on conservation measures. Results of biological monitoring show that the Postojna-Planina cave system remains a global biodiversity hotspot, home to 116 scientifically described troglobite species despite tourist use. The 2025 Postojna Cave monitoring report confirms that the cave's subterranean fauna is in good condition, even in parts of the cave with heavy tourist use.

Postojna Cave shows that responsible management, continuous monitoring, and implementation of innovative solutions can successfully balance tourism with the long-term conservation of natural assets.

Keywords: *show cave, conservation, development, sustainable management*
Ključne besede: *turistična kraška jama, ohranjanje, razvoj, trajnostno upravljanje*

Barać Caves (Croatia) – From History to a Modern Visitor Centre: Research, Protection and Tourism Development

Jame Barać (Hrvaška) – od zgodovine do sodobnega centra za obiskovalce: raziskovanje, varstvo in razvoj turizma

Neven Bočić[1], Slaven Vuković[2], Hrvoje Cvitanović[2,3], Tihana Oštrina[2]
[1] *Department of Geography, Faculty of Science, University of Zagreb, Zagreb, Croatia*
[2] *Public Institution Barać Caves, Rakovica, Croatia*
[3] *Speleological Club "Ursus spelaeus", Karlovac, Croatia*

Barać Caves comprise a complex of four caves: Upper, Lower, New Barać Cave, and Source Baraćevac Cave. They are situated in the municipality of Rakovica, near Plitvice Lakes National Park in Croatia. The value of these caves has long been recognised, leading to the establishment of the Committee for Research and Development of Barać Caves in 1892. At that time, the Upper and Lower Caves were prepared for organised visits. Although frequently visited by researchers, the caves were largely forgotten as a tourist destination until 1999, when the Committee for the Revitalisation of Barać Caves was formed. Since 2004, the Upper Barać Cave has once again been open to visitors. The caves and surrounding area are managed by the Public Institution Barać Caves - for the management of protected natural values in the Rakovica municipality. In addition to organising tourist visits, the institution encourages numerous research activities, including speleological, geomorphological, microclimatic, archaeological, biospeleological, and paleontological studies. Data from these studies have highlighted the exceptional value of the caves and the entire area. Consequently, in 2016, the wider area around the Barać Caves, covering 5.2 km², was declared permanently protected as a significant landscape (IUCN category: V Protected Landscape). According to the declaration, the aim of protection is to preserve the geomorphological and geospeleological values of the karst area, the mosaic landscape of natural and semi-natural habitats, and the associated biodiversity. Alongside protection and research activities, visitor infrastructure is also being developed. Walking trails have been established near the caves, and the most significant development project has been the construction of a visitor centre financed by the European Union. The modern multimedia interactive centre Speleon – the Centre of Underground Heritage – opened in early 2023. It features a permanent exhibition on the geological and geomorphological, paleontological, archaeological, speleological, and biospeleological characteristics of the Barać Caves and the surrounding area. The Speleological Documentation Centre is also located here, with a valuable collection of items related to the history of Croatian speleology and a speleological library of over 8,000 titles. The headquarters of the Croatian Speleological Association are also housed here.

Keywords: *cave and karst heritage, speleological research, protected landscape, visitor centre, sustainable cave tourism*
Ključne besede: *jamska in kraška dediščina, speleološke raziskave, zavarovana pokrajina, center za obiskovalce, trajnostni jamski turizem*

Learning from the Underground: Educational Strategies for the Conservation of Karst and Cave Heritage

Učenje iz podzemlja: izobraževalni pristopi k varstvu kraške in jamske dediščine

Clarissa Brun[1], Sergio Dolce[1], Franco Gherlizza[1], Franco Riosa[1], Atenaide Blasini[1]
[1] *Club Alpinistico Triestino, Trieste, Italy*

The presented initiatives demonstrate how speleological knowledge can be effectively translated into educational practices that engage students and support interdisciplinary learning across geology, biology, geography and environmental sciences. The activities combine classroom lessons, hands-on laboratories, field experiences and interactions with speleologists, aiming to introduce key concepts of karst geomorphology, groundwater processes, cave ecosystems and heritage conservation. The training activities organized by our club are based, first, on the principle that safety is the fundamental prerequisite for any caving activity. From the earliest stages of the course, students are introduced to the scientific value of cave exploration and documentation, and they are encouraged to become actively involved in the research projects carried out by the club. This approach transforms technical training into a broader educational experience, where newly trained cavers become active

contributors to speleological knowledge.

Keywords: *karst heritage, cave conservation, speleological research, environmental education, science communication*
Ključne besede: *kraška dediščina, varstvo jam, speleološke raziskave, okoljsko izobraževanje, komuniciranje znanosti*

Passive atmospheric microplastic deposition in caves: a monitoring framework from Postojna Cave

Pasivno atmosfersko odlaganje mikroplastike v jamah: okvir spremljanja na primeru Postojnske jame

Raffaele Bruschi[1,2]
[1] *Karst Research Institute ZRC SAZU, Postojna, Slovenia*
[2] *Società Adriatica di Speleologia, University of Trieste, Trieste, Italy*

Microplastic contamination in caves has mainly been investigated in sediments and waters, whereas atmospheric deposition remains almost entirely unexplored. However, subterranean environments are not isolated systems. Air circulation, natural entrances, ventilation dynamics, cold-air trapping pits effects, tourist access and underground infrastructures may allow atmospheric fibres and anthropogenic particles to enter, settle and accumulate even in deep sectors. Understanding this pathway is therefore essential for evaluating microplastic dynamics across different cave typologies.

This contribution presents the development of a cave-adapted passive monitoring framework for atmospheric microplastic deposition. The device is inspired by passive collectors used for atmospheric fallout monitoring, but has been redesigned for microplastic research and for the logistical constraints of subterranean environments. The system uses non-plastic materials, replicated sampling units and strict contamination-control procedures. Each station operates in triplicate and includes associated closed blanks to control for handling, transport and background contamination. Collectors are installed on a dedicated support, with the sampling opening elevated above the cave floor, in order to target passive deposition while reducing the influence of immediate ground-level resuspension.

The first deployment is being implemented in the Postojna Cave System, selected as a model site because it combines high tourist pressure, an underground railway, pedestrian accumulation areas and low-disturbance sectors within the same cave system. The monitoring design includes three zones: Plesna dvorana, where a transect evaluates the potential influence of the underground train; Pisani rov, used as a low-disturbance reference sector with no regular tourist presence; and Koncertna dvorana, representing the main visitor-accumulation area, where pedestrian movement and visitor presence may contribute to the release, resuspension and deposition of anthropogenic fibres and particles. Where possible, deposition data will be interpreted together with cave-use information, including visitor numbers, train frequency and maintenance activities.

Although Postojna Cave represents the first application, the broader aim is to establish a transferable protocol for investigating atmospheric microplastic deposition in different cave and karst systems. This is important because, once microplastics are detected in caves, their origin and dominant transport pathways often remain unclear. By specifically targeting atmospheric deposition, this approach can help distinguish airborne inputs from other contamination routes, supporting future comparative studies, cave protection and sustainable karst management.

Keywords: *passive sampling, airborne fibres, anthropogenic particles, cave air circulation, tourist*

pressure, contamination control, pollution pathways, karst protection
Ključne besede: *pasivno vzorčenje, vlakna v zraku, antropogeni delci, kroženje jamskega zraka, turistični pritisk, nadzor kontaminacije, poti onesnaževanja, varstvo krasa*

The Gypsum Karst of Sorbas (Almeria, Spain): Towards a new UNESCO "GeoPark"

Sadrin kras, Sorbas (Almeria, Španija): K novemu Unescovemu Geoparku

José María Calaforra[1]
[1] *Water Resources and Environmental Geology Research Group, University of Almeria, Spain*

Recently, the University of Almeria, The Experimental Station of Arid Zones (EEZA, CSIC) together with the Ministry of the Environment of the Junta de Andalucía, through its Provincial Delegation, has launched the proposal for the creation of a new UNESCO Geopark in the currents Natural Parks of the Gypsum Karst of Sorbas and the Desert of Tabernas.

The proposal has to be evaluated by a committee of international experts. Fortunately, the Sorbas gypsum Karst is becoming more and more known on an international scale. But the incredible values of Geodiversity that it houses need to be emphasised even more. Among them are such unique characteristics as:

(1) having the highest dolinization in gypsum in Europe - more than a thousand caverns

(2) some of the largest and deepest cavities in gypsum of the world,

(3) speleothems practically unique in the world such as hollow stalagmites, gypsum Christmas trees, hollow gypsum balls...

(4) karst surface forms of very high singularity such as tumuli and singular gypsum erosive escarpments and

(5) an unparalleled geological record of the Messinian Desiccation Crisis that has been studied in Sorbas by many universities around the world

This presentation attempts to examine into all this geological singularity to serve as a consistent argument basis for the geological significance of the Sorbas Gypsum Natural Park in terms of the conservation of Geodiversity on a global scale. More than enough reasons for this unique environment to become a prominent component of the UNESCO Geoparks list in the near future.

Keywords: *Sorbas Gypsum Karst, gypsum caves, geodiversity*
Ključne besede: sadrin kras Sorbas, jame v sadri, geodiverziteta

Delineation and Characterization of Karst Areas in the Friuli Venezia Giulia Region

Razmejitev in opredelitev kraških območij v deželi Furlanija – Julijska krajina

Tullio Quaia[1], Paolo Manca[2], Michele Potleca[3], Chiara Calligaris[1], Luca Terribili[2], Luca Zini[1]
[1] *University of Trieste, Department of Mathematics, Informatics and Geosciences (MIGe)*
[2] *Geological Survey, Central Directorate for Environmental Protection, Energy and Sustainable Development, Autonomous Region of Friuli Venezia Giulia*
[3] *OGS, National Institute of Oceanography and Applied Geophysics*

Through Regional Law 15/2016, the Autonomous Region of Friuli Venezia Giulia has adopted an integrated strategy for the protection and enhancement of karst systems, recognizing the close interconnection between caves, karst areas and karst aquifers, including recharge zones and spring areas. Within this framework, the Region is promoting a long-term project, in collaboration with the Department of Mathematics, Informatics and Geosciences of the University of Trieste, aimed at identifying, delineating and characterizing karst areas and their associated aquifers, including recharge zones and spring areas. To support this process, the Regional Geological Survey established a multidisciplinary working framework involving the regional water resources authority and speleological associations. Speleologists provide a key contribution through the Regional Speleological Cadastre and their active involvement in hydrogeological tracer tests. A standardized protocol was developed to delineate karst areas based on a hydrogeological approach: (1) karstifiable rocks (limestone, dolostone and evaporites), (2) surface and subsurface karst features, and (3) underground flow directions with related karst springs.

Overall, 87 regional and transboundary karst areas/hydrostructures were delineated, covering approximately 28% of the regional territory and 69% of the mountainous and hilly sectors of Friuli Venezia Giulia. Within these areas, more than 28,000 epigean karst morphotypes were identified, approximately 1,250 karst springs were recognised, with discharges ranging from a few litres per minute to more than 100 m^3/s. Groundwater vulnerability maps were produced for 24 karst areas using the COP method. The delineation of karst areas and the assessment of groundwater vulnerability provide the scientific basis for a regional strategy for the protection and sustainable management of karst groundwater resources. The project is currently being extended to the entire regional territory, with the aim of producing vulnerability maps for all regional aquifers and developing a standardized methodology for the delineation of protection zones for exploited karst springs.

Keywords: *karst hydrogeology, groundwater, karst aquifer, sustainable management, cave conservation*
Ključne besede: *kraška hidrogeologija, podzemna voda, kraški vodonosnik, trajnostno upravljanje, varstvo jam*

Brazilian Speleological Society and National Center for Cave Research and Conservation: Partnership for the Conservation of Karst and Caves

Brazilsko speleološko društvo in Nacionalni center za raziskovanje in varstvo jam: partnerstvo za ohranjanje krasa in jam

Allan Calux[1]
[1] *International Union of Speleology - UIS Bureau*

Brazilian speleological legislation constitutes a pioneering instrument that, by establishing the regulations for the sustainable use of the national speleological heritage, functions as one of the principal mechanisms for the protection of karst landscapes and caves. Through environmental (speleological) compensation, the National Center for Cave Research and Conservation (CECAV)—a specialized unit under the Ministry of Environment and Climate Change of the Federal Government—operates, in partnership with non-governmental organizations and universities, an extensive research program across diverse fields of knowledge pertinent to the subject. In this context, the objective of this work is to provide visibility to the broad array of initiatives that the Brazilian Speleological Society (SBE), in collaboration with CECAV, has been developing across all the biomes that characterize the country.

Keywords: *speleological legislation, environmental compensation, institutional partnership, cave protection, public policy*
Ključne besede: *zakonodaja o jamah, okoljska kompenzacija, institucionalno partnerstvo, varstvo jam, javna politika*

Hydrodynamics and Thermodynamic Autoregulation of the Perennial Seepage in the Etruscan Well of Perugia: A Hydraulically Isolated Perched Lens Hypothesis Under Severe Estival Drought

Hidrodinamika in termodinamična avtoregulacija stalnega pronicanja v etruščanskem vodnjaku v Perugii: hipoteza hidravlično izolirane viseče leče v pogojih hude poletne suše

Carlos Carsolio[1]
[1] *Carsolio Esculturas, Mexico*

The Etruscan Well of Perugia (late 3rd century BCE)—an ancient hilltop structure dug into an isolated high ridge—presents a persistent hydrogeological enigma. The upper 12 meters of the 37-meter-deep shaft intersect an unconfined matrix of alluvial clay and cobblestones (tassello mandorlato), while the lower section forms a watertight cistern equipped with an automated pump to prevent visitor-area flooding. Despite severe summer droughts, the upper walls maintain a perennial droplet seepage. Ground Penetrating Radar (GPR) studies reveal that the tassello mandorlato directly behind the upper travertine blocks is highly compact and consolidated, displaying an absence of structural cracks or secondary conduits. This implies that the copious seepage is strictly pore-driven rather than conduit-fed. Furthermore, widespread archaeological assertions attributing this flow to three distinct perennially active springs lack empirical validation, as structural conservation mandates prohibit block removal; the observed flow instead reflects diffuse seepage concentrated across three prominent topographically steered dripping zones. Regional structural geology rules out distant artesian mountain recharge due to an intervening fault-bounded graben, a 25-meter lower structural saddle, and the flanking Tiber Valley hydraulic sink. Consequently, the perched lens relies strictly on local meteoric recharge. While extensive historical paving restricts infiltration, it acts as a vapor barrier minimizing topsoil evaporation and preserving internal moisture. Empirical data reveals estival

drainage exceeds static atmospheric condensation by a 4:1 ratio, confirming condensation is not the primary mass source.

This paper proposes a Coalescence-Triggered Pulse Release Mechanism offering a functional analogue for fluid dynamics in dual-porosity karst systems, operating as a rigid-matrix structural equivalent to the Reverse Wieringermeer Effect. During summer droughts, while the hill's periphery desaturates, a localized saturated zone is structurally preserved at the base of the lens by a syn-sedimentary paleo-channel clay depression. This basal accumulation generates a marginal, positive hydrostatic pressure head behind the lower seepage face, maintaining pinned, convex menisci at the exposed macro-pore boundaries of the unmortared travertine lining. Concurrently, a natural chimney effect drives a convective circulation of warm, humid ambient air down the lateral stairwell. This vapor condenses upon contacting the cold shaft walls, coalescing with the pinned boundaries, flattening their convex curvature, and neutralizing the capillary retention barrier to allow gravity drainage. This volumetric loss triggers a localized desaturation wave, inducing heterogeneous macro-porous cavitation. Confined strictly to larger conduit-equivalent pore fractions, this cavitation acts as a pneumatic brake, throttling drainage through un-cavitated matrix clay films to ensure the lens elastically bleeds its reserves at an asymptotic rate throughout extreme droughts. To empirically validate these boundary-layer dynamics, a 3-meter-tall environmental macro-simulator utilizing an integrated cooling coil, active heating elements, and a forced-suction ventilation chimney is presented for structural replication and quantitative verification ahead of the symposium. Ultimately, this framework establishes a transferable predictive tool for resolving similar long-standing water-retention anomalies observed in historical hilltop wells and isolated matrix aquifers globally.

Keywords: *well, perched lens hydrodynamics, dual-porosity karst analogue, reverse wieringermeer effect, capillary barrier neutralization*
Ključne besede: *vodnjak, hidrodinamika viseče leče, kraški analog z dvojno poroznostjo, povratni Wieringermeerjev učinek, nevtralizacija kapilarne bariere*

Škocjan Caves as an Example of UNESCO World Heritage Management

Škocjanske jame, primer upravljanja Unescove svetovne dediščine

Rosana Cerkvenik[1]
[1] *Javni zavod Park Škocjanske jame, Škocjan, Slovenia*

The Škocjan Caves were inscribed on the World Heritage List in 1986. At that time, the level of protection was low, the cave was managed by a private organization, and the Reka River was heavily polluted. Today, 40 years after their inscription on the World Heritage List, the Škocjan Caves are one of the most recognizable protected areas, not only in Slovenia but also worldwide. The Škocjan Caves Park Public Service Agency manages not only the cave as a World Heritage site, but also actively contributes to the sustainable development of the biosphere reserve and to the emerging transboundary Kras-Carso Geopark.

Keywords: *World Heritage, Škocjan Caves, protected areas, biosphere reserve, Kras-Carso Geopark*
Ključne besede: *svetovna dediščina, Škocjanske jame, zavarovana območja, biosferno območje, Geopark Kras-Carso*

Using 3D Technology in Cave Documentation, Conservation, Presentation and Education

Uporaba 3D-tehnologije pri dokumentiranju, varstvu, predstavitvi in izobraževanju o jamah

Csaba Egri[1], Sarolta Borzsák[1]
[1] *Ministry of Living Environment, Hungary*

Today, the use of 3D technology is gaining ground. We are serious about keeping up with the times, so we're constantly testing state-of-the-art 3D scanners to ensure we can make accurate and precise surveys below the surface. We can now scan and model the most complex and unusual sites, from the largest halls to vast corridors, narrow caverns or even formations of all shapes and sizes. These surveys are suitable for registering all or parts of caves, documenting their current status, and monitoring changes in the future. In my presentation, I will discuss the possibilities, advantages and disadvantages of using conventional laser scanners, handheld mobile scanners, photo scanners and mobile phone scanners in caves and the possible applications of the measurements. It will also give insight into how these measurements can be used for cave registration, cave protection, presentation and promotion.

Visitor centres have been set up at several caves in Hungary, where visitors can learn about the natural geography of the cave and the surrounding area. In addition to 3-dimensional surveys, another very impressive method is the presentation of stereoscopic images, for which several technical possibilities are now available. From 3D projection rooms and 3D TVs to the latest 3D tablets and stereo image viewers, there are solutions for all sizes and types of venues to enhance the visitor experience, knowledge and understanding. And with 3D printers, we can create entire caves, large hallways, or even 3D traces of the most mundane formations from a variety of materials, making the complex world below the surface easy for the average person to understand and explore. Thanks to technology, what once seemed impossible is now part of our everyday lives and who knows what tomorrow will bring. In my presentation, I would like to show the practical application of these technologies through the example of some showcaves in Hungary.

Keywords: *3D technology, cave documentation, 3D scanning, cave conservation, science communication*
Ključne besede: *3D-tehnologija, dokumentiranje jam, 3D-skeniranje, varstvo jam, komuniciranje znanosti*

Insights into Drip Water in the Buda Castle Cave

Vpogled v preniklo vodo v jami Buda Castle

David Farkas[1]
[1] *Budapest University of Technology and Economics, Budapest, Hungary*

The Buda Castle Cave is a site of outstanding cultural, historical, and natural importance, making its long-term preservation a priority. Drip water infiltration causes both temporary and permanent water-related problems in several sections of the cave, while rock falls and ceiling deterioration may eventually lead to stability issues.

To support cave conservation, quantitative drip water monitoring was carried out using DIY tipping bucket gauges and periodic ad hoc drip water measurements. The DIY devices provided continuous, high-resolution time series of drip intensity, whereas the ad hoc measurements represented instantaneous conditions. As these measurements were repeated over multiple campaigns, they also allowed the identification of potential seasonal variations.

The results indicate strong correlations between the monitored drip sites equipped with DIY devices.

Drip water volumes were estimated from the ad hoc measurements and compared with historical observations to evaluate temporal changes. In addition, water chemistry analyses were performed to assess potential contamination and to investigate the origin of the drip water. The combined monitoring approach provides valuable information for understanding infiltration processes and supports the long-term conservation and management of the Buda Castle Cave.

Keywords: *karst hydrogeology, groundwater, karst aquifer, cultural heritage*
Ključne besede: *kraška hidrogeologija, podzemna voda, kraški vodonosnik, kulturna dediščina*

Researching CO_2 in Some Caves in the Classic Karst
Raziskovanje CO_2 v nekaterih jamah Klasičnega krasa

Fulvio Forti[1], Paolo Forti[1]

[1] *Club Alpinistico Triestino, Trieste, Italy*

The aim of this research is to understand how CO_2 behaves inside caves. Carbon dioxide is 1.5 times denser than air and therefore tends to settle at the bottom. The instrument used is a data logger with an NDIR sensor for CO_2 measurement, with a range from 0 to 10,000 ppm, as well as a thermometer and a hygrometer. The initial measurements were carried out in various Classic karst caves in both Italy and Slovenia, and we found a huge variation from cave to cave. Furthermore, in each cave, we recorded the main geological features (litho-type found on site), structural features (caves formed in interlayers, along fracture planes or faults) and geomorphological features (presence of clay fillings, collapses, concretions, etc.). To date, over twenty caves have been analysed, and the first differences in CO_2 concentration across the various levels of the caves are already visible. Generally, caves running along stratigraphic planes – even when interspersed with short vertical shaft-like sections – have CO_2 levels below 1,000 ppm, typically between 500 and 800 ppm. By contrast, in both shaft-like and tunnel-like caves where there are systems of fractures running in a N-S and NE-SW direction, a sharp increase in CO_2 is observed, with values well above 10,000 ppm. In some caves with such high values, a marked decrease in oxygen levels has also been observed, with minimum values below 17 per cent. In some caves, measurements were even taken on several occasions to verify whether the values were consistent, and in all cases the previous data were confirmed. Monitoring will continue in a growing number of new caves to test our hypothesis that caves situated on certain planes of discontinuity within the rock mass (a family of N-S and NE-SW fractures) exhibit very high CO_2 concentrations. Studies of these fracture planes reveal some gaps caused by tectonic factors, which could allow CO_2 from deep within the Earth to be released into these caves. In the future, we will seek to determine whether the high concentration of CO_2 is caused by stagnation within the cave due to poor air circulation with the external environment, or by the diffusion of CO_2 through the fracture planes from deep underground.

Keywords: *Cave CO_2, cave atmosphere, structural geology, fracture systems, Classical Karst*
Ključne besede: *jamski CO_2, jamska atmosfera, strukturna geologija, razpoklinski sistemi, Klasični kras*

Understanding Karst: Science as a Basis for Sustainable Management and Use of Karst and Caves

Razumevanje krasa: znanost kot podlaga za trajnostno upravljanje in rabo krasa ter jam

Franci Gabrovšek[1]
[1] *Karst Research Institute ZRC SAZU, Postojna, Slovenia*

The richness of karst features and processes has attracted curious minds since antiquity. How and when did karst evolve? What processes shape the surface and the underground? How does water flow through karst? What controls the underground environment and life? It turns out that the complexity arising from the simple fact that certain rocks dissolve in water at just the right rates continues to attract an ever-growing community of researchers from a wide range of disciplines, each bringing its own methods and perspectives. It is impossible to encompass all of these topics in a single lecture, so I will highlight just a few selected examples.

When it comes to karst hydrology, I consider the Cerknica Polje one of the finest examples of how contemporary scientific theories, hydraulics in particular, were applied to explain the functioning of a complex karst system between the 16th and 19th centuries. It also illustrates how closely karstology is intertwined with, and dependent upon, advances in other scientific disciplines. Only after the fundamental concepts of groundwater flow had been established was it possible to begin explaining the remarkable behaviour of this intermittent lake.

Groundwater flow through karst massifs remains one of the major scientific challenges. Although the governing physics is well understood and the constitutive equations are reasonably well established, the complexity of the subsurface geometry and boundary conditions makes an exact description across all spatial scales impossible. Understanding groundwater flow and transport is not only a scientific endeavour but also the foundation for protecting karst groundwater resources, which supply drinking water to more than 15% of the world's population.

To describe groundwater flow, we must first know where the water flows. This naturally leads to the question: how do caves form? It has long been recognised that caves develop through the dissolution of rock by groundwater. However, many fundamental questions remain at least partially unanswered. At what rates do caves develop? What controls the geometry and topology of conduit networks? Numerical models that couple groundwater flow, dissolution, and solute transport have provided important insights into these processes. Nevertheless, such models inevitably rely on assumptions and simplifications and are still unable to reproduce the full complexity of natural karst systems.

Caves are unique environments that inspire admiration but are also exceptionally fragile. They preserve invaluable archives of past environmental and climatic conditions. Reading these archives requires not only state-of-the-art analytical techniques and instrumentation but also a profound understanding of cave systems themselves. To understand and protect cave environments, we must investigate how mass, including air, gases, water, dissolved substances, and sediments, and heat are transported through caves and karst massifs. Addressing these questions requires carefully designed monitoring networks based on autonomous instruments, together with the development of conceptual and mathematical models capable of interpreting the observed processes.

Keywords: *karst processes, groundwater flow, speleogenesis, cave environment*
Ključne besede: *kraški procesi, tok podzemne vode, speleogeneza, jamsko okolje*

UIS and Croatian Speleologists and Scientists

UIS ter hrvaški speleologi in znanstveniki

Mladen Garašić[1]
[1] *International Union of Speleology - UIS*

A short review of the meaning of the International Union of Speleology (UIS) in the minds of Croatian cavers and scientists over the last 60 years

Keywords: *speleology, cave science, international cooperation, karst, caves*
Ključne besede: *speleologija, jamarstvo in krasoslovje, mednarodno sodelovanje, kras, jame*

The Developing Dynamics of the Surface of a Karstic Salt Dome: The Instance of Solotyvno (Ukraine, Transcarpathia)

Razvoj površja kraškega solnega diapirja: primer Solotvina (Ukrajina, Zakarpatje)

Sándor Gönczy[1,2], Lívia Kürti[1], Krisztián Kinárov[3], József Molnár[2]

[1] *Eszterházy Károly Catholic University, Eger, Hungary*
[2] *II. Rákóczi Ferenc Transcarpathian Hungarian University, Department of Geography and Tourism, Beregszász, Ukraine*
[3] *Zrínyi Ilona Lyceum, Beregszász, Ukraine*

Mining operations have emerged as substantial contributors to diverse environmental degradation throughout the past centuries. This assertion is especially pertinent to the degradation of surfaces and infrastructure in rock salt and potash salt deposits, where karstification leads to astonishingly swift changes, even within a human timeframe. Rock salt exhibits solubility thousands of times greater than that of limestone; thus, if unsaturated water perpetually reaches the surface of a salt formation or infiltrates the salt dome while brine is able to exit, the deterioration of the rock is significantly expedited. The issue is further intensified by mining, as it necessitates the removal of overlying silt, thereby increasing the probability of freshwater infiltrating the mines. In addition to dissolution, the mechanical energy from the influx of water into the mines also contributes to the degradation of the salt formation. The underground dissolution processes can cause the mine surface to collapse, resulting in the production of sinkholes of diverse genetic types, subsequently leading to the emergence of saltwater lakes.

Such processes can be observed in Solotyvno, where industrial-scale salt extraction occurred from 1778 to 2008. Water inflows and surface subsidence persisted throughout the 230 years of mining but intensified significantly from the 1990s onwards. This study aims to investigate alterations in surface deformations.

To assess surface alteration in the vicinity of the former salt mines from 2017 to 2021, we executed aerial surveys either during the final days of May or during the initial days of June each year utilising a Phantom 4 Pro Quadcopter. The drone executed an autonomous flight at an altitude of 70 meters over a pre-determined zone. The recordings were conducted with a 70% image overlap, which was also performed automatically. Utilising Agisoft PhotoScan, we generated an orthophoto and a surface model from the aerial imagery. We utilised ArcGIS software to process the exported elements. The theoretical ground resolution of the finalised orthophotos was under 3 cm in every instance. We

digitised the visible collapses in the image and subsequently calculated their area, perimeter, average slope angle, depth, and volume. Utilising the acquired data, we scrutinised the dynamics of surface alterations by evaluating the average, median, standard deviation, skewness, kurtosis, minimum and maximum values of the aforementioned parameters, along with their variations.

Our findings reveal that the processes in the area are mostly influenced by extremes. Nevertheless, the trends suggest a deceleration in karstification and reduction in extremes.

Keywords: *subsidence, sinkholes, UAV photogrammetry, mine flooding, anthropogenic geomorphology*
Ključne besede: *posedanje tal, udori, fotogrametrija z UAV, zalivanje rudnikov, antropogena geomorfologija*

Exploring Caves with Valentina and Proty: A New Innovative Way to Communicate Underground Sciences in Show Caves

Raziskovanje jam z Valentino in Protyjem: nov inovativen način komuniciranja podzemnih znanosti v turističnih jamah

Corrado Greco[3,4], Gianpaolo di Silvestro[2,3], Valentina Balestra[3,5,6]

[1] *Grotta Torri di Slivia - Pejca v Lazcu, Italy*
[2] *Trilobite Design Italia, Italy*
[3] *Torri di Slivia Cave, Italy*
[4] *Associazione Grotte Turistiche Italiane, Italy*
[5] *Department of Agricultural, Forest and Food Sciences, University of Turin, Turin, Italy*
[6] *Biologia Sotterranea Piemonte – Gruppo di Ricerca, Italy*

Show caves play an important role in pilot studies and in advancing knowledge of underground sciences by testing new methods and analysing preliminary data (Balestra, 2026), as well as a fundamental role in communicating scientific information to the public. Tourism and the educational exploration of subterranean environments are fostered through the sharing of knowledge and professional expertise, which come together to create new challenges and communication opportunities within the Karst region. With this goal, we created and tested an innovative new method of science communication in Torri di Slivia Cave[1] in the Classical Karst, Friuli-Venezia-Giulia, Italy, thanks to funding from the Geological Service of the Friuli Venezia Giulia Region.

The strength of the project lies in its multidisciplinary approach, aimed at conveying environmental education messages to both the general public and younger visitors through science comics. Through the “show cave” experience, visitors are guided along an experiential learning path that fosters a deeper awareness of the karst ecosystem and a more comprehensive understanding of its complexity. The communicative power of simple, detailed, and scientifically accurate illustrations provides visitors from diverse backgrounds with a multidisciplinary educational resource, facilitating the understanding of complex environmental, geological, and biological concepts. Furthermore, the project enhances the historical and social context surrounding the cave, presenting it as an educational tool capable of addressing topics that extend well beyond the strictly subterranean karst environment itself.

Torri di Slivia Cave undertook a new challenge in the field of non-formal cave education, experimenting with innovative approaches to scientific communication and the promotion of karst heritage. The initiative represents an important convergence of scientific research, advanced technologies, and local science communication, opening new perspectives for the exploration, enhancement, and conservation of subterranean heritage.

Keywords: *show caves, science communication, environmental education, visitor interpretation, karst heritage*
Ključne besede: *turistične jame, komuniciranje znanosti, okoljsko izobraževanje, interpretacija za obiskovalce, kraška dediščina*

Karst Landscapes under Pressure: Desertification Regimes across the Mediterranean Bioclimatic Gradient

Kraške pokrajine pod pritiskom: režimi dezertifikacije vzdolž sredozemskega bioklimatskega gradienta

Filippo Gregori[1]
[1] *Sapienza Rome University, Rome, Italy*

Approximately 60% of the world's karst territories fall within desertification-prone categories, yet systematic monitoring remains limited by sparse observation networks. Mediterranean karst landscapes are particularly vulnerable. In many parts of the basin, their soils are thin and poorly developed. High carbonate permeability connects the surface directly to the subsurface, amplifying the effects of anthropogenic pressure and intensifying drought cycles. Mediterranean hot-summer climates occupy an unstable equilibrium in the aridity gradient, immediately preceding semi-arid conditions. High temperatures and progressive water deficit promote surface crust formation, reducing infiltration and accelerating soil degradation independently of direct human pressure.

This study applies an unsupervised Gaussian Hidden Markov Model to an 18-variable monthly time series spanning June 1999 to June 2016. Inputs are drawn from CHELSA v2.1 climate reanalysis and Copernicus and MODIS satellite products at ~1 km resolution. Three contrasting Mediterranean karst areas are examined: the Apulian carbonate platform (~11,400 km²), the Classical karst of Slovenia/Italy (~520 km²), and the Notranjska karst (~1,030 km²). Variables span four thematic categories: thermal variables, hydrological variables, climate indices, and land surface variables. Ten latent states emerge from the data without predefined thresholds or labelled training samples. States are characterised along an aridity gradient computed directly from the input variables. Fragile states cycle rapidly amongst themselves; resilient states show high self-persistence. Monthly state maps identify when and where each pixel enters, dwells in, and exits fragile regimes.

Across the three study areas, karst systems operate in two structurally separate ecological regimes. Spontaneous transitions from the fragile to the resilient block are virtually absent, and recovery from fragile conditions requires active intervention. As the framework relies exclusively on globally available inputs, these findings are directly extensible to the wider Mediterranean basin or to karst areas lacking in-situ observations, and scalable to a global level using variables available from 1950 to the present.

Keywords: *Mediterranean karst, desertification, aridity, hidden Markov model, remote sensing*
Ključne besede: *sredozemski kras, dezertifikacija, aridnost, kras, skriti Markov model, daljinsko zaznavanje*

Underground Climate Change (UCC): A Citizen Science Network for Monitoring Climate Change in Caves

Podnebne spremembe v podzemlju: mreža občanske znanosti za spremljanje podnebnih

sprememb v jamah

Filippo Gregori[1]
[1] *Sapienza Rome University, Rome, Italy*

Karst environments cover 13% of the Earth's land surface. They are expected to supply around 80% of global drinking water resources by 2030. Temperature increases have already been documented in underground environments: +0.02°C/yr in Alpine caves (Obleitner et al., 2024), ~0.04°C/yr in Villars Cave (Genty, 2008), and 0.015°C/yr in Postojna Cave (Domínguez-Villar et al., 2015). Badino (2004) showed that caves act as natural filters of short-period meteorological variability, transmitting only long-term signals at depth. This makes them ideal observatories for climate change, but only if monitoring is sustained over decades with adequate temporal resolution and measurement precision to the hundredth of a degree. However, prior studies were conducted at a local scale with incomparable instrumentation, preventing any network-scale synthesis.

Underground Climate Change (UCC) is an Italian citizen science project launched in late 2023. It provides for the first time a coordinated framework for cave climate monitoring. A key design principle is its open-ended time horizon: UCC is conceived as a permanent observatory with no fixed end date, as results will necessarily emerge over time and multi-decadal datasets are essential to resolve climate signals transmitted within thermally low-conductive rock masses.

Instrumental accuracy is central to the approach. All instruments are subject to metrological calibration and regular drift monitoring, guaranteeing data quality and long-term comparability across stations. A standardized technical protocol defines installation criteria: 50-100 m from surface, at least 100 m from cave entrances, with specific requirements for cavity dimensions and microenvironment. Each station continuously measures air temperature and rock temperature at two depths (10 and 40 cm); water temperature is also recorded where present.

The project integrates over 600 historical temperature measurements into a national database, some dating back to 1846 (Antro del Corchia, Tuscany). A WebGIS platform is currently under development to provide open, interactive access to the full dataset, enabling spatial visualization of the network and supporting scientific analysis and public engagement.

By the end of 2025, the network comprised over 20 continuously operating stations, with a target to double this number in 2026. The long-term vision is to expand the network through international speleological partnerships, contributing to a global dataset on underground climate change.

Keywords: *climate change, cave monitoring, citizen science, speleology*
Ključne besede: *podnebne spremembe, spremljanje jam, občanska znanost, speleologija*

Sustainable Karst Management and Responsibility for Legacy Disturbances in a Protected Area

Trajnostno upravljanje krasa in odgovornost za posledice preteklih posegov v zavarovanem območju

Paul Griffiths

Karst management commonly focuses on preventing impacts from proposed development. Less attention has been given to responsibility for anthropogenic disturbances inherited from earlier land uses, particularly where ownership, management objectives, or regulatory regimes have changed over time.

Responsibility for legacy disturbances does not necessarily require intervention in every case. Rather, it may entail an ongoing stewardship duty to avoid compounding past damage and to intervene only where the likely environmental benefits outweigh the associated risks. Sustainable karst management therefore requires present-day custodians to identify inherited disturbances, evaluate whether remedial action is likely to produce a net environmental benefit, and apply precautionary, risk-based, and monitored approaches to rehabilitation.

This issue is examined through a karst inventory and risk assessment undertaken in the Moksgm'ol/Chapple–Cornwall Conservancy, a 291 km² protected area on Princess Royal Island within the coastal temperate rainforest of British Columbia, Canada. Before the Conservancy was designated in 2006, its karst areas were affected by forestry roads, logging, and limestone ballast quarries. Within the study area, the proportion of karst terrain that had been logged was nearly five times greater than the proportion of non-karst terrain.

Airborne LiDAR interpretation, field verification, karst mapping, and Source–Pathway–Receptor risk assessment were used to characterize the affected landscape and evaluate the potential consequences of proposed road deactivation. The assessment expanded the estimated extent of karst to approximately 1.6 times the area identified by existing provincial mapping and documented nearly 15 km of now-overgrown forestry roads crossing karst terrain. It also identified roads crossing allogenic catchments that direct surface water into downgradient karst systems. Potentially at-risk features included stream sinks, dolines, possible cave entrances, and karst canyons.

Interventions intended to address legacy disturbances may themselves introduce new risks. Road deactivation can generate sediment, alter surface and subsurface drainage, disrupt hydrological connectivity, or damage previously undocumented karst features. Conversely, retaining unstable roads or leaving quarry-related hazards untreated may perpetuate erosion, slope instability, unauthorized access, and other conservation concerns.

The assessment therefore did not support wholesale road deactivation or quarry rehabilitation. Instead, it recommended a site-specific, scenario-based approach in which the environmental risks and benefits of retaining, modifying, or deactivating individual road segments are evaluated before intervention. Stable road sections may appropriately be retained where further disturbance would create greater harm, whereas targeted deactivation may be justified where it would reduce long-term environmental liabilities. Quarry management should similarly emphasize limited, low-impact measures, such as erosion control and encouraging revegetation, rather than full restoration or backfilling unless these actions are clearly justified.

The case study demonstrates that responsibility for legacy disturbances in protected karst landscapes is best understood not as an automatic obligation to restore all disturbed sites, but as a continuing duty of informed, precautionary, and adaptive stewardship.

Keywords: *karst management, legacy disturbances, protected areas, risk assessment, karst rehabilitation*
Ključne besede: *upravljanje krasa, pretekli posegi, zavarovana območja, ocena tveganja, sanacija krasa*

UIS/IUCN Guidelines for Cave and Karst Protection

Smernice UIS/IUCN za varstvo jam in krasa

John Gunn[1,2]
[1] *International Union of Speleology - UIS*
[2] *University of Birmingham / BCRA, Birmingham, United Kingdom*

In 1997 the International Union for Conservation of Nature (IUCN) published 'Guidelines for Cave and Karst Protection' with the aim of increasing awareness of cave and karst protection issues, primarily within the IUCN and associated management and conservation agencies and with an emphasis on protected areas. Over the years since the guidelines were published there has been a great increase in scientific knowledge concerning caves and karst but they continue to be threatened by human activities around the world. In fact, there are exceptional, irreplaceable and hydrologically, ecologically, and culturally important cave and karst landscapes that are being damaged or threatened on a continuous basis. Hence, in 2021, as part of the International Year of Caves and Karst, the International Union of Speleology (UIS) agreed to publish a second edition of the guidelines, with the IUCN subsequently agreeing to sponsor the publication. The original guidelines were primarily concerned with geoheritage, and while this remained an important consideration in the second edition, biological issues involved in cave and karst conservation were also considered.

The protection of surface and underground karst ecosystems is particularly relevant to Goal 15 of the UN 2030 Agenda for Sustainable Development (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss). These guidelines also have relevance for Sustainable Development Goal 6 (Ensure availability and sustainable management of water and sanitation for all), as ~10% of the world's population gain their water supplies from karst, either from discrete springs or from karst groundwater. The new guidelines build and expand on the Guidelines for Geoconservation in Protected and Conserved Areas, published by IUCN in 2020, by specifically considering the protection and conservation of geodiversity, geoheritage and ecology in karst and cave areas, wherever they occur.

The Guidelines are available as a free-to-download document on the UIS website. First published in English, they have subsequently been translated into nine other languages. There is also a complete listing of the 76 individual guidelines in English and in 31 other languages. These guidelines provide a significant contribution to knowledge of the special management considerations essential for effective protection of caves and karst and are intended to form a basis for additional national and site-specific strategies to be developed in karst areas around the world.

Keywords: *cave and karst protection, conservation guidelines, geoheritage, protected areas, sustainable development goals*
Ključne besede: *varstvo jam in krasa, naravovarstvene smernice, geodediščina, zavarovana območja, cilji trajnostnega razvoja*

Organized Hungarian Speleology
Organizirana madžarska speleologija

Hegedűs Gyula[1]
[1] *Hungarian Speleological Society*

The roots of the first Hungarian speleological organization date back to 1891. It was then that an artifact, discovered during the laying of house foundations, was presented to Ottó Hermann, who reported on the find in the „Természettudományi Közlöny" (Natural Science Gazette) in 1893. This report was followed by a professional debate lasting several years, until excavations finally began in the caves of the Bükk Mountains in 1908. The results of this work were published that same year, also in the „Természettudományi Közlöny". Following the ever-increasing research activity, the Speleological Committee of the Hungarian Geological Society was established on January 28, 1910. This was the first Hungarian organization dedicated to cave exploration. As a result of intensifying activity, the Committee was reorganized into a specialized section on January 20, 1913. Eventually, hiking and tourist organizations also became involved in the work, but this was incompatible with the strictly scientific mission of the Hungarian Geological Society; consequently, on January 20, 1926, those involved in cave exploration founded the Hungarian Caving Society (HCS), as the first independent caving organization. It operated until 1944, when the Society's office was hit during the war, and was subsequently officially dissolved in 1946. From 1952 onwards, a Cave Research Section operated briefly once again under the auspices of the Hungarian Geological Society; subsequently, on December 12, 1958, the Hungarian Speleological Society (HSS) was founded and has remained active to this day. The first publications regarding organized cave research appeared in „Földtani Közlöny" (Geological Bulletin), where a dedicated section was soon established. The first independent specialized journal, „Barlangkutatás" (Cave Research), was launched in 1913, followed in 1926 by „Barlangvilág" (Cave World); however, these publications ceased when the HCS—their publisher—discontinued operations. In 1960, the HSS launched the yearbook „Karszt és Barlangkutatás" (Karst and Cave Research), featuring scientific papers, followed in 1961 by „Karszt és Barlang" (Karst and Cave), a publication covering the Society's activities and intended for release twice a year. The Society's day-to-day life and programs are covered by the „Tájékoztató" (Newsletter), which appears quarterly, having previously been published on a monthly and then bi-monthly basis.

Keywords: *cave research, caving societies, history of cave exploration, scientific journals*
Ključne besede: *raziskovanje jam, jamarska društva, zgodovina raziskovanja jam, znanstvene revije*

Sustainable Cave Conservation Management: Mitigating Human Impacts
Trajnostno upravljanje in varstvo jam: zmanjševanje vplivov človeka

Val Hildreth-Werker[1]
[1] *International Union of Speleology - UIS Bureau*

With the guiding principle of primum non nocere (do no harm), we introduce hands-on techniques as participants explore philosophies, methods, and current best practices in cave restoration via workshops and online resources. For seminars and courses, we collaborate with local teams to introduce cave-friendly restoration methods and tools for graffiti assessment/documentation/mitigation, speleothem repair, and human impact remediation. Workshops emphasize protection of natural and cultural heritage, testing of methods and materials, and consultation with speleologists in relevant disciplines. Training events focus on minimum-impact

caving principles, awareness of invasive species, and avoiding cross-contamination. Workshop and seminar materials are supported by the seminal NSS manual titled Cave Conservation and Restoration (Hildreth-Werker and Werker). The full 600-page peer-reviewed volume is now a living book, available online at https://caves.org/wp-content/uploads/2022/06/CCR-Book.pdf. Classroom and in-cave discussions explore informed decision-making—to mitigate or not to mitigate in a given spelean habitat. Teams perform in-cave impact assessment exercises and gain hands-on experience in restoring selected cave surfaces, sediments, and speleothems disrupted by development, infrastructure, tourism, and untutored visitation in wild caves and show caves. Each workshop design is appropriate to the conditions of the particular cave system and cultural region. With opportunities for in-depth analysis, in-cave application of principles, and fine-tuning of skills, participants gain practical experience in making evidence-informed decisions for sustainable cave conservation-management projects.

Keywords: *habitat restoration, speleothem repair, impact assessment, cross-contamination prevention, field training*
Ključne besede: *obnova habitatov, obnova kapniških tvorb, ocean vplivov, preprečevanje navzkrižne kontaminacije, terensko usposabljanje*

Mechanisms, Potential, and Measurement Methods of Karst Carbon Sinks

Mehanizmi, potencial in metode merjenja ponorov ogljika v krasu

Huang Fen[1], Xiao Qiong[1], Sun Ping'an[1]
[1] *International Research Centre on Karst (IRCK) under the auspices of UNESCO, Institute of Karst Geology, Chinese Academy of Geological Sciences (CAGS), Guilin, China*

As a promising nature-based carbon sequestration pathway for mitigating climate change, karst carbon sinks have been formally recognized by the IPCC. From the perspective of Earth System Science, this presentation elucidates the mechanisms, potential, and measurement methods of karst carbon sinks. The chemical dissolution of carbonate rocks, coupled with the "carbon pump effect" of aquatic biological photosynthesis, significantly enhances the stability and conversion efficiency of the sequestered carbon. The report reviews the measurement system, which combines front-end field measurements (e.g., the standard tablet method) with back-end watershed accounting (hydrochemical runoff methods and modelling). Recent evaluations show that the global annual karst carbon sink flux reaches 0.89 ± 0.23 Pg C. Observational data from typical watersheds, such as China's Yangtze and Pearl Rivers, confirm the immense carbon sequestration potential of low-latitude karst regions with favourable hydrothermal conditions. High-precision accounting of karst carbon sinks will provide crucial geological support for global carbon cycle research and climate governance.

Keywords: *CO_2 sequestration, carbonate dissolution, aquatic biological pump, watershed accounting, climate mitigation*
Ključne besede: *vezava CO_2, raztapljanje karbonatov, vodna biološka črpalka, bilančenje po porečjih, blaženje podnebnih sprememb*

Building the Aspiring Transboundary UNESCO Global Geopark Kras-Carso

Vzpostavljanje čezmejnega Unescovega globalnega geoparka Kras-Carso

Anu Kahuna[1], Katja Fedrigo[1], Sara Bensi[2], Matevž Novak[3], Martina Stupar[4], Ana Hrast[5]
[1] *Municipality of Sežana, Sežana, Slovenia*
[2] *Geological Survey of Friuli-Venezia Giulia Autonomous Region, Tolmezzo, Italy*
[3] *Geological Survey of Slovenia, Ljubljana, Slovenia*
[4] *Institute of the Republic of Slovenia for Nature Conservation, Slovenia*
[5] *ORA Kras-Brkini, Sežana, Slovenia*

The Kras-Carso Plateau (Matični Kras in Slovene, Carso Classico in Italian), shared between Slovenia and Italy, is internationally recognised as the type area of the Classical Karst, the birthplace of karst science, and the landscape that gave the world the term karst. Owing to its exceptional diversity, integrity and concentration of both surface and subterranean karst phenomena, the plateau has become a global reference area for the study of karst processes and advancement of karstology.

As geological systems and geoheritage transcend political borders, their effective conservation, interpretation and sustainable management require close international cooperation. Building upon more than a decade of collaboration, municipalities, scientific institutions and regional and national authorities from both countries are jointly developing the Aspiring Transboundary UNESCO Global Geopark Kras-Carso.

The initiative originated through the KRAS-CARSO Project (Interreg Italy-Slovenia 2007-2013), continued through the GeoKarst Project (Interreg Italy-Slovenia 2014-2020), and has been further strengthened through the strategic Interreg KRAS-CARSO II Project (Interreg Italy-Slovenia 2021-2027). These collaborative efforts have laid the foundations for the preparation of the UNESCO Global Geopark application, encompassing seventeen municipalities across the Kras-Carso Plateau. At the same time, partners are establishing a long-term cross-border governance framework through the European Grouping of Territorial Cooperation (EGTC) Kras-Carso, headquartered in Lipica, which will also host the geopark's main entry point and interpretation centre, ensuring effective and sustainable management of the territory.

Over the years, the partnership has developed an integrated management framework, enhanced the inventory, assessment, and interpretation of geological heritage, established cross-border geotrails and educational programmes, and implemented advanced GIS-based digital tools to support conservation, interpretation, and visitor management. Particular emphasis has been placed on the active involvement of local communities, stakeholders, educational institutions, and businesses, recognising geoheritage as a catalyst for sustainable regional development.

The Aspiring Transboundary UNESCO Global Geopark Kras-Carso represents an exemplary model of how a shared geological heritage can connect communities across national borders by promoting scientific cooperation, environmental education, sustainable tourism and local development, contributing directly to the Sustainable Development Goals. As the landscape that gave the world the term karst, the Kras-Carso Plateau continues to inspire international collaboration and stands as a remarkable example of how geoheritage can foster environmental stewardship, cultural understanding and sustainable development for present and future generations, in line with UNESCO's objectives.

Keywords: *geoheritage, Classical Karst, cross-border cooperation, geotrails, regional development*
Ključne besede: *geodediščina, Matični kras, čezmejno sodelovanje, geopoti, regionalni razvoj*

Karstification of Cultural Heritage

Zakrasevanje kulturne dediščine

Martin Knez[1,2,3], Tadej Slabe[1,2,3]
[1] *ZRC SAZU, Karst Research Institute, Postojna, Slovenia*
[2] *UNESCO Chair on Karst Education, University of Nova Gorica, Vipava, Slovenia*
[3] *Yunnan University International Joint Research Center for Karstology, Kunming, China*

Twenty years of field documentation of transformation traces on cultural heritage, namely buildings, rock-cut monuments, and sculptures constructed from carbonate rocks, clearly demonstrate varied yet characteristic karstification resulting from diverse environmental influences. In several instances, karstification is highly intense, necessitating urgent consideration of protection and conservation measures, as well as potential restoration. To date, protective measures have been implemented only at the remains of the Hagar Qim temple in Malta and, to a lesser extent, at the Roman arena in Nimes, while restoration efforts are also ongoing at the Acropolis in Athens.

At the same time, the study of these monuments could provide an exceptional record of karstification rates across different carbonate lithologies and environmental conditions, as many of these heritage objects are precisely dated.

Material has been collected from a wide range of global sites, including the Great Pyramid of Giza; the Hagar Qim temple in Malta; carbonate dolmens in Sardinia and southern France; Persepolis and Taq-e Bostan in Iran; the Acropolis and temples in Athens; the stone lions of Delos; the quarries of Favignana; the Pantalica necropolis in Sicily; Roman amphitheatres in Nîmes and Arles; the Pont du Gard aqueduct; the theatre in Alexandria; the medieval fortress of Les Baux-de-Provence; the Papal Palace in Avignon; Baroque heritage sites in Sicily (Modica, Ragusa); the historic centre of Cairo; and various buildings in Slovenia. Field findings from investigations of Stonehenge are also intriguing; although constructed of silicate rocks, the megaliths display distinct traces of rainfall- and runoff-induced weathering along their surfaces.

We have also succeeded in producing our first, already well-received study, explaining the karstification of the Great Pyramid of Giza.

Keywords: *cultural heritage, karstification, carbonate rocks, conservation, weathering*
Ključne besede: *kulturna dediščina, zakrasevanje, karbonatne kamnine, varstvo, preperevanje*

Integration of Karst-Specific Approaches in Existing Conservation Frameworks through Cooperation

S sodelovanjem do vključevanja krasu prilagojenih pristopov v obstoječe okvire varstva

Katarina Kosič Ficco[1], Mike Ficco[1]
[1] *VADCR Natural Heritage Karst Program, United States*

Karst management in Virginia and the United States of America (USA) involves multiple entities, including federal and state agencies, local authorities, private corporations, and landowners.

The Virginia Department of Conservation and Recreation Division of Natural Heritage Karst Program is a non-regulatory entity within the state government that primarily focuses on documenting and conserving cave and karst biodiversity. However, due to gaps in karst expertise in land management and regulatory roles at the federal and state levels, the program often provides technical assistance to other government agencies and private-sector entities.

Natural heritage programs in the USA share their biodiversity findings with NatureServe Biotics, the

North American Biodiversity Information Management System. As this system was developed for reporting findings on surface fauna and flora, the Virginia Karst Program has developed modified reporting approaches that account for the complexity and interdependence of karst systems across a variety of geological, hydrological, and biological settings.

The Virginia Karst Program also performs karst evaluations for and in cooperation with various entities. In doing so, our practices address cave and karst protection and information across different ownership contexts, including private property.

The program navigates and reconciles interagency and private-entity constraints by using a cave and karst-specific reporting approach while understanding and accommodating diverse stakeholder priorities. The Virginia Karst Program strives to provide unbiased, comprehensive evaluations of karst resources and vulnerabilities that combine thorough documentation of their findings with recommendations for best management practices to protect karst resources.

Keywords: *cave biodiversity, natural heritage programs, land-use planning, stakeholder coordination, management practices*
Ključne besede: *jamska biodiverziteta, programi naravne dediščine, prostorsko načrtovanje, usklajevanje deležnikov, upravljavske prakse*

Postojna, Venue of the 4th International Congress of Speleology and the Founding of the International Union of Speleology (September 1965)

Postojna, prizorišče 4. mednarodnega speleološkega kongresa in ustanovitve Mednarodne speleološke zveze (september 1965)

Jurij Kunaver

On the occasion of UNESCO's first International Day of Caves and Karst, we recall with joy, pride, and admiration the first major international gathering of karst researchers and speleologists held in Postojna. This was the 4th International Congress of Speleology (4th CIS), held from September 9 to 25, 1965, comprising three days of pre-congress excursions, four days for the opening ceremony and sessions, and the remainder dedicated to congress and post-congress excursions across the Dinaric karst. It was a significant international scientific and professional event that also saw the founding of the International Union of Speleology. Both events demonstrate the high regard in which Slovenian karst science and speleology were already held at the time and, even more so, the global renown of Slovenia's karst landmarks and the entire Dinaric karst region of the former joint state. It is important to remember that a large team of people worked for nearly a year to organize and carry out this event. The Honorary Committee included twenty-one prominent figures from the former joint state; the formal organizer was the Speleological Union of Yugoslavia (specifically, an Organizing Committee of eleven members), while the actual organization was carried out by a nine-member Secretariat based in Slovenia. The majority of the Secretariat members, commission and committee members, and technical staff came from the University of Ljubljana, specifically the Faculty of Arts, as well as the Karst Research Institute ZRC SAZU in Postojna, the parent SAZU institution in Ljubljana, the Geological Survey of Slovenia, two caving clubs from Ljubljana, and one from Postojna. The congress was attended by 418 people from 28 countries around the world.

Keywords: *speleological history, Slovenian karst science, Dinaric karst, scientific congresses, international cooperation*
Ključne besede: *zgodovina speleologije, slovensko krasoslovje, Dinarski kras, znanstveni kongresi, mednarodno sodelovanje*

Norway's Marble Karst: Safe and Sustainable Management?

Norveški kras v marmorju: varno in trajnostno upravljanje?

Stein-Erik Lauritzen[1,2]
[1] *Norwegian Speleological Society*
[2] *Department of Earth Science, University of Bergen, Bergen, Norway*

Norway's approximately 350 km² of carbonate rocks are predominantly regionally metamorphosed marbles, deposited during the Cambro-Silurian and transformed during the Caledonian orogeny. These processes have produced the characteristic "stripe karst" landscape elements that define the Norwegian karst type. The country hosts more than 2,000 registered karst caves, alongside an unknown — and likely far larger — number of marine abrasion caves, deep-weathering caves, and talus caves. The longest karst cave (a labyrinth system) measures 25 km, and the deepest, situated within a fjord wall, reaches approximately 580 m. Karst speleogenesis in Norway extends well beyond the Quaternary; the oldest known cavities are granite weathering caves developed in saprolite during the Permian. An increasing body of scientific documentation, accumulated over the past five decades, demonstrates the scientific, archaeological, and aesthetic value of these caves. In particular, advances

in cave stratigraphy show that caves are unique repositories of interglacial fauna and ancient DNA.

Cave protection and management fall under the Nature Diversity Act and are administered by the Norwegian Environment Agency and the regional County Governors (Statsforvaltere). Caves within national parks and other nature reserves are automatically protected, but many valuable karst sites lie outside these boundaries. A limited number of specific caves in Rana Municipality were legally protected as early as 1931, with further protections added in 1967, and several were fitted with gates. Recently, the old gates have been renewed, and a few additional caves have been gated. There is, however, growing pressure from the tourism industry, adventure travel, general recreational caving, and infrastructure development (wind farms, roads, quarries). Adventure TV productions have also contributed to the degradation of vulnerable caves by showcasing unacceptable caving behaviour.

The Norwegian Speleological Society (NGF) has taken particular responsibility for prevention, training cavers in safe and careful practices and raising general awareness of cave and personal safety and vulnerability. NGF also maintains an active emergency preparedness and rescue team, which can be activated by the police in the event of an accident. NGF collaborates closely with the other Scandinavian speleological societies as well as with the environmental protection authorities.

Keywords: *geotourism, cave tourism, visitor management, sustainable management, cave conservation*
Ključne besede: *geoturizem, jamski turizem, upravljanje obiska, trajnostno upravljanje, varstvo jam*

Geodiversity and Karst Features of the Sharbazhair Province, Sulaimani Governorate, Kurdistan Region, Iraq

Geodiverziteta in kraške značilnosti province Sharbazhair, guvernorat Sulaimani, regija Kurdistan, Irak

Fadhil Ahmed Ameen Lawa[1]
[1] *University of Sulaimani, Sulaymaniyah, Iraq*

The geodiversity of the Sharbazhair area in the Kurdistan Region of northern Iraq is of international geoheritage importance. In this article, one-third of Earth's history is documented and clarified on a newly compiled geological map of the study area. The goal of this work is to protect the unique mountain terrain, historical landmarks, and ecological environment of the Sharbazhair district, Sulaimani Governorate, Kurdistan Region of Iraq. The main objective is to contribute to the candidacy of this area for recognition as one of the geoparks of the Global Geoparks Network (International Association on Geoparks, UNESCO). In this study, about 25 geosites were evaluated to determine their rank and suitability for recognition within the aspiring Sharbazhair Geopark. Different types, sizes, shapes, and speleothem forms of caves and karst features predominate in the Cretaceous carbonates and are associated with significant archaeological history. This assessment was conducted through quantitative analysis of each proposed geosite and considered factors controlling site evaluation, such as scientific, educational, tourism, cultural, and archaeological potential, as well as degradation risk. Socio-cultural and managerial aspects related to sustainable development and local community projects were also analyzed using SWOT concepts, considering their role in upgrading multiple forms of tourism in Sulaimani Governorate and the Kurdistan Region. The Sharbazhair area is characterized by well-preserved ophiolite outcrops and records the complete history of the subduction zone between the Arabian and Eurasian plates, including the multi-stage evolution of the Kurdistan foreland during the Late Cretaceous and Cenozoic. It also includes evidence of hydrogeological systems and climatic change. The study area contains several important geological events from the Triassic to the present, including the J/Cr boundary, the Cretaceous/Paleocene boundary, the Maastrichtian

greenhouse, and the Maastrichtian extinction. The fossil biodiversity extends over 200 million years and is characterized by very interesting giant macrofossils, such as rudists, Exogyra, Gryphaea, Acteonella, ammonites, echinoderms, and rare large palaeogeographic foraminifera, including Loftusia, Orbitoides, and Nummulites. The variety of igneous, metamorphic, and sedimentary rocks collectively represents different geological events and processes, together with different minerals and gemstones, and can also be considered a natural history museum. Biodiversity data, together with data on rare and indigenous fauna and flora in this segment of the Zagros, have been included. Archaeological sites and cultural diversity were also documented and plotted on the tourism site map. Furthermore, the biodiversity and cultural diversity increase the potential score of the 25 analysed geosites and represent a major cornerstone for the sustainable development of the region. The area's distinctive geological features and scenic landscapes in all four seasons, including caves, waterfalls, rivers, canyons, and archaeological sites, give it high potential for multipurpose tourism, including geotourism, ecotourism, cultural tourism, horse riding, hiking, and water sports. Finally, the area is being considered by UNESCO Iraq and the Middle East as one of the aspiring geoparks in Iraq and the Middle East.

Keywords: *geoheritage, geosite assessment, Cretaceous carbonates, archaeological heritage, sustainable tourism*
Ključne besede: *geodediščina, ocenjevanje geoloških znamenitosti, kredni karbonati, arheološka dediščina, trajnostni turizem*

Speleological Activity of the Zwoliński Brothers in Poland: A Brief History
Speleološka dejavnost bratov Zwoliński na Poljskem: kratka zgodovina

Łukasz Lewkowicz[1]
[1] *Maria Curie-Skłodowska University, Lublin, Poland*

The aim of the paper was to present the broadly understood speleological activity of the brothers Tadeusz and Stefan Zwoliński. The paper presents biographies of both figures, then analyzes the individual stages of their speleological activity in detail, and finally characterizes the legacy of the Zwoliński brothers. The speleological activity of the Zwoliński brothers lasted several dozen years in total: it began during the Austro-Hungarian period, was continued with many successes in the interwar period and ended after the Second World War in the Polish People's Republic. At the threshold of their activity, only 44 caves in the Polish Tatras were known. The activity of the Zwoliński brothers finally brought knowledge of nearly 120 new cave facilities. Their various publications also provided a model for the development of cave documentation and influenced the tourist and scientific activities carried out there. The paper is a contribution to further research on the history of Polish speleology.

Keywords: *cave exploration, Polish Tatras, Tadeusz Zwoliński, Stefan Zwoliński, cave documentation*
Ključne besede: *raziskovanje jam, Poljske Tatre, Tadeusz Zwoliński, Stefan Zwoliński, dokumentiranje jam*

Haida - Relationship with Nature and Stewardship – Caves and Subterranean Landscapes

Haida – odnos do narave in skrbništvo – jame in podzemne pokrajine

Marlene Liddle[1]
[1] *Council of the Haida Nation*

As Haida people, our relationship with the natural world is not defined by ownership, but by responsibility. In this keynote, I will share how Yahguudang—respect for all living things—guides our understanding of land, water, and the spaces beneath them that are often unseen, but never separate from us. In Haida Gwaii, caves and karst landscapes are not empty voids in the earth; they are part of a living system that carries memory, sustains life, and connects us to our ancestors. These subterranean environments hold stories, preserve ecological histories, and provide refuge for species that depend on their integrity. For us, they remind us that what lies below the surface is just as vital as what we see.

Drawing from my work with the Council of the Haida Nation and years of stewardship alongside our people, I will speak to how Haida laws and values shape our approach to protecting these fragile systems. This includes navigating tensions between development and conservation, and ensuring that decisions are grounded in intergenerational responsibility.

This keynote is an invitation to look beyond the surface—to recognize caves and karst landscapes as living relatives within broader ecosystems, and to consider how Indigenous knowledge systems can guide more respectful and sustainable relationships with the natural world. Our teachings remind us that stewardship is not a task, but a way of being—one that requires humility, reciprocity, and care for all that is seen and unseen.

Keywords: *Indigenous governance, ancestral connections, living systems, cultural values, environmental responsibility*
Ključne besede: *domorodno upravljanje, povezave s predniki, živi sistemi, kulturne vrednote, okoljska odgovornost*

Integrating Public Policies for Cave and Karst Protection at National and Subnational Levels: The Case of Brazil and the State of São Paulo

Povezovanje javnih politik za varstvo jam in krasa na nacionalni in podnacionalni ravni: primer Brazilije in zvezne države São Paulo

Clayton Ferreira Lino[1,2], Rafael Juan Diego Moreira[1,2]
[1] *São Paulo State Speleological Council - CPESP/SEMIL*
[2] *Brazilian Speleological Society - SBE; CaveMAB Network/UNESCO*

Brazil has over 30,000 registered caves, and this number grows exponentially each year. To protect this heritage, the country currently employs some of the most advanced legislation and mechanisms, including the creation of parks and other protected areas; environmental education; specific laws governing the licensing of projects with potential impacts on karst areas; ongoing programs for exploration, mapping, research, and monitoring; management plans for cave tourism; and environmental compensation funds for authorized impacts, among others. This system is founded on the 1988 Brazilian Constitution's designation of all caves as federal assets (public property), the establishment of participatory councils and specialized bodies for cave study and protection at both federal and state levels, and partnerships among the government, the business sector, and the speleological community. This presentation aims to describe the system—along with its progress and

challenges—serving as potential inspiration for other countries within the UIS and the CaveMAB/UNESCO network.

Keywords: *public policy, environmental legislation, multilevel governance, cave and karst protection, Brazil*
Ključne besede: *javna politika, okoljska zakonodaja, večnivojsko upravljanje, varstvo jam in krasa, Brazilija*

Built on Water: Yucatán's Karst Aquifer and the Maya Train

Zgrajeno na vodi: kraški vodonosnik Jukatana in Majevski vlak

Irma Losada Olmos[1], Roberto Rojo[1]
[1] *University of California, Los Angeles (UCLA), Los Angeles, United States*

The northern coast of the state of Quintana Roo in southeast Mexico is home to an impressive and vast subterranean world: Yucatán's karst aquifer. Containing the two most extensive anchialine cave systems on the planet—Sac Actun and Ox Bel Ha—and nearly 2,000 kilometers of explored caves, this aquifer is also known for its unique archaeological, paleontological, and ecological dimensions. Yet, the past two decades have tested the resilience of the aquifer due to the rapid urban growth of this famous tourist region, raising concerns about the physical integrity of its caves and the pollution of its subterranean rivers. The arrival of the Maya Train, a 1,525 km-long passenger and cargo train that started operating in 2024, has increased human pressure on an already fragile and vulnerable karst system. This mega-project has not only modified many of the aquifer's caves by perforating them with concrete and steel pillars but is also threatening the quality of its water for the years to come. Drawing from first-hand cave explorations along Section 5 of the train (which connects Cancún with Tulum), this presentation examines the relevance of Yucatán's karst aquifer and argues that moving below the surface is a crucial step to understanding infrastructure and development projects such as the Maya Train. The surface and the subsurface cannot be understood as separate dimensions: through this multi-dimensional approach, both human and non-human life on Earth become even more precious.

Keywords: *karst hydrogeology, groundwater, karst aquifer, Yucatán karst, infrastructure impacts*
Ključne besede: *kraška hidrogeologija, podzemna voda, kraški vodonosnik, kras Jukatana, vplivi infrastrukture*

Subterranean Landscape Fragmentation Drives Cryptic Diversification in the Olm (Proteus anguinus)

Fragmentacija podzemne krajine spodbuja prikrito diverzifikacijo človeške ribice (Proteus anguinus)

Chiara Manfrin[1], Marco Restaino[1]
[1] *Department of Life Sciences, University of Trieste, Trieste, Italy*

Subterranean habitats are highly fragmented and poorly connected environments that often promote strong genetic structuring in obligate cave-dwelling species. We investigated the spatial distribution of the only troglobitic vertebrate in Italy, the Olm, across the Italian sector of the Classical Karst, representing the westernmost extent of its natural range. Genetic lineage distribution was assessed using the mitochondrial cytochrome c oxidase subunit I (COI) marker, complemented by morphological

analyses of individuals collected from multiple caves along the regional hydrological gradient. We also developed a non-invasive morphology-based method for the individual recognition of olm specimens, providing a practical tool for long-term population monitoring and conservation without the need for marking or invasive handling. This study represents the most comprehensive survey of Italian olm populations conducted to date. We identified the sympatric occurrence of two mitochondrial lineages (Ljubljanica and Karst), exhibiting a pronounced upstream–downstream distribution pattern. A sharp transition in lineage composition occurred over a remarkably short distance (~1 km), indicating that local hydrogeological discontinuities act as barriers to dispersal and gene flow. Further downstream, within the Reka–Timavo and Isonzo aquifer systems, only the Karst lineage was detected. These results demonstrate that the hydrological architecture of karst aquifers, together with local subterranean barriers, plays a pivotal role in shaping the genetic structure of cave-adapted organisms. The fine-scale spatial segregation of lineages highlights the ecological complexity of karst groundwater ecosystems and underscores the need to integrate hydrogeological connectivity and non-invasive monitoring approaches into conservation strategies for subterranean biodiversity.

Keywords: *olm, subterranean biodiversity, conservation genetics, karst hydrogeology, groundwater*
Ključne besede: *človeška ribica, podzemna biodiverziteta, varstvena genetika, kraška hidrogeologija, podzemna voda*

Collecting Empires: Dominik Bilimek and Early Subterranean Zoology between Politics and Field Research

Zbirateljski imperiji: Dominik Bilimek in zgodnja podzemna zoologija med politiko in terenskim raziskovanjem

Johannes Mattes

The Moravian Cistercian monk and collector Dominik Bilimek (1813–1884) is regarded as one of the earliest European naturalists to investigate subterranean fauna in Latin America. During the second French intervention in Mexico, from 1861 to 1867, he accompanied Maximilian of Habsburg, the newly installed emperor of Mexico, to the region. There, he explored the Grutas de Cacahuamilpa near Taxco de Alarcón and compared their fauna with specimens and observations from his earlier work in Postojnska jama in Carniola. After the victory of the Mexican republican forces and Maximilian's execution, Bilimek remained curator of the emperor's collections, which he brought back to Europe and later exhibited at Miramare Castle near Trieste. Before his Mexican expedition, Bilimek had aligned himself with the imperial ambitions and intellectual agendas of Vienna's central administration while teaching at the monarchy's military institutes. In the aftermath of the revolutions of 1848–49, large-scale research initiatives, including geoscientific, biological, and archaeological surveys, were launched to preserve the Habsburg Monarchy as a supranational polity in the face of internal and external crises and to legitimize its territorial framework as a natural as well as cultural unit. These developments coincided with the first wave of zoological interest in the caves of Carniola, which stimulated efforts to identify comparable findings in other karst regions of the monarchy. Drawing on historical sources, this paper examines the intersection of political visions and field practices in the early study of cave biology. Particular attention is paid to the sites, networks, and modes of collection.

Keywords: *subterranean zoology, history of speleology, scientific collecting, Habsburg Monarchy, Latin America*
Ključne besede: *podzemna zoologija, zgodovina speleologije, znanstveno zbirateljstvo, Habsburška monarhija, Latinska Amerika*

Biodiversity of Underground Tipan Cave and Naga-Kabasalan Protected Landscape (NKPL), Zamboanga Sibugay, Philippines

Biotska raznovrstnost podzemne jame Tipan in zavarovanega območja Naga-Kabasalan (NKPL), Zamboanga Sibugay, Filipini

Marc Mentens[1]
[1] *Zamboanga Peninsula Cavers Association, Inc., Zamboanga City, Philippines*

Zamboanga Sibugay is the third and youngest province in the Zamboanga Peninsula, Philippines. It is endowed with karst areas towards the borders of Zamboanga del Norte, Zamboanga del Sur, and Zamboanga City. Underground Tipan Cave was first explored in 2016 by the Provincial Environment and Natural Resources Office – Zamboanga Sibugay of the Department of Environment and Natural Resources Region 9 and the Zamboanga Peninsula Cavers' Association, Inc. The biodiversity assessment data collected inside and outside the caves in the area helped pave the way for the site to be declared a protected area.

The Naga-Kabasalan Protected Landscape became an additional component of the Expanded National Integrated Protected Areas System on April 8, 2022, through the passage of Republic Act 11686. It is the first protected area under the second district of the province, the twelfth protected area in the region, and the only karst protected area in the Zamboanga Peninsula.

Through the ZamPen Cavers, volunteer spelunkers from Speleo Netherlands and Belgian cavers have collaborated with the Protected Area Management Office, the DENR, and the Provincial Government Office to conduct an annual caving expedition in the area since 2023. To date, the expedition has resulted in the identification of about 74 cave entrances, of which only six have been found to be connected to two separate caves. The surveyed length of Underground Tipan Cave was about 1.7 km in 2016 and had reached 22 km by March 2024.

Potential connectivity to other cave systems is possible and needs to be explored further with the help of cave divers. Significant species of fish, herpetofauna, and flora have been documented in the area. In fact, a new species of flora was discovered by local researchers in 2023, together with new distribution records for the protected area. Proper management, conservation, and protection of this remarkable site will depend on the baseline data established for the site to aid the governing body in developing science-based policies.

Keywords: *biodiversity, protected landscape, karst conservation, cave exploration*
Ključne besede: *biotska raznovrstnost, zavarovana pokrajina, varstvo krasa, raziskovanje jam*

Extrusions of Iron Oxides in Karstified Calcareous Soils of the North Adriatic: A Study and Mapping Project for Site Protection

Izločki železovih oksidov v zakraselih karbonatnih tleh severnega Jadrana: študija in kartiranje za varstvo najdišč

Enrico Merlak[1]
[1] *Commissione Grotte "E. Boegan", Trieste, Italy*

The phenomenon of iron oxide extrusions in Upper Cretaceous and Paleocene limestones in the eastern North Adriatic has received little or no attention, and no specific studies are available in the scientific literature. In the absence of a more precise term, the author uses "extrusion" to describe the

apparently anomalous presence of solid oxide bodies within compact limestone in karst areas affected by intense tectonic deformation.

The first significant finding was recorded during the initial exploration of Grotta Impossibile in Cattinara near Trieste and was presented at the XXI National Congress of Speleology in Trieste. Diffractometric analyses performed by Davide Lenaz of the Department of Mathematics and Earth Sciences of the University of Trieste identified a dominant composition of goethite α-$Fe^{3+}O(OH)$, with smaller quantities of kaolinite $Al_2(Si_2O_5)(OH)_4$, phyllosilicates, and traces of hematite. A complete absence of the calcareous phase was confirmed in the extrusions. The boundaries of the extrusions show a clear separation between the limestone host rock and the oxide body.

The frequency of these occurrences suggests the need for field research aimed at detecting oxide bodies exposed on the surfaces of slightly fractured and very compact limestones. To date, 22 extrusions have been recorded, all in Upper Cretaceous and Paleocene limestones in areas affected by strong tectonic compression. More detailed fieldwork and mapping could provide researchers with a basis for further studies and support the classification, understanding, and protection of these specific phenomena.

Keywords: *iron oxides, goethite, karstified limestone, North Adriatic, site protection*
Ključne besede: *železovi oksidi, goethit, zakraseli apnenec, severni Jadran, varstvo najdišč*

The International Union of Speleology and Its Mission
Mednarodna speleološka zveza in njeno poslanstvo

Zdeněk Motyčka[1]
[1] *International Union of Speleology - UIS*

The International Union of Speleology (UIS) is an international, non-profit, non-governmental organization that brings together cave explorers and scientists dedicated to the systematic study of caves and karst phenomena. Established in 1965, its primary mission is to foster international collaboration, develop global speleology and promote the conservation of caves and karst on a global scale.

Today, the UIS operates through a network of 57 member countries and 20 specialized scientific commissions, including karst geomorphology, hydrogeology, biospeleology and others. These groups help share knowledge and connect specialists from around the world.

One of the most important activities of the UIS is the International Congress of Speleology, held every four years. It provides an opportunity for researchers and cavers to present the results of cave and karst exploration and research.

Overall, the UIS also plays an important role in raising awareness and promoting the sustainable protection of caves and karst areas worldwide. The International Day of Caves and Karst is an initiative of the International Union of Speleology (UIS) and was proclaimed by UNESCO at the 43rd General Conference in 2025.

Keywords: *UNESCO, geoheritage, karst heritage, sustainable management, cave conservation*
Ključne besede: *UNESCO, geodediščina, kraška dediščina, trajnostno upravljanje, varstvo jam*

GIS-Based Mapping and Characterisation of Karst Hills in the Gua Musang–Lipis Area, West Malaysia

Kartiranje in karakterizacija kraških vzpetin na območju Gua Musang-Lipis v zahodni Maleziji z uporabo GIS

Ros Fatihah Muhammad[1], Wan Nurul Ain Wan Abdul Aziz[1]
[1] *Universiti Malaya, Kuala Lumpur, Malaysia*

A method for extracting karst terrain based on topographic feature points is proposed for this preliminary study. The positive-relief karst in the study area is developed within north–south-trending, relatively thin beds and lenses of limestone and marble in the largely argillaceous Permo–Triassic Gua Musang Formation, covering an area of approximately 9,300 km². Geological maps from the MyGEMS Portal generated by the Department of Minerals and Geoscience Malaysia, available karst hill data, together with elevation, perimeter, profiles, and area obtained from Google Earth Pro, were standardised and analysed in ArcGIS Pro. Where accessible, the occurrence of the hills was verified through fieldwork. Overlay analysis was performed to determine the distribution of the hills in relation to the surrounding lithology. Grouping analysis based on the spatial combinations of peaks, saddles, nadirs, and karst profiles was used to classify the karst hills into two broad groups: isolated hills, consisting of a single peak, and clusters comprising multiple peaks separated by saddles, with each hill delineated as a polygon. A total of 194 individual hills was identified, of which 153 are isolated hills. No distinct distribution pattern was observed, and further analyses of their morphology and controlling factors are ongoing.

Keywords: *spatial analysis, positive-relief terrain, limestone hills, remote sensing, geomorphological classification*
Ključne besede: *prostorska analiza, pozitivni relief, apnenčaste vzpetine, daljinsko zaznavanje, geomorfološka klasifikacija*

Karst as a Cognitive Tool for Inhabiting an Extended Temporality

Kras kot spoznavno orodje za bivanje v razširjeni časovnosti

Marta Murru[1]
[1] *Department of Architecture and Project, Sapienza University of Rome, Rome, Italy*

The work proposed here is the fruit of ongoing doctoral research in Landscape and Environment, within a school of architecture. Through the phenomenon of karst, the research questions and stress-tests the transformative capacity of landscape, understood as a set of relations (spatial, material, social) triggered by various acting processes, rather than as a mere object to be shaped.

This thesis stems from the need to discover another way of inhabiting the World — one that increasingly reminds us that our practices can no longer exclude collaboration with the more-than-human, and that calls for a less individualistic and more plural way of living. Climate change is the condition that most directly reveals this necessity, through a temporal paradox: human life — superficial, fast, immediate — has built a relationship of power over, and dependence on, deep, slow and promiscuous cycles that it is evidently no longer able to manage, either for itself or for the Planet.

Given the scale of the problem, the thesis proposes karst as a tool for cognitive training, through the discipline of landscape, in order to learn to inhabit an extended temporality, within a plural, lively and often contradictory World. Experiencing this requires training ourselves in the complexity of life, and

above all in the deep times contained within our present. From this perspective, karst allows us to practise the act of "making landscape" — of being in relation regardless of the nature of what enters that relation — and to cultivate awareness, by making different times of action coexist through its quality as a threshold connecting surface and depth. The karst landscape, understood as the set of relations triggered by the bio-geo-chemical processes that characterise it, is thus studied in its alternative co-habitability with respect to the current critical condition, in the hope that it may help to show collaboration as the possibility of a fairer and more far-sighted life.

The poster presents an overview of the work in progress — images, key literature and future perspectives — including an initial participatory knowledge experiment developed with an environmental-education Centre and an artist collective, linking research, education and the care of the karst landscape.

Keywords: *landscape theory, deep time, surface–subsurface relations, participatory experiment, environmental care*
Ključne besede: *teorija pokrajine, globoki čas, razmerja med površjem in podzemljem, participativni poskus, skrb za okolje*

Geohazards in Karst: Impacts on Society and Natural Environment, and Actions of Risk Mitigation

Geološko pogojene nevarnosti v krasu: vplivi na družbo in naravno okolje ter ukrepi za zmanjševanje tveganj

Mario Parise[1], Isabella Serena Liso[1]
[1] *University Aldo Moro, Bari, Italy*

Karst environments represent some of the most fragile and complex geological systems on Earth, characterized by high heterogeneity, rapid hydrological responses, and strong interactions between surface and subsurface processes. In such settings, a wide range of natural and anthropogenic hazards can occur, often with sudden onset and significant impacts. These hazards may lead to severe degradation of natural resources, including groundwater systems of strategic importance, as well as substantial damage to infrastructure and built-up areas.

Recovery from hazardous events in karst terrains is frequently challenging, time-consuming, and economically demanding. In many cases, the impacts may be long-lasting or even irreversible, particularly when they affect groundwater quality or land usability. Furthermore, the intrinsic difficulty in predicting karst processes increases the vulnerability of exposed communities.

In this contribution, we provide an overview of the principal geological hazards affecting karst regions, with particular attention to their triggering mechanisms, spatial distribution, and potential impacts on human activities and societal systems. Special emphasis is placed on the most characteristic karst geohazards, such as sinkholes and flash floods, which are amplified by the rapid infiltration and conduit flow typical of karst aquifers.

Additionally, the study addresses other critical issues increasingly observed in karst areas, including seawater intrusion in coastal karst aquifers, which threatens freshwater availability, and the progressive advancement of desertification processes, exacerbated by climate change and unsustainable land use practices. These phenomena further highlight the sensitivity of karst systems to both environmental and anthropogenic pressures.

This contribution emphasizes the need to improve current knowledge of karst processes in order to enhance risk assessment and support effective mitigation strategies, ultimately contributing to increasing the resilience of communities affected by karst geohazards.

Keywords: *sinkholes, flash floods, groundwater vulnerability, seawater intrusion, desertification*
Ključne besede: *udori, hudourniške poplave, ranljivost podzemne vode, vdor morske vode, dezertifikacija*

Speaker for the Dead – Ice Caves as the First Karst-Related Casualty in Our War on Planet Earth

Govornik za mrtve – ledene jame kot prva s krasom povezana žrtev našega boja s planetom Zemlja

Aurel Perșoiu[1,2,3], Matej Blatnik[4], Nenad Buzjak[1,5], Sanda Iepure[1,6], Ján Kaňuk[7], Jure Košutnik[4], Stein-Erik Lauritzen[8], Michaela Nováková[9], Rannveig Øvrevik Skoglund[10], Dalibor Paar[11], László Palcsu[12], Christos Pennos[1], Tea Blatnik[13], Yorgos Sotiriadis[14], Jozef Šupinský[8], Marjan Temovski[11], Stavros Zachariadis[15]

[1] *Emil Racoviţă Institute of Speleology, Cluj-Napoca, Romania*
[2] *Ștefan cel Mare University, Suceava, Romania*
[3] *School of Geology, Department of Physical Geography, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[4] *Karst Research Institute ZRC SAZU, Postojna, Slovenia*
[5] *Department of Geography, Faculty of Science, University of Zagreb, Zagreb, Croatia*
[6] *Faculty of Biology and Geology, Babeș-Bolyai University, Cluj-Napoca, Romania*
[7] *PHOTOMAP, s.r.o., Košice, Slovakia*
[8] *Department of Geology, University of Bergen, Bergen, Norway*
[9] *Institute of Geography, Faculty of Science, Pavol Jozef Šafárik University, Košice, Slovakia*
[10] *Department of Geography, University of Bergen, Bergen, Norway*
[11] *Department of Physics, Faculty of Science, University of Zagreb, Zagreb, Croatia*
[12] *Isotope Climatology and Environmental Research Centre (ICER), HUN-REN Institute for Nuclear Research (ATOMKI), Debrecen, Hungary*
[13] *SO Velebit Club, Zagreb, Croatia*
[14] *Department of Geography, Harokopio University of Athens, Greece*
[15] *Ministry of Culture, Ephorate of Corinth, Greece*

Ice caves (i.e., caves hosting perennial ice accumulations) are soon to become a memory. For millennia, ice from caves was harvested by local populations for water supply for both human and animal consumption, as a food preservative or as an ingredient for ice cream and beer. First mentioned in the 12th century in a religious text in India, ice caves became subjects of general curiosity in 15th-century Europe due to the unusual preservation of ice in summer and, since the late 19th century, of scientific study. These studies came in time to document the least desirable process: continuous, accelerated, and irreversible loss of ice as a result of ongoing changes in global climate. The aim of this talk is twofold. First, we will document the worldwide loss of cave ice and the driving mechanisms behind this process. Second, and most importantly, we call for 1) the implementation of continuous, accelerated, and in-depth research programs in ice caves and 2) a coordinated effort to extract and preserve ice from caves for future studies, thus preserving their climatic and environmental memory for the benefit of us all and as a reminder of what we have lost.

Keywords: *cave ice loss, climate change, environmental memory, ice preservation, palaeoclimate records*
Ključne besede: *izguba jamskega ledu, podnebne spremembe, okoljski spomin, ohranjanje ledu, paleoklimatski zapisi*

A New Precise Definition of the Dinaric Karst Zoogeographic Boundaries Based on Genomic Studies of Cave Beetles

Nova natančna opredelitev zoogeografskih meja Dinarskega krasa na podlagi genomskih raziskav jamskih hroščev

Slavko Polak[1]
[1] *Notranjski Muzej Postojna, Postojna, Slovenia*

Due to cyclical climate changes, particularly pronounced periods of aridification, members of certain animal groups have, over millions of years of evolution, colonized caves and adapted to life in these extreme habitats. The Dinaric karst is considered one of the most subterranean species-rich regions in the world. Among subterranean organisms, the group of Leptodirini beetles represents one of the greatest evolutionary radiations in caves. In our study, we performed molecular analyses on 147 samples of subterranean Leptodirini beetles from the Western Palearctic. Using polymerase chain reaction (PCR) and standard methods, we amplified six gene segments, which we then used for molecular phylogenetic analysis. All analysed genera of subterranean Leptodirini beetles formed a monophyletic group with clades that can be clearly defined geographically. We conclude that the evolution of this beetle group probably began in the region of the present-day Balkans. This was followed by a relatively rapid expansion of the ancestral lineages across the entire territory of Europe, where the representatives of these groups separately colonized subterranean habitats. Within the isolation of karst massifs, geographically distinct evolutionary radiations occurred. In the Balkans, these radiations occurred within well-defined geographical clades: the Stara Planina, Southern Carpathian, Rhodope, Eastern Alpine, Northern Dinaric, and Southern Dinaric clades. Within the boundaries of the Dinaric Karst, representatives of the Northern Dinaric and Southern Dinaric clades coexist and partially overlap. Using the geolocation of sites and cartographic representations of the distribution of genera, we have determined new, precisely defined external zoo-geographic boundaries of the Dinaric Karst region. Understanding the evolutionary origin of karst regions and subregions provides new insights into sustainable cave management and appropriate cave biota protection.

Keywords: *Leptodirini, subterranean, phylogeny, zoogeographic boundaries, Dinaric Karst*
Ključne besede: *Leptodirini, podzemlje, filogenija, zoogeografske meje, Dinarski kras*

Hydrogeological Investigations to Delineate the Recharge Area of Bobcat Cave for the Protection of Alabama Cave Shrimp on Redstone Arsenal, in Madison County, Alabama, USA

Hidrogeološke raziskave za določitev napajalnega območja jame Bobcat za varstvo alabaške jamske kozice na območju Redstone Arsenal v okrožju Madison, Alabama, ZDA

Gheorghe M.L. Ponta[1]
[1] *Geological Survey of Alabama, Alabama, United States*

The Geological Survey of Alabama conducted a groundwater monitoring study to delineate the recharge area of Bobcat Cave, on and near Redstone Arsenal, as part of a larger monitoring project for the protection of the Alabama Cave Shrimp, a federally listed endangered species found in the Bobcat Cave system on Redstone Arsenal. Groundwater flow direction was determined by measuring water levels in fifteen onsite and two offsite wells, two caves and one spring.

The comparison of seasonal water level fluctuations in Matthews and Bobcat Caves, selected existing

wells on the facility, and water surface elevations of Jaya Springs, Indian Creek, and the Tennessee River adjacent to the project area offers an understanding of groundwater movement. The water quality and discharge rates of surface water runoff were evaluated to directly quantify the water quality threats to the existing Alabama Cave Shrimp population. Trace metals, nutrients, and other commonly used indicators were evaluated to determine the sources and potential contaminants of surface waters entering the groundwater system. Based on our findings, a new recharge area was delineated for Bobcat Cave. At the current concentrations and rate of application, the recorded variations in water quality may not appear to influence the Alabama Cave Shrimp population. However, any change in land use in the recharge area that alters either water quality or water quantity may potentially affect shrimp population stability.

Keywords: *groundwater monitoring, endangered species, water quality, groundwater flow, land-use change*
Ključne besede: *spremljanje podzemne vode, ogrožene vrste, kakovost vode, tok podzemne vode, sprememba rabe tal*

The Hammamet Karst Aquifer as a Strategic Groundwater Reservoir (Semi-Arid Region, North East of Algeria)

Kraški vodonosnik Hammamet kot strateški rezervoar podzemne vode (polsušno območje severovzhodne Alžirije)

Legrioui Radhia[1]
[1] *Department of Geology, University of Science and Technology Houari Boumediene, Bab Ezzouar, Algeria*

The Hammamet region, located in northeastern Algeria, near the Algerian-Tunisian border, hosts an important karst aquifer system developed within Maastrichtian carbonate formations. In this semi-arid region, groundwater stored in karstified limestones represents a strategic resource for domestic supply, agricultural activities, and regional socio-economic development. This study aims to understand the hydrogeological functioning of the Hammamet karst aquifer based on geological, structural, hydrochemical, and isotopic investigations. The aquifer is characterized by extensive fracturing and karstification controlled by Atlasic tectonic structures. The karst forms observed in the Bouakkous karst system, including dolines, dissolution cavities and perennial springs, illustrate the interaction between geological evolution and groundwater circulation. Hydrogeological analyses indicate that recharge occurs mainly through direct rainfall infiltration into the fractured and karstified carbonate formations. Spring discharge monitoring reveals rapid hydrodynamic responses to precipitation events, highlighting the presence of preferential underground flow pathways and a well-developed conduit network. Hydrochemical data show predominantly calcium-bicarbonate water types resulting from carbonate dissolution, while stable isotope signatures confirm a meteoric origin of groundwater and relatively rapid recharge processes. Also, the study emphasizes the hydraulic relationships between the carbonate massifs and adjacent alluvial aquifers, demonstrating the regional importance of the Hammamet karst system as a natural groundwater reservoir. However, the high permeability of the karst environment increases its vulnerability to contamination and overexploitation, particularly under increasing water demand and recurrent drought conditions associated with climate variability. Besides its hydrogeological importance, the Hammamet karst constitutes a valuable geological and environmental heritage that contributes to water security in northeastern Algeria. Finally, understanding its functioning is essential for sustainable groundwater management, karst conservation, and climate change adaptation strategies in the study area.

Keywords: *karst aquifer, groundwater resources, karst hydrogeology, groundwater vulnerability,*

semi-arid region

Ključne besede: *kraški vodonosnik, viri podzemne vode, kraška hidrogeologija, ranljivost podzemne vode, polsušno območje*

Utilizing Structural Lineament Mapping with Digital Elevation Models for Understanding Speleogeneic Patterns in the Mammoth Cave Plateau

Uporaba kartiranja strukturnih lineamentov z digitalnim modelom višin za razumevanje speleogenetskih vzorcev na planoti Mammoth Cave

Ljubomir Risteski[1], Patricia Kambesis[1]

[1] *Department of Earth Environmental and Atmospheric Sciences, Western Kentucky University, Bowling Green, Kentucky, United States*

Lineament analyses provide a valuable framework for understanding the structural controls on karst development, groundwater flow, and surface–subsurface interactions in karst terrains. In the Mammoth Cave region of south-central Kentucky, the intersection of mapped faults, joints, and fracture zones with topographic lineaments strongly influences the orientation of cave passages, sinkhole alignments, and conduit-dominated aquifers. By integrating remote sensing of 10-inch resolution Digital Elevation Models (DEM), ArcGIS-based lineament mapping, and ongoing field verification, this study highlights the role of regional structural trends in the Mammoth Cave Plateau in guiding speleogenesis and level development within the Mammoth Cave Plateau. It can be utilized to identify zones of preferential flow pathways and can therefore improve vulnerability mapping, help predict contaminant transport, and influence land-use decisions within sensitive recharge areas. The results indicate that lineaments of NE–SW and NW–SE trending orientation exert some directional influence on conduit orientation, thereby influencing both the hydrologic regime and the geomorphic expression of the Mammoth Cave Plateau. These findings show the importance of structural mapping in karst terrains, providing an interpretive framework for predicting anisotropic groundwater flow, delineating zones of enhanced vulnerability, and refining conceptual models of karst aquifer dynamics. In addition, this research demonstrates that lineament analyses offer an essential tool for advancing both theoretical understanding of karst evolution and applied strategies for the conservation and management of large cave systems.

Keywords: *karst geomorphology, fracture networks, tectonic controls, remote sensing, GIS, terrain analysis, conduit development*

Ključne besede: *kraška geomorfologija, razpoklinske mreže, tektonska pogojenost, daljinsko zaznavanje, GIS, analiza reliefa, razvoj prevodnih kanalov*

Karst Literacy Is a Foundation for Effective Policy, Groundwater Protection, and Hazard Mitigation

Poznavanje krasa kot temelj učinkovitih politik, varstva podzemne vode in zmanjševanja nevarnosti

Limaris Soto[1], Ira D. Sasowsky[2]
[1] *University of Nova Gorica, Nova Gorica, Slovenia*
[2] *Department of Geosciences, University of Akron, Akron, United States*

Environmental literacy enables citizens to make sound decisions about land, resources, and policy, yet many lack a strong scientific foundation or understanding of Earth systems. This gap is especially notable in karst areas, where complex and interconnected surface-to-subsurface drainage is difficult to visualize and contaminants can move rapidly through groundwater. Strengthening karst literacy improves environmental understanding and supports sustainability awareness, environmental governance, effective policy, groundwater protection, and hazard mitigation. This study documents cave and karst education programs to evaluate how multisector efforts inform decision-making across professional, public, and educational audiences. An inventory of publicly available materials was classified by sector, audience, delivery format, and geographic distribution. Results show that NGOs are the primary drivers of karst education, by developing resources and engaging diverse audiences, while government agencies and universities provide significant but more specialized support. Most initiatives operate nationally, whereas global and regional programs coordinate, support, and build capacity where local education is limited. Geographic patterns reveal strong concentration in high-income regions, such as North America and Europe, underscoring disparities in access to karst literacy. Cooperation among existing programs reduces costs, improves consistency, and reinforces shared goals, and is likely more effective than creating new initiatives, especially when aligned with efforts such as UNESCO's International Day of Caves and Karst. Effective karst education requires audience-specific, evidence-based communication to address misconceptions and inform decisions. Strengthening partnerships, integrating karst principles into planning and infrastructure decisions, and elevating karst literacy among key stakeholders are essential for sustainable management of vulnerable karst systems. To ensure meaningful outcomes, communication must be rooted in local context and customs shaped by the realities and risks experienced by communities living on karst.

Keywords: *environmental education, science communication, decision-making, public awareness*
Ključne besede: *okoljsko izobraževanje, komuniciranje znanosti, odločanje, ozaveščanje javnosti*

Sustainable Management of Karst Waters

Trajnostno upravljanje kraških voda

Zoran Stevanović[1]
[1] *Centre for Karst Hydrogeology, Faculty of Mining & Geology, University of Belgrade, Belgrade, Serbia*

Karst terrains are widely distributed across the world, covering some 15% of the ice-free continental surface, while karst aquifers are one of the main potable water sources used in the world. They supply water to about 700 million people or approximately 9% of the global population.

As a result of the specific water regime and behaviour of karst, local populations often suffer from water shortages regardless of the fact that they may live in some of the most water-rich regions in the world, such as those in SE Europe. In the mountains high above sea level and the erosional base, the groundwater table can be very deep, with no available surface waters, and the only way to provide

water to local villagers and their livestock is to build cisterns and specific intakes for collecting rainwater.

Karst aquifers are among the globally richest water resources, but only if we consider their maximal and average discharges, not those in the low-water season, when water demands are regularly much higher, especially in coastal and tourism-developed regions. Therefore, engineering interventions are often needed to regulate the typical great variation in the water regime throughout the year and to ensure a stable water supply.

In the arid part of the world in Africa and Asia, apart from climate variations, population growth is another factor that causes water shortage and depletion of many aquifers. Even if they are rich in water reserves, local karst aquifers cannot keep pace with the expansion of some cities, in which the number of inhabitants has increased 50-fold in as many years, as has been witnessed in some countries. Although karst aquifers are one of the main sources - sometimes even the sole source - for local potable water supply and irrigation of fertile lands, many areas experience water shortages, and deep drilling remains the only way to provide potable water to the population.

The building of dams and the capture of karst rivers into huge reservoirs is a very sensitive issue, and sometimes negative effects such as water losses in highly permeable karstic rocks or due to evaporation, environmental changes, and hazards to water-dependent ecosystems may prevail over the positive effects of such structures.

Systematic monitoring and the establishment of early warning systems for the observation of karst groundwater quantity (spring discharges and water table) and its chemical and microbiological quality is the best way to raise knowledge on aquifer behaviour and to introduce timely preventive measures for sustainable water use and its protection from pollution.

Keywords: *karst hydrogeology, groundwater, karst aquifer, karst geohazards, risk mitigation*
Ključne besede: *kraška hidrogeologija, podzemna voda, kraški vodonosnik, kraške geološko pogojene nevarnosti, zmanjševanje tveganj*

Why Another Textbook on Karst and Caves – Developing an Accessible and Interactive Open Textbook

Zakaj še en učbenik o krasu in jamah – razvoj dostopnega in interaktivnega odprtega učbenika

Tim Stokes[1]
[1] *Vancouver Island University, Nanaimo, Canada*

Providing education is vital to help understand, manage and protect karst landscapes and caves that are valuable and sensitive resources. In Canada, undergraduate university courses on karst and/or caves are rare. However, at Vancouver Island University the author was given the opportunity to provide an introductory course on karst landscapes and caves for almost 20 years to undergraduate students, most of whom were in the Geoscience Program, but also to students from Geography, Forestry, Fisheries, Archaeology and other sciences. This popular course started out as a full online course, but gradually evolved into a hybrid course, with once-a-week meetings and a series of three field trips. Based on this teaching and other field experiences, it was decided to develop an introductory open textbook on karst and caves to share the materials and to provide a foundation for other instructors to teach this course.

As an open textbook, materials will be available with a Creative Commons (CC) license allowing an instructor advance permission to use all or any part of this work provided appropriate credit is given

to the author. This approach lets instructors modify or adapt the materials to better suit their course learning objectives. Written at an undergraduate level, the open textbook will be broad in scope, multi-disciplinary and cover many aspects of karst and caves with links to more detailed resources.

Open Textbooks provide greater accessibility as they are free and at no cost to students, can be downloaded and printed in multiple formats (e.g., as .pdfs or EPUBs) and viewed on a range of digital devices (e.g., phones, tablets, computers), where the content is responsive and sized automatically. Open Textbooks also allow for more interactivity with the inclusion of videos, learning activities and problems, case examples, self-test quizzes and in-depth discussion questions. Many open textbooks are published using Pressbooks software. Revisions and updates to the open textbook can be done rapidly and as required, without the need for republishing. One of the modern-day challenges and opportunities in teaching is Artificial Intelligence (AI), which might be used for information gathering, completing assignments or problem solving. Careful review and editing of the open textbook by recognized experts will help ensure its scientific accuracy and its long-term value as a trusted educational resource.

Keywords: *karst education, geoscience teaching, science communication, digital learning resources, student accessibility*
Ključne besede: *izobraževanje o krasu, poučevanje geoznanosti, komuniciranje znanosti, digitalna učna gradiva, dostopnost za študente*

Hydrogeological and sedimentological changes in the contact karst of the Postojna Basin: Geodiversity as an archive of the past

Hidrogeološke in sedimentološke spremembe v kontaktnem krasu Postojnske kotline: Geopestrost kot arhiv preteklosti

Astrid Švara[1], Nadja Zupan Hajna[1]
[1] *Karst Research Institute ZRC SAZU, Postojna, Slovenia*

The geodiversity of caves and karst preserves records of millions of years of landscape evolution. Protecting it is essential for understanding the past and managing karst areas responsibly in the future. The contact karst of the Postojna Basin provides an important setting for investigating links among tectonic evolution, hydrogeological change, speleogenesis and sedimentation. Cave passages, clastic sediments and speleothems preserve evidence of former watercourses, groundwater-level changes, tectonic uplift and long-term landscape evolution. The development of cave systems in this area was previously interpreted mainly as a response to climatic fluctuations. Recent multidisciplinary research, however, shows that tectonic processes also exerted a major influence on long-term changes in surface and underground drainage. The study area lies within the compressional regime of the External Dinarides and is influenced by the counterclockwise rotation of the Adriatic Microplate. During the Late Cenozoic, these processes contributed to tectonic segmentation, changes in relief, river diversions and the reorganisation of underground drainage. Two main sedimentary records are preserved in larger cave systems: allogenic clastic sediments associated with surface-water inflow and active underground flow, and speleothems deposited mainly after the reduction or cessation of allogenic input. Their succession records transitions between epiphreatic and vadose conditions and enables reconstruction of depositional environments, groundwater dynamics and cave-passage development. Individual phases are dated using palaeomagnetic and palaeontological methods, as well as U–Th dating. The results indicate major Plio–Quaternary hydrogeological reorganisation of the Postojna Basin, including changes in underground drainage and diversion of the Nanoščica River. Periods of relative tectonic stability enabled the development of extensive horizontal passages and prolonged

deposition of allogenic sediments. Phases of uplift and groundwater-level lowering promoted river incision, vadose-passage development, abandonment of older conduit passages and speleothem deposition. Cave sediments, speleothems and fossil passages are irreplaceable natural archives. Their loss would mean the irreversible destruction of part of the geological history of the Postojna Basin.

Keywords: geodiversity, contact karst, cave sediments, speleogenesis, tectonic evolution, hydrogeological reorganisation
Ključne besede: geopestrost, kontaktni kras, jamski sedimenti, speleogeneza, tektonski razvoj, hidrogeološke spremembe

From Knowledge to Conservation: Community-Based, Low-Cost Management of Tourist Caves in the La Danta Karst System, Colombia

Od znanja do varstva: skupnostno upravljanje turističnih jam z omejenimi sredstvi v kraškem sistemu La Danta v Kolumbiji

Nathalia Vanessa Uasapud Enríquez[1]
[1] *International Union of Speleology – UIS*

Tourism in rural areas of Colombia is frequently developed by landowners and local communities as an important source of supplementary income. In many cases, however, tourism activities have evolved with limited planning and management, leading to impacts on cave environments and conflicts among communities, landowners, and environmental authorities. The La Danta karst system, located in eastern Antioquia, Colombia, includes several caves that have been used as tourist attractions for decades. As a result, significant impacts have accumulated over time, including graffiti, sediment compaction, and deterioration of archaeological heritage. Although management plans were proposed by environmental authorities, their implementation was limited by the lack of financial and technical resources available to local stakeholders.

Research conducted in La Gruta and Marleny caves adopted a participatory approach in which landowners accompanied scientific investigations and actively contributed to the documentation of cave features, biodiversity, and environmental conditions. This process strengthened local understanding of the ecological and scientific value of the caves and increased awareness of their vulnerability to human disturbance. Subsequent studies evaluated visitor carrying capacity and identified a range of management measures required to reduce tourism-related impacts. However, many of the recommended actions exceeded the economic capacity of the local community. Consequently, management efforts focused on practical and affordable measures, including access restrictions to sensitive sectors, guide training, continuous supervision of guiding activities, and the delimitation of visitor routes and tourism zones.

The implementation of these actions has resulted in a more conservation-oriented management model. Although tourism-related impacts persist due to the inherent fragility of karst and cave environments, qualitative monitoring through repeat photography and field inspections indicates that the rate of deterioration has decreased compared with previous years. The experience demonstrates that community engagement, local ownership of scientific knowledge, and low-cost management interventions can significantly improve the conservation and sustainable use of tourist caves. The La Danta case provides a practical and replicable example for rural communities seeking to balance cave conservation with local economic opportunities derived from tourism.

Keywords: *geotourism, cave tourism, visitor management, community-based management, cave conservation*

Ključne besede: *geoturizem, jamski turizem, upravljanje obiska, skupnostno upravljanje, varstvo jam*

Geoparks, Karst and Caves
Geoparki, kras in jame

Ilias Valiakos[1,2]
[1] *European Geoparks Network, Digne-les-Bains, France*
[2] *Lesvos Island UNESCO Global Geopark, Mytilene, Greece*

UNESCO Global Geoparks are single, unified geographic areas where sites and landscapes of international geological significance are managed through a holistic approach integrating protection, education and sustainable development. By linking geological heritage with natural, cultural and intangible values, they empower local communities to protect their landscapes while fostering sustainable tourism, environmental awareness and regional development. Through the participation of local stakeholders, scientific institutions and public authorities, they serve as living laboratories where Earth heritage becomes a catalyst for education, innovation and territorial resilience.
The Global Geoparks Network (GGN) facilitates cooperation, knowledge exchange and the sharing of good practices among UNESCO Global Geoparks. In Europe, these activities are coordinated through the European Geoparks Network (EGN), the regional network of the GGN, which supports collaboration, capacity building, geoconservation, education, sustainable tourism and community engagement.
Karst landscapes and cave systems are among the most distinctive expressions of Earth's geological heritage, reflecting the interactions of geological, hydrological, climatic and biological processes. Many UNESCO Global Geoparks encompass internationally significant karst landscapes and caves, providing outstanding settings for understanding, conserving and sustainably managing these unique geological environments. Their scientific, ecological and cultural values contribute to geoconservation, scientific research, biodiversity conservation and groundwater protection. They also offer opportunities for environmental education, geoscience communication and responsible geotourism, demonstrating how geological heritage can support sustainable development and strengthen local communities.
Balancing conservation with sustainable public access remains a challenge, particularly in fragile subterranean ecosystems increasingly affected by tourism, land-use and climate change. Experiences from UNESCO Global Geoparks demonstrate that integrated management strategies combining research, geoconservation, visitor interpretation and community participation can effectively protect and sustainably manage these environments. By promoting responsible geotourism, strengthening scientific literacy and fostering international cooperation, UNESCO Global Geoparks provide an effective framework for conserving karst heritage while enhancing territorial resilience and supporting sustainable local development.

Keywords: *UNESCO Global Geoparks, karst, caves, geoheritage, geoconservation, sustainable geotourism*
Ključne besede: *Unescovi globalni geoparki, kras, jame, geodediščina, varstvo geološke dediščine, trajnostni geoturizem*

Mapping the Distribution of Karst Sinkholes Across Latvia Using High-Resolution LiDAR Data

Kartiranje razširjenosti kraških vrtač v Latviji z uporabo visokoločljivih podatkov LiDAR

Madara Vitkovska[1]
[1] *University of Latvia, Riga, Latvia*

In Latvia, karst has developed in both carbonate rocks – limestone and dolomite (mainly in the past) and sulphate rocks (gypsum) of the Upper Devonian age. Most surface sinkholes are associated with the Upper Devonian Salaspils Formation gypsum and are concentrated in the central and southern parts of the country where the Quaternary cover is thin, and karst processes are still active today (Karušs et al. 2023). Geophysical surveys have also revealed buried sinkholes, for example beneath a bog near Allaži (Džeriņš et al. 2023). Despite a long research tradition, the national picture still rests largely on local, site-specific surveys (Džeriņš et al. 2023; Karušs et al. 2023) rather than a consistent, country-wide inventory, even though karst is an active geohazard with implications for land use, infrastructure and conservation (Gutiérrez 2014).

This study aims to build a systematic, country-wide inventory and distribution map of karst sinkholes (kritenes in Latvian) in Latvia, in order to clarify the spatial extent and intensity of karst processes. Sinkholes are identified and manually digitized in QGIS from a high-resolution LiDAR-derived elevation model, interpreted through multidirectional hillshade, relief and slope visualizations, and cross-checked against existing geological maps; candidate depressions are further assessed using morphometric parameters such as area, depth and circularity index (Shannon et al. 2019). Preliminary mapping results focus on the gypsum-karst areas of central Latvia, in the vicinity of Baldone, before being extended nationwide.

Initial mapping documents abundant sinkholes and shows that LiDAR data reveal features beyond earlier field inventories, including depressions masked by vegetation or land use. Work is ongoing, with the inventory being progressively extended across Latvia including some local areas where karst sinkholes have not been recognized so far. The completed dataset will provide a reproducible baseline for karst-process research, geohazard assessment, spatial planning and training dataset for machine learning.

This work presents the methodology and preliminary results of an ongoing MSc thesis.

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Keywords: *LiDAR, sinkhole mapping, spatial data, karst geohazards, risk mitigation*
Ključne besede: *LiDAR, kartiranje vrtač, prostorski podatki, kraške geološko pogojene nevarnosti, zmanjševanje tveganj*

Geodiversity Sustains Biodiversity in Karst

Geodiverziteta podpira biotsko raznovrstnost v krasu

Pei Wang[1]
[1] *Institute of Hydrobiology, Chinese Academy of Sciences, China*

The relationship between geodiversity and biodiversity is a foundational yet evolving topic in Earth sciences. This paper proposes a novel framework from an evolutionary perspective, arguing that Geodiversity Sustains Biodiversity (GSB) across three integrated levels: Elemental, Morphological, and Compositional diversity. At the Elemental Level, chemical elements (C, H, O, N, P, S, etc.) serve as the fundamental building blocks of life and DNA, with historical milestones like the Great Oxidation Event (GOE) driving mineral and biological diversification. At the Morphological Level, abiotic forms—such as varied water bodies and landforms—provide unique habitats and micro-climatic shelters that support specialized species and communities. At the Compositional Level, the complex interplay of rocks, soils, and climate shapes global terrestrial and aquatic ecosystems, from the Amazon Rainforest to the deep-sea hydrothermal vents. The study further highlights the conservation significance of this link, noting that 14% of UNESCO Global Geoparks overlap with Biosphere Reserves, particularly in karst regions. We conclude that geodiversity not only provides the material basis for the origin of life but continues to shape biological evolution through geological mechanisms like geographical isolation and tectonic activity.

Keywords: *geoheritage, geosphere–biosphere interactions, conservation value, geoparks*
Ključne besede: *geodediščina, povezave med geosfero in biosfero, naravovarstvena vrednost, geoparki*

Future Challenges for Cave and Karst Conservation

Prihodnji izzivi varstva jam in krasa

Paul W. Williams[1]
[1] *International Union of Speleology – UIS*

Caves and karst provide many natural resources, including water supplies for around a billion people. Caves also contain sheltered natural repositories of environmental and cultural history that can extend back millions of years. Many of these important scientific and cultural sites have been protected by national and international agencies, including UNESCO. However, while considerable progress has been made in protecting many of the world's most important karst areas, there are some outstanding omissions. One of these is the international type area of karst, the Dinaric Karst, that is protected in part but not as a comprehensive series of sites that together convey the nature and meaning of karst. This is in striking contrast to the type-site for humid tropical/subtropical karst, the South China Karst, a World Heritage property that extends as a series of interrelated sites from the mountains to the monsoonal lowlands. This property was enlarged gradually, as nominations of its various parts were made over several years. The situation in the Dinaric region is more complex, because the karst extends across several countries. But despite the difficulties of coordinating multinational political and scientific agencies, the initiation of a programme to achieve a World Heritage trans-national serial nomination of the 'Classical Karst' should be possible. Its initiation would be a fitting legacy of this first celebration of the International Day of Caves and Karst. Other internationally important karst sites also require similar protection, including the Nullarbor Plain of Australia and the karstified salt glaciers (namakier) of Iran. In each case the scientific imperative is

clear, but without political support progress will be difficult.

Keywords: *UNESCO World Heritage, Classical Karst, protected areas, international cooperation*
Ključne besede: *Unescova svetovna dediščina, Klasični kras, zavarovana območja, mednarodno sodelovanje*

Carbon Sequestration in Karst Surface Aquatic Systems
Vezava ogljika v kraških površinskih vodnih sistemih

Xiao Qiong[1,2,3]
[1] *International Research Centre on Karst, UNESCO*
[2] *China-Slovenia "Belt and Road" Joint Laboratory on Karst Geology*
[3] *Institute of Karst Geology, Chinese Academy of Geological Sciences, Guilin, China*

Karst carbon sinks, though neglected, do exist. Aquatic organisms and microbial action can fix inorganic carbon produced by carbonate weathering. Using models to calculate the global karst carbon sink is essential. On average, the karst carbon sink flux of the whole basin is 14.5 t C/km² yr^{-1}, which totals about 90,000 t C/yr. That is to say, about 330,000 t CO_2/yr are absorbed by carbonate weathering in the Lijiang River Basin, which is equivalent to about 320,000 t CO_2 emitted by tourists in Guilin City in 2012. The solute load method was used to estimate the karst carbon sink in the Lijiang River Basin over 23 years. The carbon sink over many years showed an overall growth trend, but the fluctuation was large. On the basis of the estimation results of karst carbon sinks over 23 years, a time-series prediction model is used to predict the Lijiang River Basin from 2023 to 2030. The prediction results continue the volatility and trend shown by the historical data.

Keywords: *karst carbon sink, Lijiang River Basin, aquatic organisms, carbonate weathering, time-series prediction*
Ključne besede: *ponor ogljika v krasu, porečje reke Lijiang, mikrobna aktivnost, raztapljanje karbonatov, napovedovanje časovnih vrst*

International Research Centre on Karst, UNESCO
Mednarodni raziskovalni center za kras, UNESCO

Zhong Liang[1,2,3]
[1] *International Research Centre on Karst, UNESCO*
[2] *China-Slovenia "Belt and Road" Joint Laboratory on Karst Geology*
[3] *Institute of Karst Geology, Chinese Academy of Geological Sciences, Guilin, China*

Established in 2008, IRCK is the first category II centre concerning geosciences under UNESCO and is also a participating organization of GEO (2021) and an affiliated organization of IUGS (2024). Through scientific research, publication, and international cooperation, IRCK aims to promote the development of karst dynamics, including karst and climate change, karst water resources and water security, karst rocky desertification and eco-industry, karst geoheritage diversity conservation and sustainable utilization, and karst geohazard prevention and early warning, serving the sustainable development of karst areas. In 2016, IRCK launched the large international scientific plan “Resources and

Environmental Effects of Global Karst Dynamic Systems" in Guilin, with supporting letters received from 32 renowned karst geologists across 17 countries. The plan is dedicated to providing scientific solutions for the sustainable development of karst regions worldwide. In 2026, the international standard Technical Requirements for Karst Critical Zone Monitoring was successfully issued.

Since its establishment, IRCK has hosted or co-organized 41 international conferences, signed 24 international cooperation agreements with 18 countries, and successively implemented 6 International Geoscience Programme (IGCP) projects (IGCP 299, IGCP 379, IGCP 448, IGCP 513, IGCP 5989, and IGCP 661). In addition, IRCK has actively organized 17 international training courses, benefiting over 505 foreign trainees from 61 countries around the world.

Keywords: *karst research, international cooperation, karst monitoring, training programmes*
Ključne besede: *raziskovanje krasa, mednarodno sodelovanje, spremljanje krasa, programi usposabljanja*

The formation mechanism and potential heritage value of the World's super cavern The Miao Chamber in Ziyun County, Guizhou, China

Mehanizem nastanka in potencialna dediščinska vrednost jamske dvorane Miao (Guizhou, Kitajska), ene največjih jamskih dvoran na svetu

Zhou Wenlong[1]
[1] *Guizhou Institute of Mountainous Resources, Guizhou Academy of Sciences, Guizhou, China*

As the world's largest cavern chamber by both volume and surface area, the Miao Chamber Cavern in Ziyun County has attracted global attention. However, its formation mechanism has not yet been systematically elucidated, and its potential heritage value urgently needs to be explored. The formation of Miao Chamber Cavern is closely related to the 3D surface-underground spatial structure and is strictly controlled by the hydrogeological setting of the Getu River Basin, representing a masterpiece shaped by the interaction of multiple factors. The Miao Chamber Cavern exhibits a unique "double-dome" morphology controlled by multiphase tectonic activities. The Lower Permian medium- to thick-bedded massive pure limestone and favorable fold structures provided the key material foundation and water inlets. Multi-source and wide-area recharge created superior hydrodynamic conditions, while progressive collapse enlargement continuously modified the chamber, making it an outstanding example reflecting major stages of Earth's evolutionary history. The immense cavity, exceptional morphological features, and sedimentary/accumulation landforms of Miao Chamber Cavern also possess remarkable aesthetic value. Furthermore, the Getu River Basin, which hosts Miao Chamber Cavern, preserves traditional Miao culture and practices, including cave-dwelling communities (Zhongdong), cave hanging coffins, freehand rock climbing, and the epic culture of King Yalü, all of which are facing a crisis of intergenerational transmission. In summary, to effectively achieve the sustainable conservation and revitalization of this world-class geological heritage and cultural island, systematic exploration of its potential heritage value is urgently needed. The Miao Chamber Cavern and its Getu River Basin possess outstanding natural and cultural heritage endowments and are expected to become one of the first preparatory sites in Guizhou Province to be nominated as a UNESCO Mixed (Natural and Cultural) World Heritage Site.

Keywords: *cave morphology, karst evolution, geological heritage, UNESCO World Heritage Site candidate*
Ključne besede: *morfologija jame, razvoj krasa, geološka dediščina, kandidat za Unescovo svetovno dediščino*

Sustainable Tourism and Conservation Measures in the Škocjan Caves

Trajnostni turizem in naravovarstveni ukrepi v turistični jami Škocjanske jame

Tomaž Zorman[1]
[1] *Javni zavod Park Škocjanske jame, Škocjan, Slovenia*

This contribution presents an example of sustainable cave management based on a defined carrying capacity, with an emphasis on management that strongly considers nature and natural processes, while reducing impacts on the cave ecosystem through various measures.

Keywords: *sustainable tourism, cave management, carrying capacity, cave ecosystem, nature conservation measures*
Ključne besede: *trajnostni turizem, upravljanje jam, nosilna zmogljivost, jamski ekosistem, naravovarstveni ukrepi*

From an Idea to a UNESCO International Day

Od ideje do Unescovega mednarodnega dne

Nadja Zupan Hajna[1,2]
[1] *Karst Research Institute, ZRC SAZU, Postojna, Slovenia*
[2] *International Union of Speleology - UIS*

The International Day of Caves and Karst (IDCK), celebrated annually on 13 September, was proclaimed by the UNESCO General Conference in November 2025 as a new international observance dedicated to raising global awareness of the importance of caves and karst. This proclamation represents the first formal recognition of caves and karst within the framework of UNESCO international observances and establishes a permanent international platform for promoting their scientific, environmental, cultural, educational, and socio-economic values.

The initiative originated within the International Union of Speleology (UIS) and developed over several years through the preparation of scientific documentation, international consultation, and close cooperation between the scientific community, governmental institutions, and UNESCO. The proposal was formally submitted by the Republic of Slovenia. It received the support of more than 150 international, regional, and national organisations, was co-sponsored by 67 UNESCO Member States, and was adopted by consensus at the UNESCO General Conference in Samarkand.

The proposal emphasised the global significance of caves and karst for groundwater resources, subterranean biodiversity, geoheritage, cultural heritage, education, scientific research, and sustainable development. Particular emphasis was placed on its contribution to several United Nations Sustainable Development Goals, especially those related to clean water, biodiversity conservation, climate resilience, and the protection of natural and cultural heritage.

Slovenia played a central role throughout the initiative. The Classical Karst, from which karst landscapes worldwide derive their name, together with the country's long tradition of karst research, speleology, and speleobiology, internationally recognised scientific institutions, and the headquarters of the International Union of Speleology in Postojna, provided a strong scientific and institutional foundation for the initiative.

Beyond its symbolic significance, IDCK provides a permanent international framework for strengthening research, education, international cooperation, conservation, and the sustainable

management of cave and karst environments through annual global activities.

Keywords: *International Day of Caves and Karst, UNESCO, International Union of Speleology, Slovenia, karst science*
Ključne besede: *Mednarodni dan jam in krasa, UNESCO, Mednarodna speleološka zveza, Slovenija, krasoslovje*

GENERAL INFORMATIONS

SPLOŠNE INFORMACIJE

PRACTICAL INFORMATION

Registration

- Registration is possible on Friday (8:00–12:30) and Saturday (8:30–11:00) in the Cultural Centre Postojna (Gregorčičev drevored 2a, Postojna).
- **Registration is obligatory for all participants.**

Oral presentations

- Lectures will take place in the Cultural Centre Postojna (Gregorčičev drevored 2a, Postojna).
- **PowerPoint presentations should be given to the organizers during the break before the Session with the presentation.**
- **Maximum duration of the lecture is 15 min** (12 min for talk and 3 min for discussion). **Invited lecturers (keynote speakers) have 20 min for the lecture**. Due to a tight schedule, we ask you to please be punctual.

Posters

- **Poster size: mandatory max. format is A0 – 841 x 1189 mm (portrait layout).**
- Poster display will be held at the Cultural Centre Postojna (Gregorčičev drevored 2a, Postojna).
- Leave the posters at the registration desk on Friday, September 11th, between 8:00 and 9:00.
- Stand by your poster during the poster display.

Meals

- Lunches are not organized during the session days.
- Simple lunches will be provided during excursions on Thursday and Sunday, but we recommend bringing some additional snacks.
- Lunch breaks are included into the program on Friday and Saturday. Several restaurants are available, including Štorja pod stopnicami, Bar Bor, Pri kaminu, Čuk, Pizzaria Minutka, Okusi Filiponov (see the map below).

Excursions

- Participation in the excursion is possible only if you registered for it during registration.
- All excursions will be combined with a bus drive and walk (few km per day).
- Bus departure for the excursions is from the Postojna bus station. Be punctual!
- Because of visits of caves, walking shoes and field clothes are obligatory. At most excursions, a moderate walking is expected. Please, be ready for highly possible rain.
- Insect repellent is recommended, as we will be walking in areas where ticks (Ixodes ricinus) are common. They can transmit Lyme disease and tick-borne encephalitis. Please check yourself carefully each evening after the excursion.
- Participation in the excursions is voluntary and at participants own risk. The organizers accept no liability for any loss, damage, injury or death arising from or in connection with the excursions. Participants are advised to obtain appropriate insurance coverage and must comply with the organiser's instructions.

Official ceremony

- The ceremony on September 12th will take place in Postojna Cave, so please dress warmly and wear appropriate, comfortable, non-slip footwear. As this is a gala event, evening and formal attire is recommended.
- Attendance is limited to participants who registered for the ceremony when completing their conference registration, as well as invited guests and ambassadros. Due to the limited number of seats in the cave, priority is given to honored and other invited guests, elderly people, and people who have difficulty standing due to health or other justified reasons.

- As the cave train departs at 18:00, please arrive at the meeting point in front of Postojna Cave by 17:15. No later train will be provided. There is also a specific boarding order, so please follow the instructions at the location.
- Before the train departs, the official group photo will be taken. Please do not be late!
- You can reach the event location on foot. If you are coming by car, the first parking lot is available on the left before you cross the bridge.

Organised local transport with Toyota GO

Toyota GO app: Participants who would like to use organized local transportation during the event are kindly requested to download the Toyota GO app using the QR code below.

Account setup: After installation, create a user account and select the Postojna unit as the location.

Transportation reservation: All available options and times will be published in the app. It is mandatory to book the desired time in advance — we recommend one day in advance or at the latest early in the morning on the day of transportation. Timely reservations allow the organizers to optimally plan vehicles and routes.

Priority entry: Passengers with reservations have priority. The remaining free seats will be available to unannounced passengers until the capacity is filled.

Schedule and capacities: Transportation will take place on Friday and Saturday, September 11 and 12:

- Morning times: 2 vans drive (each makes 3 laps on its own route).

- Afternoon times: 1 van drives (makes 3 laps on its own route).

Please see the attached map for exact routes.
Note: The listed departure times are for informational purposes only and may vary slightly due to traffic conditions.

OSNOVNE INFORMACIJE

Registracija

- Registracija bo mogoča v petek med 8:00 in 12:30 ter v soboto med 8:30 in 11:00 v Kulturnem domu Postojna (Gregorčičev drevored 2a, Postojna).
- Registracija je obvezna za vse udeležence.

Ustne predstavitve

- Predavanja bodo potekala v Kulturnem domu Postojna (Gregorčičev drevored 2a, Postojna).
- PowerPointove predstavitve je treba organizatorjem oddati med odmorom pred sklopom, v katerem bo predstavitev.
- Predavanje lahko traja največ 15 minut: 12 minut za predstavitev in 3 minute za razpravo. Vabljeni predavatelji imajo za predavanje na voljo 20 minut. Zaradi zgoščenega programa vas prosimo, da se predvidenega časa dosledno držite.

Posterji

- Največji dovoljeni format posterja je A0 – 841 × 1189 mm, v pokončni postavitvi.
- Posterji bodo razstavljeni v Kulturnem domu Postojna (Gregorčičev drevored 2a, Postojna).
- Posterje oddajte pri registraciji v petek, 11. septembra, med 8:00 in 9:00.
- Med predstavitvijo posterjev bodite prisotni ob svojem posterju.

Prehrana

- Kosila med dnevi, namenjenimi predavanjem, niso organizirana.
- Med ekskurzijama v četrtek in nedeljo bo zagotovljeno preprosto kosilo, vendar priporočamo, da s seboj prinesete tudi dodatne prigrizke.
- Odmor za kosilo je v petek in soboto vključen v program. V bližini je na voljo več restavracij, med drugim Štorja pod stopnicami, Bar Bor, Pri kaminu, Čuk, Pizzaria Minutka in Okusi Filiponov; glejte spodnji zemljevid.

Ekskurzije

- Ekskurzije se lahko udeležijo samo udeleženci, ki so se nanjo prijavili ob registraciji.
- Vse ekskurzije vključujejo vožnjo z avtobusom in nekaj kilometrov hoje na dan.
- Avtobusi za ekskurzije bodo odpeljali z avtobusne postaje Postojna. Bodite točni!
- Zaradi obiskov jam so obvezni pohodni čevlji in primerna terenska oblačila. Na večini ekskurzij je predvidena zmerno zahtevna hoja. Bodite pripravljeni tudi na zelo verjeten dež.
- Priporočamo uporabo sredstva proti insektom, saj bomo hodili po območjih, kjer so pogosti klopi vrste Ixodes ricinus. Ti lahko prenašajo lymsko boreliozo in klopni meningoencefalitis. Priporočamo, da se vsak večer po ekskurziji skrbno pregledate.
- Udeležba na ekskurzijah je prostovoljna in na lastno odgovornost udeležencev. Organizatorji ne prevzemajo odgovornosti za izgubo, škodo, poškodbe ali smrt, ki bi nastale med ekskurzijami ali v povezavi z njimi. Udeležencem svetujemo, da si zagotovijo ustrezno zavarovanje, ter jih prosimo, da upoštevajo navodila organizatorjev.

Uradna slovesnost

- Slovesnost 12. septembra bo potekala v Postojnski jami, zato se toplo oblecite in obujte primerno in udobno obutev, ki preprečuje zdrse. Ker gre za gala prireditev, so priporočljiva večerna in slovesna oblačila.
- Udeležba je omejena na udeležence, ki so se na slovesnost prijavili ob registraciji na konferenco, ter na vabljene goste in ambasadorje. Zaradi omejenega števila sedežev v jami so ti prednostno namenjeni častnim in drugim vabljenim gostom, starejšim osebam ter osebam, ki zaradi zdravstvenih ali drugih utemeljenih razlogov težje stojijo.

- Ker jamski vlak odpelje ob 18.00, pridite na zbirno mesto pred vhodom v Postojnsko jamo najpozneje do 17.15. Poznejši prevoz z vlakom ne bo organiziran. Določen je tudi natančen vrstni red vkrcanja, zato vas prosimo, da dosledno sledite navodilom na lokaciji.
- Pred odhodom v jamo bo tudi skupinsko fotografiranje, zato prosim ne zamujajte!
- Do lokacije dogodka lahko pridete peš. Če boste prišli z avtom, je za vas na voljo prvo parkirišče na levi strani, predno prečkate most.

Organizirani lokalni prevoz

Aplikacija Toyota GO: Udeležence, ki bi med dogodkom želeli uporabljati organizirani lokalni prevoz, vljudno prosimo, da si prek spodnje QR-kode prenesete aplikacijo Toyota GO.

Nastavitev računa: Po namestitvi ustvarite uporabniški račun in kot lokacijo izberite enoto Postojna.

Rezervacija prevoza: Vse razpoložljive možnosti in termini bodo objavljeni v aplikaciji. Želeni termin obvezno rezervirajte vnaprej — priporočamo en dan prej oziroma najpozneje zgodaj zjutraj na dan prevoza. Pravočasna rezervacija organizatorjem omogoča optimalno načrtovanje vozil in poti.

Prednost pri vstopu: Potniki z rezervacijo imajo prednost. Preostala prosta mesta bodo na voljo nenajavljenim potnikom do zapolnitve zmogljivosti.

Urnik in kapacitete: Prevozi bodo potekali v petek in soboto, 11. in 12. septembra:

- Jutranji termini: Vozita 2 kombija (vsak opravi 3 kroge po svoji liniji).
- Popoldanski termini: Vozi 1 kombi (opravi 3 kroge po svoji liniji).

Natančne poti si oglejte na priloženem zemljevidu.

Opomba: Navedeni časi odhodov so informativni in se lahko zaradi prometnih razmer nekoliko spremenijo.
Navedeni časi so informativni in lahko zaradi prometnih oziroma drugih nepredvidenih razmer nekoliko odstopajo.

MAP OF POSTOJNA

ZEMLJEVID POSTOJNE



1 - Karst Research Institute ZRC SAZU / Inštitut za raziskovanje krasa ZRC SAZU
2 - Cultural Center of Postojna / Kulturni dom Postojna
3 - Postojna bus station / Avtobusna postaja postojna
4 - Entrance to Postojna cave / Vhod v Postojnsko jamo

A - Pizzeria and restaurant Minutka / picerija in restavracija Minutka
B - Bistro Štorija / Bistro Štorija
C - Restaurant Proteus / Restavracija proteus
D - Bistro Bar Bor / Bistro Bar Bor
E - Pizzeria and restaurant Čuk / Picerija in restavracija Čuk

Post office / pošta
ATM / bankomat
Market / trgovina
Bakery / pekarna
Fast food / hitra prehrana

ADDITIONAL PROGRAM

SPREMLJEVALNI PROGRAM

Large Carnivore Center DINA

A unique educational and entertainment center, where you can experience the world of the wolf, lynx and bear in the atmosphere of an enchanted forest with the help of virtual and augmented reality. At dusk beneath the treetops, the richness of wildlife will reveal itself to you, while modern technology will introduce you to the world of large carnivores in an engaging and entertaining way.

Opening Hours (11–13 September 2026):

- Thursday–Friday: 10.00–15.00
- Saturday–Sunday: 10.00–17.00



Figure 8: Large Carnivore Center DINA (photo: The Seasonal Lakes of Pivka Natural Park)

Ecomuseum of the Seasonal Lakes of Pivka

The Ecomuseum tells the story of water, stone and people. During periods of high water, as many as seventeen intermittent lakes appear in the valley. Interactive presentations of wetlands, dry meadows, shrublands, forests and caves are complemented by displays of the exceptionally diverse plant and animal life of the Pivka Basin.

Opening Hours (11–13 September 2026):

- Thursday–Friday: 10.00–15.00
- Saturday–Sunday: 10.00–17.00



Figure 9: Ecomuseum of the Seasonal Lakes of Pivka (photo: The Seasonal Lakes of Pivka Natural Park)

Park of military history Pivka

A museum and tourist centre offering visitors an insight into Slovenia's rich military history heritage, with a special emphasis on the 1991 War for Slovenian Independence. The collection of tanks, cannons and armoured vehicles is complemented by several exhibitions, while the greatest attraction is the P-913 Zeta submarine, which can also be visited inside.

Opening Hours (11–13 September 2026):

- Thursday–Friday: 10.00–15.00
- Saturday–Sunday: 10.00–17.00



Figure 10: Park of military history Pivka (photo: The Seasonal Lakes of Pivka Natural Park)

Seasonal lakes of Pivka Nature Park

Seasonal lakes of Pivka Nature Park repesents an intertwining of karst landscape and a dynamic water world. During periods of heavier rainfall, numerous intermittent lakes appear, creating unique living conditions. The area is characterised by rich meadows, forests and exceptional biodiversity of plant and animal species.



Figure 11: Pivka Natural Park (photo: The Seasonal Lakes of Pivka Natural Park)

The Notranjska Museum Postojna

1) Independent tour of the Karst Museum exhibition, the outdoor exhibition depot and lapidary, the Crime and Fruit exhibition, which focuses on the phenomenon of graffiti, and all children's corners. The exhibitions are available in Slovenian and English.

More information: https://www.notranjski-muzej.si/Home?lang=en

2) Experience the KARSTHUNT game for individuals and families with older children (11 years and above), available by prior reservation and an additional payment of €50 per team (maximum five people per team). The game is available in Slovenian, English, and Italian.

More information: https://www.notranjski-muzej.si/objava/1157845

3) Play the experience "Become a Kraso(s)lovec!" in groups of up to 10 people, including younger children, by prior reservation and with an additional payment of €30 per group (maximum 10 people). The game is available in Slovenian.

More information: https://www.notranjski-muzej.si/objava/1245678

4) Self-guided tour of the exhibition with free use of Museum Chat for Families. The game is available in Slovenian and English.

More information: https://www.notranjski-muzej.si/objava/776771

5) Independent tour of the exhibition with free use of audio guides in Slovenian, German, and Italian.

More information: https://www.notranjski-muzej.si/objava/1242164

Opening Hours:

Tuesday – Sunday: 10.00 – 17.00

NEOTROPICA

Embark on a tropical adventure and discover nature's hidden treasures. How many unusual inhabitants can you find in this magical world? Test your research skills and immerse yourself in the tropical atmosphere, right here in Postojna. Strange? Perhaps. Wonderful? Without a doubt.

Opening Hours:

Tuesday – Sunday: 10.00 – 18.00 (last entrance 17.00).

For groups, advance notice is required, and we also recommend reservations for all other dates.

More information and price list: https://neotropica.si/en/boutique-tropical-exhibit/

Sightseeing the city: Bourgeois promenade

Accessible every day of the year with a guide book, which visitors can receive free of charge at the Postojna Visitor Centre (Trg padlih borcev 5, 6230 Postojna). A guided tour is also available, but in this case prior notice is required at least one week in advance by email: info@visit-postojna.



Celebrating the International Day of Caves and Karst

Free Guided City Tour

11. September 2026 · 10:00
12. September 2026 · 16:00

Meeting point: in front of the Karst Research Institute ZRC SAZU
Duration: 1,5 hour
Language: English
Free of charge

Advance registration is recommended for organisational purposes: info@visit-postojna.si | +386 (0)40 122 318

Explore the town of Postojna where karst stories come to life.

A gentleman's experience in the oldest barbershop in Slovenia

The barbershop with the longest beard in Postojna has been brought to life with original equipment and a new story. The space in the legendary pink house on the corner combines the concept of a century-old tradition and the mastery of the legends from the Ozbič family with modern barbering and hairdressing techniques.

Opening Hours:

Monday – Friday: 8.00 – 20.00

Saturday: 8.00 – 14.00

More information and price list: https://www.lukas-den.com/#dm

Adventure Park

Adventure Park Postojna offers a unique, primal and exciting walk through the forest canopy, where you can test your ingenuity and adventurous spirit and experience a truly special day.

Opening Hours:

2 to 27 September: Saturday, Sunday: 12.00 – 18.00

More information: https://pustolovski-park-postojna.si/index-en.html#C6

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